UNIVERSIDADE FEDERAL DO ESTADO DO RIO DE JANEIRO
CENTRO DE CIÊNCIAS EXATAS E TECNOLOGIA - CCET
PROGRAMA DE PÓS-GRADUAÇÃO EM INFORMÁTICA - PPGI

ACCOUNTABILITY EVALUATION IN SYSTEMS-OF-INFORMATION SYSTEMS BASED ON SYSTEMS THINKING

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RIO DE JANEIRO, RJ - BRASIL
NOVEMBRO DE 2021

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TESE DE DOUTORADO APRESENTADA COMO REQUISITO PARCIAL PARA OBTENÇÃO DO TÍTULO DE DOUTOR PELO PROGRAMA DE PÓS-GRADUAÇÃO EM INFORMÁTICA DA UNIVERSIDADE FEDERAL DO ESTADO DO RIO DE JANEIRO (UNIRIO). APROVADA PELA COMISSÃO EXAMINADORA ABAIXO ASSINADA.

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C794 Cordeiro de Paula, Felipe

Accountability Evaluation in Systems-of-Information Systems based on Systems Thinking / Felipe Cordeiro de Paula. -- Rio de Janeiro, 2021. 243

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Tese (Doutorado) - Universidade Federal do Estado do Rio de Janeiro, Programa de Pós-Graduação em Informática, 2021.

1. Accountability. 2. Information Systems. 3. Systems-of-Information Systems. 4. Systems Thinking. 5. Framework. I. Pereira dos Santos, Rodrigo, orient. II. Pires Vieira de Vasconcelos, Aline, coorient. III. Título.

"*Se os seus sonhos estiverem nas nuvens, não se preocupe, pois eles estão no lugar certo, agora construa os alicerces para alcançá-los.*"

(Autor desconhecido)

Acknowledgments

Thanks to Professor Rodrigo and Professor Aline Pires Vieira de Vasconcelos for guiding me on this journey, for the opportunity to learn throughout this process, and for being welcomed into the Complex Systems Engineering Laboratory. I thank the evaluation board: Davi Viana dos Santos, Fernanda Filgueiras Sauerbronn, Gleison dos Santos Souza, and Sean Wolfgand Matsui Siqueira for accepting to evaluate this thesis research.

Thanks to my husband Silvio for the companionship, and for being so understanding and caring.

Thanks to my parents, Athenagoras and Laercia (in memoriam), for the support and encouragement they always gave me, for understanding my lack of availability, even in difficult times. I am very grateful to my brothers Diogo, Otávio, and Aurelio for everything.

Thanks to my friends Carlos Cunha, Bruna Lima, Natália Rodrigues, Nadja, Francisco, Juliana, Sandro for encouraging and supporting me. For all the partnerships built over these 30 months. Every conversation, laughter, support, encouragement was vital in this process.

Thanks to Lucas Oliveira for his availability and dedication to the front-end and back-end of the tool. The result was excellent.

Thanks to all members of the Complex Systems Engineering Laboratory for the essential exchanges and discussions throughout the process. In particular, Lucas and Luciana who supported me so much in the final stretch.

Thanks to Renata Mendes de Araujo for guiding this thesis research until August 15, 2018.

Thanks to the support of the secretariat Ives, Leandro, and Douglas.

Thanks to the participants of the exploratory studies, survey study, and tool evaluation study, whose feedbacks were vital for the thesis body of knowledge and thesis solution, especially Professor Patricia Lago.

I would like to thank the Superior Institute of Education of Rio de Janeiro (Iserj) for supporting my research.

Finally, I thank everyone who was part of my doctoral career.

CORDEIRO, Felipe P. **Avaliação de Accountability em Sistemas-de-Sistemas de Informação Baseada em Visão Sistêmica**. UNIRIO, 2021. 243 páginas. Tese de Doutorado. Programa de Pós-Graduação em Informática, UNIRIO.

RESUMO

Em Sistemas de Informação (SI), *accountability* engloba estratégias que estimulam comportamentos responsáveis em seus processos. *Accountability* se concentra em definir e manter pessoas-processos-tecnologias funcionando em harmonia para cumprir as metas de negócios. No entanto, avaliações de *accountability*, particularmente considerando vários SI trabalhando juntos para cumprir um objetivo, são pouco exploradas, como em SoIS (*Systems-of-Information Systems* ou Sistema-de-Sistemas de Informação). A fim de preencher essas premissas, é proposta uma abordagem de avaliação de *accountability* que visa apoiar a compreensão do contexto de SoIS e facilitar a tomada de decisão em cenários investigados por gestores. Para este objetivo, são usados conceitos de visão sistêmica, SoIS e *accountability*. Portanto, foi desenvolvido um modelo conceitual para compreender elementos que formam arranjos de SoIS à luz de *accountability*, cujos elementos foram extraídos de um mapeamento sistemático da literatura, estudos exploratórios e uma avaliação com 21 especialistas (gestores e pesquisadores de SI). Como resultado, um *framework* para avaliação de *accountability* em SoIS foi desenvolvido, chamado AESoIS (*Accountabily Evaluation in Systems-of-Information Systems*). AESoIS visa apoiar gestores de SoIS na compreensão de cenários organizacionais e propor soluções relativas à avaliação de *accountability* fundamentada em três critérios: engajamento, gerenciamento e regulação. Além disso, uma ferramenta de apoio foi construída e se concentra em estratégias de modelagem de cenários de SoIS. Por fim, os recursos do AESoIS foram avaliados com gestores em organizações educacionais apoiadas por SoIS por meio de um estudo de viabilidade da solução desenvolvida. Como resultado da avaliação do AESoIS, é destacada a relevância da compreensão e modelagem de SoIS para mapear cenários e ainda a eficácia do AESoIS.

Palavras-chave: *Accountability*; Sistemas de Informação, Sistemas-de-Sistemas de Informação; Visão Sistêmica; *Framework*; Avaliação.

CORDEIRO, Felipe P. **Accountability Evaluation in Systems-of-Information Systems Based on Systems Thinking**. UNIRIO, 2021. 243 pages. D.Sc. Thesis. Graduate Program of Informatics, UNIRIO.

ABSTRACT

In Information Systems (IS), accountability encompasses strategies that hold responsible behaviors considering IS purposes. In fact, accountability focus on setting and holding people-process-technology to a common expectation by maintaining all levels of responsibility for accomplishing SoIS purposes. However, its implications remain unclear when it focuses on evaluation strategies, particularly considering several IS working together to accomplish an organizational objective, such as SoIS (Systems-of-Information Systems). In order to fulfill these premises, an accountability evaluation approach is proposed to support the SoIS context understanding and facilitate decision-making in scenarios investigated by managers. To achieve this goal, concepts of systems thinking, SoIS, and accountability are used. Therefore, to characterize accountability evaluation, a conceptual model for understanding SoIS from the accountability perspective was developed, with elements extracted from systematic mapping studies in the IS domain, exploratory studies, and an evaluation by 21 specialists (IS managers and researchers). As a result, a framework is developed, called as AESoIS (Accountability Evaluation in Systems-of-Information Systems). AESoIS aims to support SoIS managers to understand organizational scenarios and propose solutions related to accountability evaluation based on three criteria: engagement, management, and regulation. In addition, a tool was developed and focuses on modeling strategies to support SoIS scenarios. AESoIS solutions were evaluated with managers in educational organizations supported by SoIS based on a feasibility study. The relevance of understanding and modeling SoIS scenarios is highlighted, as well as the AESoIS effectiveness.

Keywords: Accountability; Information Systems, Systems-of-Information Systems; Systems Thinking; Framework; Evaluation.

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Abbreviations

AEM	-	Accountability Evaluation Model
AESoIS	-	Accountability Evaluation to Systems-of-Information Systems
ASM	-	Accountability Suggestion Map
BPM	-	Business Process Management
BPMN	-	Business Process Management Notation
BPSoIS	-	Business Process to Systems-of-Information Systems
CD4A	-	Class Diagram for Analysis
CLD	-	Causal Loop Diagrams
Coord IS	-	Coordination Information System
CQ	-	Closed Question
LabESC	-	Complex Systems Engineering Laboratory
DB	-	Database
DSR	-	Design Science Research
EG IS	-	Educational Guidance Information System
FM IS	-	Frequency Management Information System
GQM	-	Goal-Question-Metric
GranDSI-BR	-	Grand Research Challenges in Information Systems in Brazil
GUI	-	Graphical User Interface
HIPPA	-	Health Insurance Portability and Accountability Act
IRI	-	Information Reuse and Integration
IS	-	Information System
IT	-	Information Technology
OQ	-	Open Question
PE IS	-	Pedagogical Guidance Information System
QC	-	Quality Criteria
RQ	-	Research Question
SAR	-	Systemic Action Research
SC IS	-	Shift Coordination Information System
SE	-	Software Engineering
SESoS/WDES	-	Joint International Workshop on Software Engineering for Systems-of-Systems and Workshop on Distributed Software Development, Software Ecosystems and Systems-of-Systems
SMS	-	Systematic Mapping Study
SoIS	-	Systems-of-Information Systems
SoS	-	Systems-of-Systems
SP IS	-	Principal Information System
SSM	-	Soft Systems Methodology
ST	-	Systems Thinking
UML	-	Unified Modeling Language
WTDSI	-	Workshop on Theses and Dissertations in Information Systems

Chapter 1 - Introduction

Studies on information systems arrangements have shown significant expansion over the years, notably those related to systems-of-information systems (SoIS). However, the practical and better-founded approaches of SoIS, especially addressing accountability evaluation strategies for understanding SoIS context, are still insufficient.

This chapter is organized into sections as follows: context, motivation, problem definition, presentation of research proposal hypothesis, research methodology, and the thesis outlines.

1.1 Context

Accountability is a non-functional requirement[1] (Pearson, 2014) for holding responsible actions in organizations regarding obligations and sanctions (Feltus *et al.*, 2009) and must encompass evaluation strategies (Bissland, 1990; Pearson, 2014). Accountability has received widespread attention in many fields (e.g., politics, business, computer science, and education), especially in Information Systems (IS).

Concerning IS domain, accountability is a quality requirement (Pearson, 2014) that may help organizations meet the demands of society, government, and their business objectives with more responsibility, and therefore improving efficiency and effectiveness (AccountAbility, 2008a; Schultze *et al.*, 2020). As an IS requirement, accountability describes structures that need to be in place to facilitate responsibility (Stahl, 2006). It encompasses a quality or state of being accountable, and it is an obligation or willingness to accept responsibility for one's actions to improve it (Bolton, 2003; Leither *et al.*, 2004; Stahl, 2006; Khadraoui & Feltus, 2012).

However, successful accountability is often challenging in several domains (Janssen, 2007; Vance *et al.*, 2015; Schultze *et al.*, 2020). Various factors affect the effectiveness of accountability and its success in IS (Alter, 1999; Brien & Marakas, 2010; Laudon & Laudon, 2011; Stair & Reynolds, 2015). In this context, accountability may

[1] Non-functional is a requirement that specifies criteria that can be used to judge the operation of a system, rather than specific behaviors (Pearson, 2014).

address different factors in IS area (people-process-technology), e.g., (i) people (people-to-people collaboration, sharing of information and knowledge between teams for improving individual accountability and focusing on people demands), (ii) process (managerial demands for accountability strategies), and (iii) technology (developing programming languages and security applications to support accountability). Moreover, the following examples detail the accountability lens in IS:

- a preventive approach to online security and privacy (Feigenbaum *et al.*, 2012; Vance *et al.*, 2015);
- a fundamental value for good governance (Dubnick, 2002; Guimarães *et al.*, 2019);
- requirement for software development (Nissenbaum, 1996; Cockburn & Highsmith, 2001; Baracaldo & Joshi, 2013; Zakaria *et al.*, 2019); and
- monitoring and analyzing people's behavior (Ray, 2012; van Toorn *et al.*, 2020).

Among these factors, evaluation can affect accountability success (Bunda, 1979; Laukkanen, 1998; Amrein-Beardsley & Holloway, 2019). Concerning evaluation and accountability, the AccountAbility - AA1000[2] Accountability Principles Standard (AccountAbility, 2008a) defines the basic premises of accountable organizations:

- develop strategies based on a comprehensive and balanced understanding of and response to material issues and stakeholder issues and concerns;
- set goals and standards against which the strategy and associated performance can be managed and judged; and
- disclose credit information about strategies, goals, standards, and performance to those who take actions and decisions based on this information.

Furthermore, accountability must also be applied to a complex IS arrangements for covering evaluation in complex architecture. Accountability evaluation aims to provide means for optimizing organizational processes according to the scope of the business. Thus, for an organization to be considered accountable, the different IS must also support or provide this requirement as part of an accountability analysis strategy. For example, considering the connections between IS, evaluating its functioning, stimulating people's

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[2] The AA1000 was developed using a broad-based, multi-stakeholder process. A period of initial research that included a widely broadcast e-survey was followed by face-to-face consultations in 20 countries with a comprehensive range of stakeholders and a series of workshops with specific stakeholder groups.

feedback, and supporting business processes (Gajanayake *et al.*, 2011a; Araujo, 2016; Cordeiro & Santos, 2019a, 2019b), as it can contribute to organizational longevity (Cooper & Owen, 2007; AccountAbility, 2015; Cooper & Coetzee, 2020). It is also important to note that an essential point of this thesis is that people's feedbacks to whom a given IS scenario is accountable will depend on the environmental circumstances. Singh *et al.* (2019) argue that as an accountability facilitator:

> "*This includes making it easier to determine which person or organization is responsible for a particular decision/action, its effects, and from (and to) whom an explanation is owed for that happening*".

In addition, the AA1000 Stakeholder Engagement Standard (AccountAbility, 2015) details the relevance of understanding people roles, namely stakeholder engagement and its relationship in the organizational environment:

> "*Stakeholder engagement is a journey (...) They (organizations) discover that a better understanding of their stakeholders results in an easier and more receptive operating environment*" (AccountAbility, 2015).

Such an approach focuses on evaluating scenarios supported by IS arrangements to contribute to people's involvement and create better products and services considering organizational context (Shires & Craig, 2003; Rasche & Esser, 2006; Cordeiro & Santos, 2019a; NSF, 2021). However, due to the complex IS arrangements that require solutions, we still lack research to address the influence of people on business (Araujo, 2016; Al-Shbail & Aman, 2018; Piperagkas *et al.*, 2020). In such environments, complexity presents itself in different forms, e.g., through various people demands, interoperability between technologies, and other ways of processing data, but it must work harmoniously to achieve organizational objectives. For example, in the context of complex systems, Alampalli and Pardo (2014) pointed out:

> "*a complex system is a sociotechnical system with many independent and interdependent components that interact in a nonlinear way (behavior cannot be expressed as summations of the activity of individual components) and has interdependencies that are difficult to describe and predict and design*".

Therefore, dealing with complex organizations with different systems requires the understanding of several challenges, such as ethics in people relationships and proper use of resources. In this context, an example of complex systems is systems-of-systems (SoS). Maier (1998) defines SoS as:

> "*SoS is a complex system resulting from the interoperability of constituent systems, managing resources, and capabilities with managerial and operational independence that collaborate to produce emergent behaviors to achieve a specified global mission*".

Thus, SoS demands arise from the need to implement and analyze large, complex, independent, and heterogeneous systems working cooperatively (Azarnoush *et al.*, 2006; Jamshidi, 2008; Li, 2021). Considering a parallel between SoS and IS, if each component system in an SoS arrangement is an IS, this SoS can be viewed as a particular type: System-of-Information Systems or SoIS. SoIS is a "*specific type of SoS in which the set of constituent systems include IS that interoperate with other constituents to achieve goals*" (Graciano Neto *et al.*, 2021). SoIS is the focus of this thesis, to be investigated through an accountability evaluation lens.

In this context, it is worth mentioning that SoIS is a way to meet emerging business demands that cannot be met by an IS isolated (Saleh & Abel, 2015; Fernandes *et al.*, 2018; Mohsin *et al.*, 2019; Teixeira *et al.*, 2019). Furthermore, SoIS inherits SoS characteristics and adds the socio-technical and business nature of the IS (Maier, 1998; Graciano Neto *et al.*, 2017; Fernandes *et al.*, 2019). In this way, SoIS increases the complexity in the IS area, since it must consider SoIS mission/goal and explore people-process-technology.

Concerning Li (2021), the specificity of SoIS lies in the difference between the IS and other systems. An IS contains a set of interrelated components that perform activities aiming at collecting, processing, storing, and distributing information, while a system is a set of elements dynamically interrelated to perform activities aiming to achieve a specific goal. In comparison, the characteristic of the IS is its objective concerning the information. Thus, SoIS uses information from separated IS to aggregate existing services and produce new ones. A good practice is the Internet. Internet is a SoIS that contains different IS providing various services to users (see Figure 1).

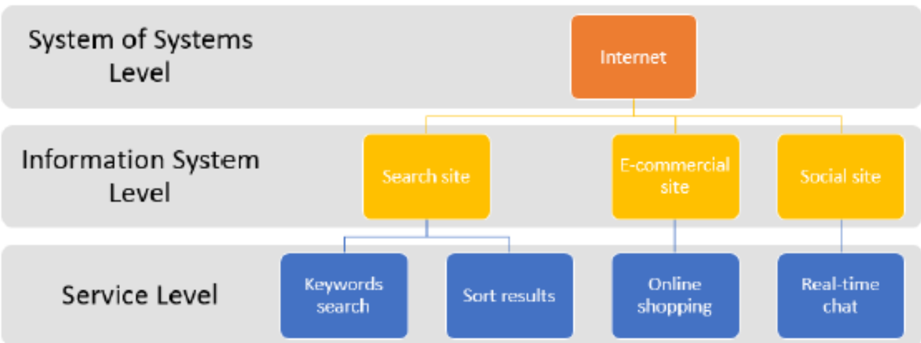

Figure 1 - Internet as a SoIS example. Source: (Li, 2021).

It shows the Internet at the SoS level, the IS level formed by several IS operating independently and respective services. SoIS is a maturing topic in IS research that is evolving (Fernandes *et al.*, 2018). For example, Graciano Neto *et al.* (2021) describes SoIS initiatives, such as (i) autonomous cars and buses, (ii) intelligent bus stop, (iii) public finances IS, (iv) fuel station IS, (v) the smart transportation system itself, and (vi) the business process that support SoIS.

In this line, Graciano Neto *et al.* (2021) discuss critical technological and theoretical gaps in SoIS, addressing notable gaps regarding specific notations for SoIS modeling, engineering methods, and tools, including the relationship between technology and business levels. However, to integrate such relationships, SoIS needs to focus on exchanging information and responsibilities between the different constituent IS. One method is investigating accountability in SoIS architecture, where each constituent IS can represent its data and may influence to solve a portion of a global SoIS goal (Cordeiro & Santos, 2019b). As an example of accountability in complex arrangements, Singh *et al.* (2019) present a discussion in SoS context, as follows:

> "*accountability is often discussed with a single organization, or a system's context, as discrete systems, where the entities involved are known or predefined, e.g., concerning the actions undertaken by a particular organization. However, the increasingly interconnected nature of systems means that in many cases, they do not operate discretely and isolated but employed as part of an SoS with potentially many entities involved*".

In other words, accountability related to IS arrangement, mainly SoIS, can play a role in mapping responsibility, contributing to understanding the composition of constituent IS for accomplishing SoIS goals. Therefore, this thesis ties accountability as a requirement when examining constituent IS influencing the SoIS architecture. Accountability seems to be a requirement for modeling relationships among constituent IS driven to information flow through and across elements that form a SoIS.

Additionally, the National Science Education[3] initiative is an example of the impacts of accountability in complex systems. The initiative, in January 2021, launched a program to encourage research on designing accountable software. In this initiative, the

[3] DASS - https://researchfunding.duke.edu/designing-accountable-software-systems-dass

agency asserts that society is becoming highly dependent on software applications, systems, and platforms, for functionality in all aspects of business, government, and daily life.

Consequently, it is necessary to seek new solutions, given the increase in laws and regulations to support complex systems. In such scenarios, software must be accountable and comply with laws and regulations, i.e., the software systems must be designed with legal and regulatory compliance in mind. Furthermore, complex software should adapt to changing laws and regulations, evolving with citizen expectations and social norms (NSF, 2021). To cope with such an accountability lens, Singh *et al.* (2019) argue that one reason for demanding accountability in complex systems occurs is because it details the nature of the information flows and the relationships that tend to be invisible or opaque.

Regarding this context, this thesis explores the accountability evaluation approach in SoIS. In addition, the thesis is characterized by three SoIS fundamentals (Saleh & Abel, 2015, 2016): business process, constituent IS, and people demand, as follows:

- **Business processes** are interrelated events, activities, and decision points that involve a series of actors and objects, which collectively generate an outcome of value to at least one customer. Business rules govern them, and they are understood regarding their relationships to provide a view of sequence and flow (BKCASE, 2018). Business process management (BPM) deals with process management scenarios to coordinate people and systems, including (i) sequential workflow, (ii) straight-through processing, (iii) case management, (iv) content life cycle management, (v) collaborative process work, and (vi) value chain participation;
- **Constituent IS** is defined as IS interoperating in a SoIS and belonging to organizations to accomplish goals (Teixeira *et al.*, 2019); and
- **People** detail the actor's role, which describes a group of people who have a mutual interest in the SoIS goals and can affect or be affected by those goals (Gonçalves *et al.*, 2014; Fernandes *et al.*, 2020).

Therefore, one of the current issues is generating a relevant parallel between accountability evaluation and SoIS, which is the primary concern of this thesis. This section introduced these issues, mainly addressing people's interactions with constituent IS and business processes to support SoIS scenario understanding.

1.2 Motivation

Accountability is a challenge for the IS domain that has become a significant concern worldwide in government and business (AccountAbility, 2008b; Zou *et al.*, 2009b; Araujo, 2016). Several authors discuss accountability scope and different areas, such as politics (Waladi *et al.*, 2019), philosophy (Martin, 2007), computer science (Feigenbaum *et al.*, 2012), and accounting (Abreu *et al.*, 2009; Oliveira *et al.*, 2016).

More recently, there has been attention to accountability from IS community in Brazil. Araujo (2016), in the book *Grand Research Challenges in Information Systems in Brazil 2016-2026*, focused on accountability as a topic of interest for IS research, notably for solutions to perceive accountability associated with regulation. In e-government, Chen *et al.* (2019) detailed the impact of citizen-centric innovation enhancing efficiency and accountability. Furthermore, accountability plays a desirable positive manifestation in the concentrate on improving results, processes, and systems (Burga & Rezania, 2017; Findler *et al.*, 2018; Harris *et al.*, 2019). This thesis mainly addresses accountability, aiming to establish an accountability evaluation approach in SoIS. Regarding these trends, accountability is an essential factor to be achieved by everyone individually or in society (AccountAbility, 2008a; Hall *et al.*, 2017).

On the opposite side, without comprehending strategies for sustaining accountability, in which all organizational parts are motivated, and the processes should be understood from beginning to end, accountability through people will not be effective (Koh & Heng, 1996; Estuar *et al.*, 2016; M. Zhang *et al.*, 2020). As an example, Chen *et al.* (2011) argue that user participation affects the quality of the product development process, and it has a significant influence on IS success.

Additionally, previous studies detail the relevance of accountability and its influences (either positive or /negative) in business processes, IS use, and user feedback. It demonstrates challenges to sustain accountability in organizations, primarily considering (i) critical thinking for evaluating business activities, (ii) people's behaviors to accomplish SoIS goal, and (iii) technology (manual or computed systems) for supporting SoIS. For example, understanding the IS interactions that support educational organizations is challenging. It is because the organizational mission is to promote human growth through education. However, this growth goes through beliefs, cultures, and habits, which are influenced by the technologies and processes that guide the organization. In this type of motivation, the investigation of accountability can collaborate to better understand the dynamics of constituent IS as a strategy to improve educational processes by mapping responsibilities, conditions, sanctions, and obligations.

Regarding this motivation and previous context, several studies address accountability as a factor for IS success; the same has not happened to SoIS (Beckers *et al.*, 2016; Findler *et al.*, 2018; Schultze *et al.*, 2020). Studies addressing accountability and SoIS are practically non-existent. For example, Graciano Neto *et al.* (2017) briefly mention accountability and its influence on citizens/society, particularly those able to develop their applications.

In another example, Teixeira *et al.* (2019) argue the lack of accountability studies in SoIS. Similarly, the studies do not address methods or strategies for evaluation. In addition, Singh *et al.* (2019) suggest that accountability is an open challenge in complex arrangements, as it demands acknowledging responsibilities, but sometimes in complex dynamics, the cause is unknown. Moreover, several studies do not provide details and a clear view of the effects of accountability in organizations supported by IS, particularly those with different IS that operate together to accomplish an organizational objective.

To understand such complex arrangements, this thesis is motivated by the lack of accountability evaluation in SoIS, mainly focusing on modeling demands and solutions (Fernandes *et al.*, 2020; Santos *et al.*, 2020; Oliveira, 2021; Neto *et al.*, 2021). We are motivated to investigate the parallel between accountability evaluation and SoIS, which can contribute to understanding constituent IS behavior by observing responsibilities in SoIS arrangements and their use over time. Therefore, this thesis aims to provide SoIS context understanding by exposing a broader view of constituents' behaviors and their interactions. Such an approach can drive interventions and actions to support SoIS scenario understanding by mapping responsibilities and their influences on the SoIS context.

Examining the relationships between SoIS elements in its architecture will help explain SoIS scenario for improving managers' decision-making. Furthermore, Santos *et al.* (2021) identified that SoIS lacks notations, tools, gaps, and opportunities open in SoIS research. The authors assert that SoIS needs specific formal modeling and verification techniques to deal with its underlying complexity/ dynamism, mainly associated with the business process level. In addition, this thesis is interested in modeling SoIS context that uses business processes to identify interoperability links. Despite mapping, the links between constituent IS, the tool does not address the processes of dynamics and accountability. Thus, evolving a SoIS tool for modeling and mapping accountability is another thesis motivation.

Finally, we are particularly motivated to investigate accountability evaluation to provide modeling opportunities to SoIS context understanding. Such an approach focuses on mapping and addressing organizational problems from investigated SoIS scenarios to better compression and support decision-making for SoIS users and managers. These points motivated the conduction of the studies carried out in this thesis.

1.3 Problem Statement

Organizations are increasingly concerned about the quality of the products and services they develop. In addition, competition continues to advance globally, and customers increasingly demand better services (Dyba, 2005; Passos, 2014; Graciano Neto *et al.*, 2021; Li, 2021). In this problematization, a vital factor in guaranteeing the survival of a business is accountability. The AA1000 Accountability Principle Standards (AccountAbility, 2008a) assert that an organization must actively engage with its stakeholders to fully identify and understand issues that impact its performance. They must focus on developing a strategic approach to sustaining demands around economic, environmental, social, and performance influences to create accountable business strategies for better performance objectives.

However, although studies in the literature considered accountability through several lenses, as detailed in previous sections, its effects on human factors related to IS use are not entirely clear (Brien & Marakas, 2010; Ning *et al.*, 2015; Skoumpopoulou & Robson, 2020). Indeed, human participation has existed for years, but the IS domain still demands research since new demands, new clients, new technologies, services, and products keep evolving.

Another challenging problem of accountability in SoIS is evaluation (Bunda, 1979; Laukkanen, 1998; Amrein-Beardsley & Holloway, 2019). Many studies address accountability superficially and without delving into evaluation strategies. Evaluating constituent IS dynamics, its functioning considering people's feedback, and the characteristics of business processes are open-ended accountability challenges, as they can contribute to organizational longevity (Cooper & Owen, 2007; AccountAbility, 2015; Cooper & Coetzee, 2020). It should be feasible for SoIS managers to question or even suggest feedbacks at any moment for improving accountability, but reality demonstrates otherwise. For example, if a user does not see and perceive the impacts of their decisions on organizational objectives, accountability will hardly occur (AccountAbility, 2015; Beckers *et al.*, 2016; Cordeiro *et al.*, 2020).

While traditional IS presents tools and methodologies for the construction or even SoS modeling, we lack research addressing links between constituent IS (Graciano Neto *et al.*, 2017; Fernandes *et al.*, 2018; Graciano Neto *et al.*, 2021) and accountability influences. Thus, it is worth evaluating accountability in SoIS, especially when people influence the arrangement dynamics. Evaluation requires us to construct a solution that generates SoIS context understanding, which can aid knowledge regarding business processes and affect the effectiveness and the success of organizational objectives.

To this end, the following problem must be addressed:

Problem 1: What is the accountability context in IS, and how to model it as SoIS concern?

Problem 2: How to perform accountability evaluation in SoIS to improve its understanding?

Problem 3: How to model SoIS elements considering accountability evaluation?

Therefore, this thesis concerns defining, modeling, and applying accountability evaluation in SoIS. Besides, we attempt to build a tool for SoIS scenario modeling.

1.4 Objectives and Hypothesis

To deal with the problems listed in Section 1.3, the thesis objective is detailed as a general objective and hypothesis. The general objective of this thesis is: **Establish an accountability evaluation approach in systems-of-information systems, aiming to achieve SoIS scenario understanding.** In addition, the general objective can be detailed into the following specific goals:

- **Describe an accountability evaluation model drawn from the existing accountability models and theoretical studies on the subject.**

As a contribution, it aims to organize a body of knowledge based on a literature review on accountability in IS research, which encompasses SoIS, by analyzing previous definitions of accountability. Then, we consider the advantages of the unified modeling language (UML) in terms of interpretability and notation.

- **Develop a set of accountability suggestions for evaluating SoIS scenarios.**

We propose a set of accountability suggestions as indicators to sustain accountability evaluation, permitting us to assess SoIS elements architecture for improving critical thinking and supporting SoIS modeling.

- **Develop an accountability evaluation framework.**

It is necessary to explore how to specify and implement the proposed UML model. For this, we make use of the relationships among model elements and SoIS. Based on this architecture, we build a framework for supporting the proposed accountability evaluation approach in modeling a SoIS scenario regarding SoIS elements, interconnections, time, and accountability criteria.

- **Develop a tool to support the proposed framework.**

Based on the proposed framework, we developed a web-based prototype based on the work of Oliveira (2021). Oliveira (2021) developed a Master's thesis focused on BPMN and SoIS, which resulted in a business process SoIS method named BPSoIS[4]. In this thesis, we explore the BPSoIS tool with a module for supporting accountability evaluation concerning SoIS scenario understanding and modeling.

- **Execute a feasibility study for the proposed computational tool.**

With the proposed thesis tool, the approach can be processed to generate accountability evaluation, which encompasses the diagnosis of SoIS scenarios, namely Accountability Evaluation for SoIS (AESoIS). AESoIS aims to demonstrate SoIS elements relationships for supporting SoIS scenario understanding by mapping SoIS scenarios and contributing to SoIS longevity. Experiments are carried out on an educational organization's dataset as a module integrated into BPSoIS, as Oliveira (2021) proposed to test the tool performance. The results obtained from this dataset are compared and evaluated from an effectiveness lens.

Additionally, from the challenges pointed out in Section 1.3 and the facts stated above, the thesis hypothesis is defined as:

H1 - Accountability evaluation affects SoIS context understanding, precisely SoIS arrangement. From this hypothesis, some research questions (RQ) are established throughout our work. Some effort was spent in research studies on accountability for SoIS, as part of RQ1, RQ2, and RQ3, as follows:

RQ1 - How can an accountability evaluation identify behaviors among SoIS elements to support an organizational objective?

[4] BPSoIS is a method based on analyzing business process models to generate an architectural model for SoIS architecture, based on Fernandes *et al.* (2019) SoIS model.

As an output from RQ1, we identified the analogy of accountability dimensions to SoIS area. During the studies, we noticed that accountability might be achieved through an evaluation strategy. For the accountability evaluation approach, three forces are observed: engagement related to people demand, management related to process, and regulation related to technology. Then, we conducted two exploratory studies addressing SoIS scenario understanding. Such an approach helps define a modeling strategy for mapping SoIS elements, their relationships, and interdependencies. In turn, an interview with 21 IS specialists (managers and researchers) for assessing key concepts and a model for accountability evaluation is presented. Such a question aims to answer the first problem from Section 1.3.

RQ 2 - How to generate the representation of SoIS arrangement based on accountability evaluation?

As an output from RQ2, we developed a framework for covering findings from RQ1, i.e., the AESoIS framework. It encompasses a strategy for collecting data from the organizational environment supported by SoIS. Such an approach aims to investigate an organizational problem through an accountability lens by modeling the relationships among SoIS elements and accountability influences. Such a question seeks to answer the second problem from Section 1.3.

RQ3 - Is the proposed AESoIS tool feasible to aid practitioners in performing accountability analysis with effectiveness?

The feasibility study was conducted with practitioners in a real scenario to evaluate the AESoIS solution. In turn, during the thesis, we have collaborated with several people on different scientific projects. In particular, we are cooperating with the author who developed a method for mapping SoIS architectures (Oliveira, 2021) to build the accountability evaluation application. This collaboration allowed the creation of the AESoIS tool and its evaluation, with a feasibility study conducted with SoIS practitioners in a real scenario to evaluate the proposal. Such a question aims to answer the third problem from Section 1.3.

In summary, this research aims to examine the accountability perspective to propose and evaluate an approach for mapping SoIS scenario, more specific analysis about an investigated scenario. Therefore, this thesis concerns defining, modeling, and using the accountability evaluation to SoIS. Besides, it applies the accountability evaluation solution as a module for an automated tool for SoIS modeling by addressing business process investigation.

1.5 Methodology

From the issues detailed in Section 1.4, the research methodology in Figure 2 is divided into three main phases: (i) the conception phase, (ii) the implementation phase, and (iii) the evaluation phase. For each phase, the publication vehicles in which its results were published are mentioned.

From Phase 1 to Phase 3, a literature review was carried out to identify what has been discussed accountability in several domains. Phase 1 provides an overview of accountability in IS. Phase 2 encompasses a review of complex systems, such as SoS and SoIS. As a result, in Phase 1, a study was published at the *2018 XLIV Latin American Computer Conference* (CLEI 2018), available in (Cordeiro & Araujo, 2018). It addresses school routines regarding technological solutions and accountability influences in an educational organization. In turn, based on findings made in previous phases, a proposal for research (Phase 3) was elaborated and it supported the approval in a doctoral qualify exam. Furthermore, based on the refinement of the doctoral qualify proposal, it was published in the *XI Workshop on Theses and Dissertations in Information Systems* (WTDSI 2019), available in (Cordeiro & Santos, 2019a)

From Phase 4 to Phase 5, the initial literature review included a theoretical background regarding SoIS characteristics and systems thinking, addressing causal loops and modeling strategies. Furthermore, two studies were published in SoIS, major considering the SoIS elements and their interconnections. One study focuses on one SoIS conceptual model for mapping SoIS characteristics, as a result of a collaboration with colleagues from the Complex Systems Engineering Laboratory (LabESC), and available in (Fernandes *et al.*, 2019). Such results were published at *IEEE 20th International Conference on Information Reuse and Integration for Data Science* (IEEE IRI 2019). Another publication derived from LabESC collaboration focuses on identifying interoperability links to map interconnected interconnections among constituent IS (Fernandes *et al.*, 2020). Furthermore, the literature review objective was to carry out an ad hoc review about accountability in IS, which included research on concepts, models, tools, frameworks, and solutions about ISO standards, systemic representation, and SoIS. Such results were published in the *XVI Brazilian Symposium on Information Systems* (SBSI 2020).

The next phases detail two exploratory studies planned and conducted to investigate a problem that is not clearly defined. Bélanger and Allport (2008) assert that such investigations illuminate the initial understating of complex scenarios in a natural and realistic setting. It can be used for theory development or for testing the impact of some factors on variables of interest. In this context, the exploration aimed to investigate SoIS scenario, specifically SoIS in the educational organizations supported by several constituents IS. The studies explore the understanding of causal relationships between SoIS elements that make up IS arrangement.

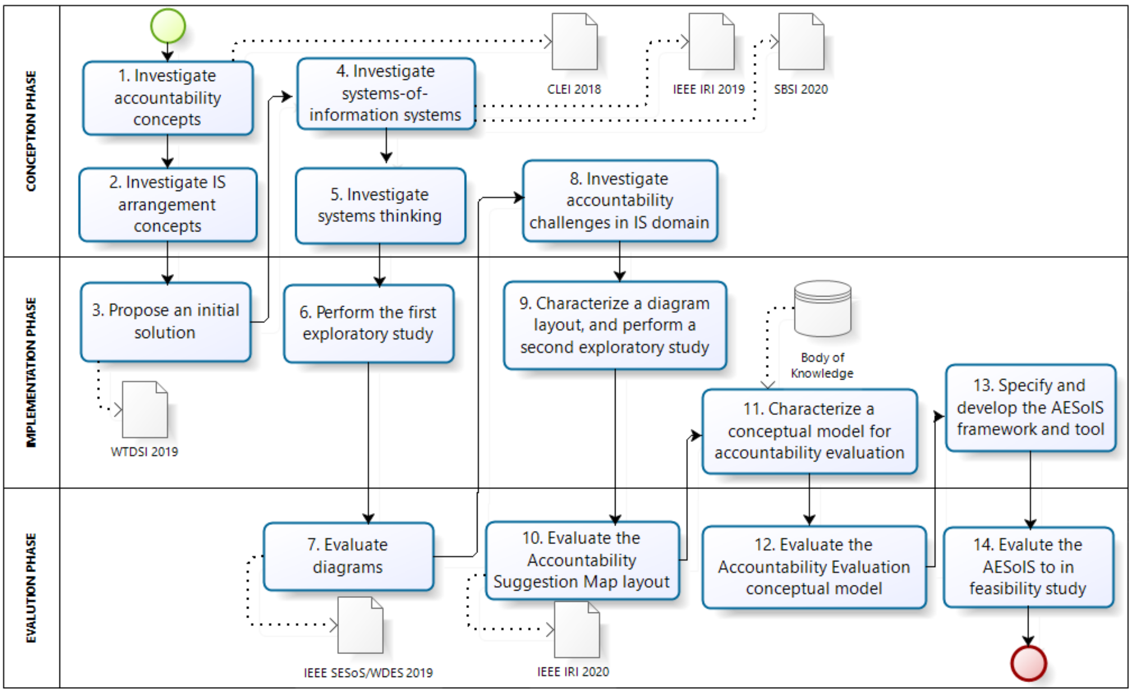

Figure 2 - Research methodology.

Phase 6 encompasses the first primary research. It was executed from October to December 2018, and its goal was to present an initial investigation on systemic aspects of a SoIS scenario in the context of an educational SoIS. As a result, the generated diagrams were evaluated by feedbacks from SoIS users and SoIS researchers, who assessed the diagrams (Phase 7). This research provided an initial conceptual model for representing accountability for SoIS architecture. Furthermore, it was published in the *2019 IEEE/ACM 7th International Workshop on Software Engineering for Systems-of-Systems and 13th Workshop on Distributed Software Development, Software Ecosystems and Systems-of-Systems* (IEEE SESoS/WDES 2019), available in (Cordeiro & Santos, 2019b).

In addition, Phase 8 describes a systematic mapping study (SMS). Petersen *et al.* (2015) state that "*SMS is an overview of a research area through classification and* *counting contributions*". This secondary study helped to reveal accurate results on the thesis subject. We proposed an SMS protocol with five steps in this process: (i) define research scope; (ii) collect data; (iii) select studies; (iv) extract data; and (v) perform analysis and discussion. SMS protocol covered six digital libraries with no time or area restrictions, covering until mid-2020. As a contribution, this study presented key concepts of accountability and research challenges for IS research, which address SoIS, organized in three accountability dimensions: engagement, management, and regulation.

Phase 9 is a secondary study with information collected from Phase 7. It was executed from November to December 2019, and its goal was to evaluate a diagram proposal as a structure that represents systemic behaviors over time, known as the Accountability Suggestion Map (ASM) layout. The proposed layout details an approach for designing accountability in the context of IS arrangements, notably SoIS. As a result, Phase 10 describes an evaluation study-based data from the initial exploratory study, which was evaluated by the educational organizational manager (i.e., school principal). Finally, ASM layout was evaluated, including the accountability criteria approach from SMS findings. Such a result was published in the *IEEE 21st International Conference on Information Reuse and Integration for Data Science* (IEEE IRI 2020), available in (Cordeiro *et al.*, 2020).

Phase 11 considers the body of knowledge from SMS findings and exploratory studies to analyze a proposed model, called Accountability Evaluation Model (AEM). AEM covers a conceptual model of accountability in IS domain, focusing on an evaluation. Additionally, in Phase 12, a survey is planned and conducted through semi-structured interviews with IS specialists (managers and researchers) who have experience in IS management. After the evaluation, a qualitative analysis of the responses was carried out, followed by AEM refinement. Such a result is a contribution, laying out the foundation for the thesis accountability evaluation strategy.

Phase 13 describes concepts and strategies for developing a framework concerning accountability evaluation. The framework contains all elements from AEM, and ASM notation. We named the framework as Accountability Evaluation for SoIS (AESoIS). In order to verify the framework, the AESoIS tool is developed for incorporating the framework guidelines. Phase 14 refers to the evaluation of AESoIS tool, as a module for BPSoIS. AESoIS tool aims to support IS arrangements understanding by IS/SoIS managers and allows them to follow strategies for mapping SoIS scenario understanding.

Thus, AESoIS is a semi-structured BPSoIS module, as a thesis contribution for modeling SoIS scenarios and contributing with a set of customizable accountability indicators for IS/SoIS practitioners to support SoIS modeling.

Additionally, Phase 14 proposes a feasibility study focusing on modeling a business process problem extracted from BPSoIS and incorporating SoIS information through the AESoIS module. Further, the feasibility study also addressed a scenario without supporting BPSoIS. Regarding the proposed solution, the feasibility study focused on a two real scenarios, i.e., two different Brazilian educational organizations in the State of Rio de Janeiro regarding (i) five academic management practitioners; (ii) BPSoIS data related to the investigated problem; and (iii) exploratory study data (it encompasses scenarios not supported by business process, as proposed at BPSoIS).

1.6 Outline

This Ph.D. thesis is organized into eight chapters.

This chapter presented the context of our work, the motivation for this research, the problem identified as a gap in theory and practice. Furthermore, the objective of this thesis was explained and the methodology that guided us towards our scientific contribution.

Chapter 2 presents a discussion on this research's main topics: accountability, SoIS, and tools for modeling complex systems.

Chapter 3 presents two exploratory studies focusing on the analysis of real educational SoIS, as a scenario. Such an approach aims to help better understand SoIS scenario considering system thinking lens, notably causal loop and designing. It introduces the ASM layout as a resource for providing an approach for modeling SoIS scenarios.

Chapter 4 presents an SMS of accountability in IS focusing on the investigated subject. The proposed SMS methodology is explained considering tools, processes, and input/outputs. Furthermore, research challenges are also introduced to expand the understanding of accountability. Finally, this chapter proposes three accountability criteria (engagement, management, and regulation) for supporting evaluation.

Chapter 5 presents a conceptual model, as a result of SMS and exploratory studies insights. It details the model, its elements, definitions, and sources. It also includes an approach of accountability evaluation, considering three evaluation dimensions (engagement, management, and regulation). Additionally, a model evaluation was planned and executed with 21 specialists who evaluated the proposed model. In the end, a final accountability evaluation model is developed as a thesis contribution.

Chapter 6 details the framework. It includes a conceptual framework and shows the adopted strategy for integrating AEM into the BPSoIS tool. As a result, it presents the AESoIS framework tool-supported for the SoIS context. It encompasses the tool development process and guidelines.

Chapter 7 explains a feasibility study conducted to evaluate the AESoIS solution based on the developed framework and computational tool. It focuses on the feasibility of the solution in assisting SoIS managers and users in the execution of AESoIS activities and their impact on SoIS understanding. It also discusses the main findings observed while conducting the study.

Chapter 8 concludes this document. We present the final remarks, the contributions of the thesis, and the limitations of this research. Finally, we point out future work.

In addition to the eight chapters, there are seven appendices.

APPENDIX I presents the BPM notation for supporting business process modeling.

APPENDIX II organizes the exploratory study survey: consent form, characterization form, and execution form.

APPENDIX III shows the AEM propositions feedbacks from participants of conceptual model fragments, feedbacks from participants addressing the complete AEM version, AEM elements and descriptions, and glossary of AEM relationships.

APPENDIX IV presents the AESoIS framework guidelines.

APPENDIX V presents the AESoIS tool and the process-driven support to develop front-end and back-end programming.

APPENDIX VI addresses the feasibility study, and it is formed by the following documents: consent form, characterization form, execution form, execution form extension, evaluation of study, and tool guide.

APPENDIX VII presents feedbacks from participants from the feasibility study in detail, as follows: feedbacks from execution form, and study evaluation in two educational organizations, as scenarios.

Chapter 2 - Theoretical Background

In this chapter, accountability is introduced, considering initial concepts, obtained from the first to fifth methodology phase. It is followed by a theoretical background of SoIS addressing business process management. Furthermore, it includes resources for modeling complex IS arrangements. The basis of the approach is recognizing IS structures, notably SoIS and accountability.

This chapter is organized into sections as follows: accountability overview, SoIS, tools for modeling complex systems, and the final remarks.

2.1 Accountability

This section organizes preliminary accountability topics, covering concepts and definitions of the subject in IS/SoIS. It includes an investigation of the relationship between accountability and evaluation; furthermore, it presents conceptual accountability models.

2.1.1 Concepts and Definitions

An initial literature review for accountability was executed for supporting the thesis body of knowledge describes the lack of consensus on the subject (Nissenbaum, 1996; Afonso, 2012; Homerin, 2016; Barroso, 2018). Accountability definitions are quite broad and are adapted to many domains (Gortmaker *et al.*, 2005; Chen *et al.*, 2019; Cordeiro & Santos, 2019a). Gortmaker *et al.* (2005), in the public administration context, states accountability as "*a relationship between two parties, in which an individual or agency is held to answer for a performance that involves some delegation of authority to act*".

Gortmaker *et al.* (2005) also explore other definitions of accountability, mentioning that it "*always involves an actor with the duty to render an account and another actor with the power to judge or impose sanctions*". Authors compare both definitions and argue that "*duty to render an account*" corresponds with the "*delegation of authority to act*", and "*held to answer implicitly assumes that one party has the power to judge the other party's performance*".

In another example, Feigenbaum *et al.* (2012) covered accountability related to IS and Computer Science, and they mentioned that the concept of accountability is central to many activities and arrangements in government and business. It includes elections, workplace hierarchies, a delegation of authority, and fiduciary responsibility. However, Feigenbaum *et al.* (2012) assert that there is no agreement on a precise definition of the term, and indeed different researchers use it to mean other things.

In the same extreme situation, several authors focus on accountability adapted to an investigated scenario. Janssen (2007) argues that although accountability is not a well-defined term, it is broadly conceived and implies answerability for one's actions or omissions and their consequences. Accountability should ensure that constituents and politicians understand how resources are used, and decisions are made. Thus, in the computational context, Janssen (2007) uses the fundamentals of accountability as a coordination strategy for public services interactions, reducing friction costs and quickly adapting to changing circumstances at a low cost. Accounting is another domain that applies accountability, for example, through accounting information systems. Azmi and Sri (2020) define such systems as computer-based systems that process financial information and support decision tasks in coordination, organizational control, and strategic decision-making. It plays a role in supporting accountability in terms of fiduciary stewardship of resources. Guimaraes *et al.* (2019) address democratic and transparent management to understand society and account holders for verification of service provision. Authors cite a national case and the credibility crisis due to misuse of public resources. This way of understanding the role of accountability as an instrument of social participation is shared in the IS community in Araujo (2016).

More recently, there has been attention to accountability from IS scientists. It is worth mentioning that the book *Grand Research Challenges in Information Systems in Brazil 2016-2026* (GranDSI-BR) (Boscarioli *et al.*, 2017) uses the same type of comprehension. GranDSI-BR contains the results of this seminar, including chapters written by researchers of the Brazilian IS scientific community. For example, Araujo (2016) asserts that accountability "*has been seen as individual responsibility and concerns for the public interest (responsibility)*". It is related to democracies that seek to control the actions of governments (control), including the needs of their citizens (responsiveness), considering democracies infrastructure for dialogue.

In contrast, despite the challenges of finding the best definition or comprehending accountability across domains, these studies demonstrate the relevance of encouraging accountability in organizations. Specifically, in IS domain, the intersection between accountability and IS has been the object of increasing attention (Stahl, 2006; Vance *et* *al.*, 2013; Amaya *et al.*, 2014; Bernardi, 2017; Cordeiro *et al.*, 2020). However, ad hoc reviews tend to focus on technology (Pearson, 2011, 2014), even though the sense of accountability has a broader scope. For example, in IS context, Vance *et al.* (2013) focus on accountability, addressing two strategies in policy security: virtue and mechanism.

As a virtue, accountability is a "*quality in which a person displays a willingness to accept responsibility, a desirable trait in public officials, government agencies, or firms; hence, in this use, accountability is a positive feature of an entity*".

As a mechanism, accountability is "*a process in which a person has a potential obligation to explain their actions to another party who has the right to pass judgment on the actions as well as to subject the person to potential consequences for his or her actions. Accountability theory focuses on the process of accountability*".

Thus, it is not new that accountability is a consensus in each domain that should be encouraged individually and organizationally (Nordin & Prøitz, 2017). Sinclair (1995) argues that "*nobody argues with the need for accountability, but how accountability is defined and provided is far from being resolved*".

From Sinclair (1995) research until nowadays, we are still facing challenges for defining accountability. Fox (2007) argues that concepts of transparency and accountability are closely linked: transparency is supposed to generate accountability, and both promote good governance. Khadraoui and Feltus (2012) use Sinclair (1995) and Fox (2007) research to create a responsibility model that considers accountability, defined as "*it represents the obligation concerning to a business activity and the justification that this obligation is achieved to someone else, under threat of sanction*".

Furthermore, despite these several definitions, in general, all share the sense of someone or something (e.g., sensors or systems) being able to judge and creating an environment of responsibility based on evaluation (Feigenbaum *et al.*, 2011; 2012). In addition, as demonstrated in this section, accountability occurs in different forms:

- a preventive approach to security and online privacy (Vian *et al.*, 2017; Alabool *et al.*, 2018);
- a fundamental value for good governance in public or private organizations (Edward *et al.*, 2015);
- an organizational objective to ensure the proper functioning and increase monitoring (Ray, 2012);
- a support tool to democracy (Svolik, 2013); and

- it is a type of non-functional requirement, that is, a quality that defines how a system is supposed to be, as opposed to functional requirements, which define what a system is supposed to do (Pearson, 2014). Pearson argues that accountability is closely related to non-functional requirements such as privacy, security, and compliance and needs to examine how it can be provided, especially relating to data protection.

Finally, accountability is a multidimensional concept found in several literature references. Regarding all the above definitions, this thesis research uses the following accountability definition:

Accountability is a non-functional requirement[5] (Pearson, 2014) ***for holding responsible actions in organizations regarding obligations and sanctions*** (Feltus *et al.*, 2009) ***and must encompass evaluation strategies*** (Bissland, 1990; Pearson, 2014)**.**

However, it is noteworthy that it is necessary to search for evidence on the scope of accountability and IS research despite this preamble. To achieve this goal, the following sections address the research topic combining accountability with evaluation and conceptual models,

2.1.2 Accountability and Evaluation

The relationship between accountability and evaluation has coexisted for decades. Bunda (1979) discussed the concepts of accountability and evaluation as contemporaries' subjects and derived from the legislative context. At that time, the line between accountability and evaluation was blurred, which created confusion about the purpose of each term. Moving forward in time, Sawer (1990) argued that the concept of evaluation derives from three elements: using information (evidence) to determine the value or worth of a program (judgment) and a third component (criteria). It suggests that evidence and review must consider comprehending the objectives, intentions, and expectations involved.

Therefore, Sawer (1990) describes the integration of accountability with evaluation. Accountability implies an external rather than an internal orientation - evaluation of brothers rather than us. It is worth noting that the author described the relationship

[5] Non-functional is a requirement that specifies criteria that can be used to judge the operation of a system, rather than specific behaviors (Pearson, 2014).

considering evaluation characteristics, i.e., evaluation can be considered as contributing to management, where the focus is on internal decision-making and external audiences.

However, accountability is not directed exclusively to external audiences but also includes internal accountability, where employees must be encouraged to have accountable behavior, which requires evaluation (Frink *et al.*, 2018). With the advancement of technologies and considering complex systems structures, the relationship between accountability and evaluation has also evolved. For example, Portela (2012) discusses educational systems, accountability, and the role of evaluation. Portela asserts that accountability and evaluation have become an integral part of education systems, and the day-to-day practice of educators in many countries around the world, e.g., practices, professionals, and institutions concerned with assessment, scrutiny, audit, and inspection, continue to proliferate. Portela (2012) states that "*accountability evokes evaluation and evaluation evokes accountability (...) and you will usually find both terms accompanying each other*".

As opposed to Bunda (1979) and Sawer (1990) that address the existence of the relationship, Portela (2012) describes an integration among them. The author argues that evaluation is usually assumed to serve different purposes, while accountability is often mentioned as one of such purposes. It is not unusual to present accountability as a purpose or function of evaluation. In this way, evaluation can be defined as "*the systematic collection and interpretation of evidence, leading, as part of the process, to a judgment of value with a view to action*" (Portela, 2012).

According to Wolf (1990 apud Portela, 2012) this definition embodies four core elements to the evaluation approach:

a) **Systematic collection of evidence** implies that information needs to be gathered. In addition, it also indicates that data needs to be acquired systematically;
b) **Interpretation of evidence** highlights that evaluation does not consist merely of collecting evidence and providing information that describes something. Collected evidence is to be analyzed and made sense of with great care. Systematic collection, analysis, and interpretation of evidence provide a reporting mechanism required for accountability;
c) **Judgment of value** reveals that evaluation neither is exhausted in description nor is a mere interpretation of that being described. The evaluation also implies drawing judgments about the worth of something. A value judgment is a statement

that ascribes value to something: when saying something is good or is better, you are making a value judgment. These judgments are to be drawn as reasonably and as carefully as possible, and a major basis for doing this should be the evidence that has been systematically gathered and interpreted. Moreover, evidence cannot answer whether (or not) something is good or better. But evidence can and must assist subjects in answering. There is an additional condition to be met: subjectivity needs to be identified and defined to be neutralized or, at least, controlled. Therefore, some normative references or standards are usually considered (specific goals or objectives, for instance). These are the standards embodying individual or institutional values required in accountability to state whether something is important. Evidence will assist in demonstrating that such measures have been met; and

d) **Orientation to action** raises that the undertaking resulting in a judgment of value is deliberately tackled for future action and achievements. The decision on future action (for instance, punishment), taken in light of the judgment of that being evaluated, may be conceived of as another judgment of value because there will be a statement ascribing value to a choice. However, this second judgment is usually within the scope of agents besides evaluators (for instance, policymakers).

Currently, accountability and evaluation are widely used in the context of sustainability in several areas. Gualandris *et al.* (2015) propose an artifact for sustainable evaluation and verification, encompassing all activities for identifying key sustainability: metrics; collect, process data; reliability, the accuracy of any data and results. As a result, the relevance of this information to multiple stakeholders is discussed; and subsequently, some or all of this information is disclosed. Kaur and Lodhia (2019) discuss the public sector as a steward for social and environmental issues, focusing on delivering public policy and promoting social welfare. To achieve this, roles and responsibilities must be explicit, linked to a sustainability agenda.

Kaur and Lodhia (2019) assert that the public sector has far greater responsibilities for promoting and supporting sustainable development than the private sector. Ribeiro *et al.* (2020) focus on social responsibility, which assumes a voluntary character of the organizations toward the impacts of their decisions and activities in society and the environment. Ribeiro (2020) considers systems' demands on transparency and ethical behavior that contribute to sustainable development, evaluating sustainability accountability in higher education based on emerging non-financial reporting models. In this way, evaluation can then be used in the decisions of an organization. For example, performance will improve when management occurs because it focuses on future results, even by observing the quality of past performance.

Thus, this thesis is guided to establish an accountability evaluation approach. Therefore, the following section describes elements of accountability that contribute to understanding influences in IS arrangements, focusing on people's feedback concerning business processes dynamics.

2.1.3 Conceptual Models for Accountability

In this section, some related works of accountability are presented regarding conceptual models' examples. Pearson (2014) explains in Figure 3 a hierarchy pyramid concerning cloud environments regarding (i) mechanisms and tools, (ii) practices, (iii) attributes, and (iv) accountability as a goal. Mechanisms and tools enhance accountability in organizations by including privacy and security controls appropriate to the context. Practices define the central behavior of an organization adopting an accountability-based approach as an organizational objective. Practice examples illustrate governance, ensure appropriate actions, explain and justify those actions, and remedy any failure to act appropriately. Attributes describe the conceptual components that should be analyzed through accountability: observability, verifiability, attribution, transparency, accountability, responsibility, appropriateness, and effectiveness.

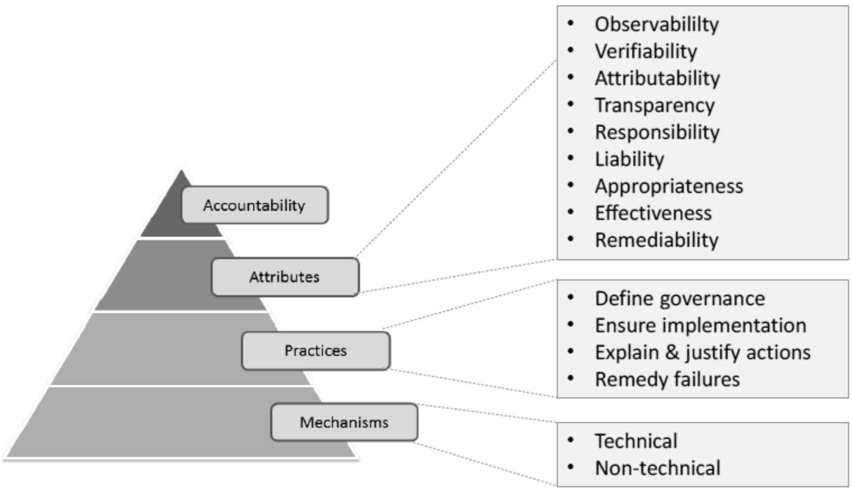

Figure 3 - Model of accountability. Source: (Pearson, 2014).

Furthermore, at the top of the pyramid, accountability represents the acceptance of responsibility for the stewardship of personal and/or confidential data with which it is entrusted in a cloud environment. It depends on data for processing, storing, sharing, deleting, and otherwise using the data according to contractual and legal requirements from when it is collected until when the data are destroyed.

Pearson (2014) emphasized that accountability is tough to achieve in the cloud context. The author pointed out some challenges: government surveillance, potential weak links in the dynamically formed cloud service chains, and the current shallowness of transparency and verifiability in the cloud context. Another example of modeling addressing accountability is proposed by Feltus *et al.* (2009, 2010; 2012), who presented a responsibility model based on a UML diagram that includes accountability, as shown in Figure 4.

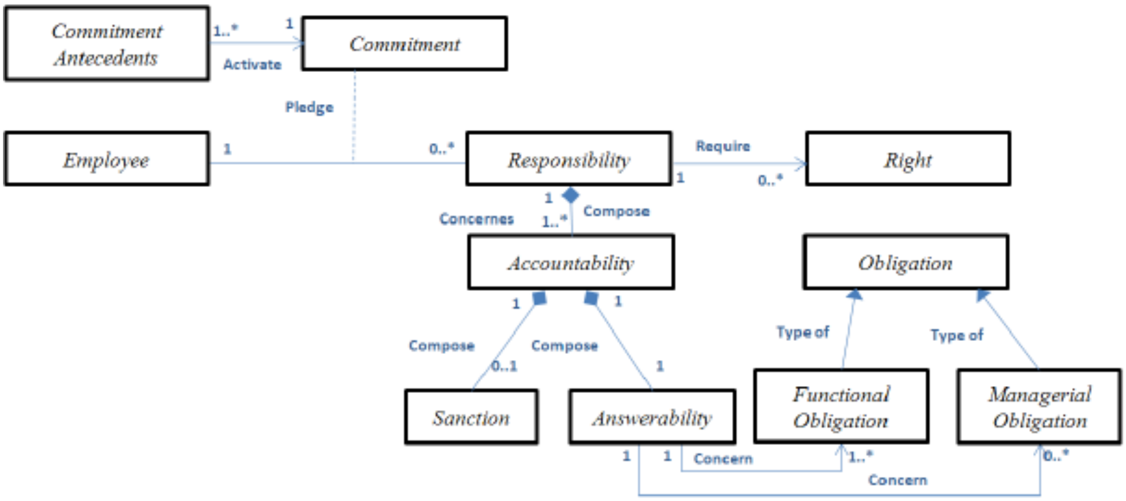

Figure 4 - Responsibility model UML diagram. Source: (Feltus *et al.*, 2010).

It emerged from literature's incomes of responsibility conceptual components issued from social, management, physiology, and computer science. Feltus *et al.* (2010) assert that the responsibility concept highlights many definitions and several highlighting accountabilities. Although the model does not represent IS, the meta-concepts help create a body of knowledge of accountability, especially considering accountability characteristics. For example, obligation, sanction, and right are fundamental key concepts for accountability. Figure 4 shows the model and Table 1 summarizes elements definitions. Besides this theoretical accountability background, the remaining parts of this chapter are organized with SoIS and tools for modeling complex systems, which aims to explore SoIS literature and modeling strategy concerning to SoIS scenario.

Table 1 - Responsibility model description adapted from Feltus *et al.* (2010).

Term	Definition
Accountability	It describes the structures, which must be in place to facilitate responsibility, and that responsibility is the ascription of an object to a subject, rendering the subject answerable for the object.
Answerability	An obligation or moral duty to report or explain the action or someone else's action to a given authority.

Table 1 - Responsibility model description adapted from Feltus *et al.* (2010) (Part 2).

Commitment	It is pledged by the employee related to that assignment or delegation process represents his/her moral engagement to fulfill the action and the assurance that he does respect an ethical code.
Commitment's antecedent	It describes variables for enforcing the commitment as an alternative solution.
Employee	It represents an actor.
Obligation	A role must do with respect to a situation (functional obligation), as well as what a role must do in order to fulfill a responsibility such as directing, supervising, and monitoring (managerial obligation).
Functional Obligation	It describes what a role must do with respect to a state of affairs (e.g. execute an activity).
Managerial Obligation	It describes what a role must do in order to fulfill a responsibility such as directing, supervising, and monitoring.
Responsibility	It encompasses the idea of having an obligation to ensure that something happens.
Right	It encompasses facilities required by an employee to fulfill his/her accountabilities.
Sanction	Positive or negative action, as a corrective mechanism.

2.2 Systems-of-Information Systems

This section organizes SoIS theoretical background, covering concepts and definitions of the subject in SoIS. It includes an investigation of a conceptual SoIS model, and a method for generating SoIS architecture as part of strategies for supporting SoIS scenarios understanding.

2.2.1 Concepts and Definitions

IS is a set of dynamically interconnected components for collecting, storing, and processing data and providing information and knowledge to support organizational decisions within three distinct IS area: people, process, and technology (Alter, 1999; Brien & Marakas, 2010; Laudon & Laudon, 2011; Stair & Reynolds, 2015; Araujo, 2016). However, when multiple IS work collaboratively to achieve a mutual goal, they create what is known as a complex system (Alampalli & Pardo, 2014; Graciano Neto *et al.*, 2017; Teixeira *et al.*, 2019). A complex system comprises several independent and interdependent parts interacting in a non-linear way, i.e., the behavior cannot be precisely expressed/predicted/designed due to the sum of the activities of individual parts (Alampalli & Pardo, 2014). Complex systems have (i) adaptation, (ii) self-organization, and (iii) emergence (Ottino, 2007).

A particular type of complex system is the so-called System-of-Systems or SoS (Maier, 1998). In SoS, constituents are independent systems working together. They preserve their ownership, objectives, development methods, and funding. For example, a smartphone is an SoS as it includes a touch screen, camera, CPU, internet connection, etc. An arrangement of independent systems that involve one or more IS is so-called Systems-of-Information Systems or SoIS (Graciano Neto *et al.*, 2017; Majd & Marie-

Hélène, 2017; Li, 2021). Therefore, while SoS is primarily concerned with a technical artifact (e.g., software), SoIS is involved with other IS elements, such as processes, technologies, and people needed to achieve IS interoperability (Maier, 1998; Gonçalves *et al.*, 2014; Soares & Amaral, 2014). SoIS has specific properties, such as (i) the existence of information flows among the constituent IS; (ii) a business process-oriented nature; and (iii) information creation and added value through interoperability among IS and their organizations, which cannot be obtained if their constituent IS operate in isolation (Fernandes *et al.* 2019).

SoIS is formed by several constituents IS. It uses the individual functionalities offered to achieve business goals (Saleh & Abel, 2016; Graciano Neto *et al.*, 2017). Connectivity and cooperation between the arrangement's constituents occur through one or more interoperability links (Fernandes *et al.*, 2020) that link two or more systems. In this case, it is worth considering the relevance of including business process and human factors (Soares & Amaral, 2014; Graciano Neto *et al.*, 2021; Li, 2021). Moreover, it involves cultural, social, human, communication, negotiation, and diplomacy (Soares & Amaral, 2014). SoIS may gather social and human elements, such as strategies representing stakeholders' decisions and behaviors to create value and innovative ideas (Laudon & Laudon, 2011; Soares & Amaral, 2014).

According to Saleh and Abel (2017), SoIS have been used in an educational context by addressing learning systems. In this environment, learners use these IS to generate and share ideas, explore their thinking, and acquire knowledge from other learners. However, due to the failure of indexing methods, learners often fail to reach their desired resources. In an attempt to properly define SoIS mechanisms, the authors argue that it is necessary to consider: (i) the willingness to share resources with a community to achieve a common goal; and (ii) the fact that the shared resources can come from different IS. In such an educational environment, a SoIS leader should emphasize strategies, such as (i) supporting sharing of resources; (ii) supporting communication of different IS; and (iii) the references for shared resources should be stored and retrieved easily.

In order to allow pedagogical recommendations, Ali *et al.* (2017) describe an architecture concerning to learning SoIS, the MEMORAe SoIS. MEMORAe is an environment that orchestrates a SoIS. Ali *et al.* (2017) argue that "*it can be seen as a knowledge base related to SoIS systems allowing the organization, sharing, and access to the resources of the various component systems*". Such architecture aims to manage heterogeneous information resources within organizations and to facilitate organizational learning. It considers an organization as a group of members interacting with each other. In another example of educational SoIS, Fernandes *et al.* (2021) present a method to identify potential interoperability links that can support the emergence of a SoIS. To achieve such a purpose, the technique was applied to an educational environment. Results indicate that the technique helped identify potential links among constituent IS considering the environmental characteristics related to accountability investigation.

From the above fundamental, SoIS management covers understanding the relationships between constituent IS, processes, and functionalities. Thus, in the next sections, a conceptual model for SoIS is addressed, which aims to detail elements of the arrangement and a method for extracting knowledge based on BPM.

2.2.2 Conceptual Model for SoIS

A conceptual model converges the accumulated knowledge from researchers and practitioners of any area by adopting concepts and relating them to each other (Fernandes *et al.*, 2019). During the thesis research, a conceptual model for SoIS was built to identify the elements involved in complex IS arrangement, as part of research with colleagues from LabESC at UNIRIO. Figure 5 summarizes the SoIS conceptual model proposed by Fernandes *et al.* (2019).

For this purpose, we analyzed systems reporting complex systems; as an outcome, the proposed model aims to support project managers and engineers to distinguish a SoIS from other classes of systems (Fernandes *et al.*, 2019). The white boxes represent the entities related to constituent IS, whereas the gray boxes are entities directly associated with SoIS. The study was conducted in two steps: (i) literature review to explore the existing concepts regarding meta-concepts of SoIS; and (ii) adaptation from an existing conceptual model, evolved from Gonçalves *et al.* (2014) SoIS model. In addition, for assessment purposes, we verified if a SoIS is classified whether they are a SoIS or not, according to the proposed model, e.g., Space SoIS Case 1. The case describes a scenario of the space domain (Graciano Neto *et al.*, 2018). The Space SoIS provides environmental data collected by satellites to organizations that develop applications and research in different fields, such as weather forecast, climatology, environment monitoring, and study on deforestation (Graciano Neto *et al.*, 2018). Table 2 presents the definitions of the key concepts required to explain meta-concepts.

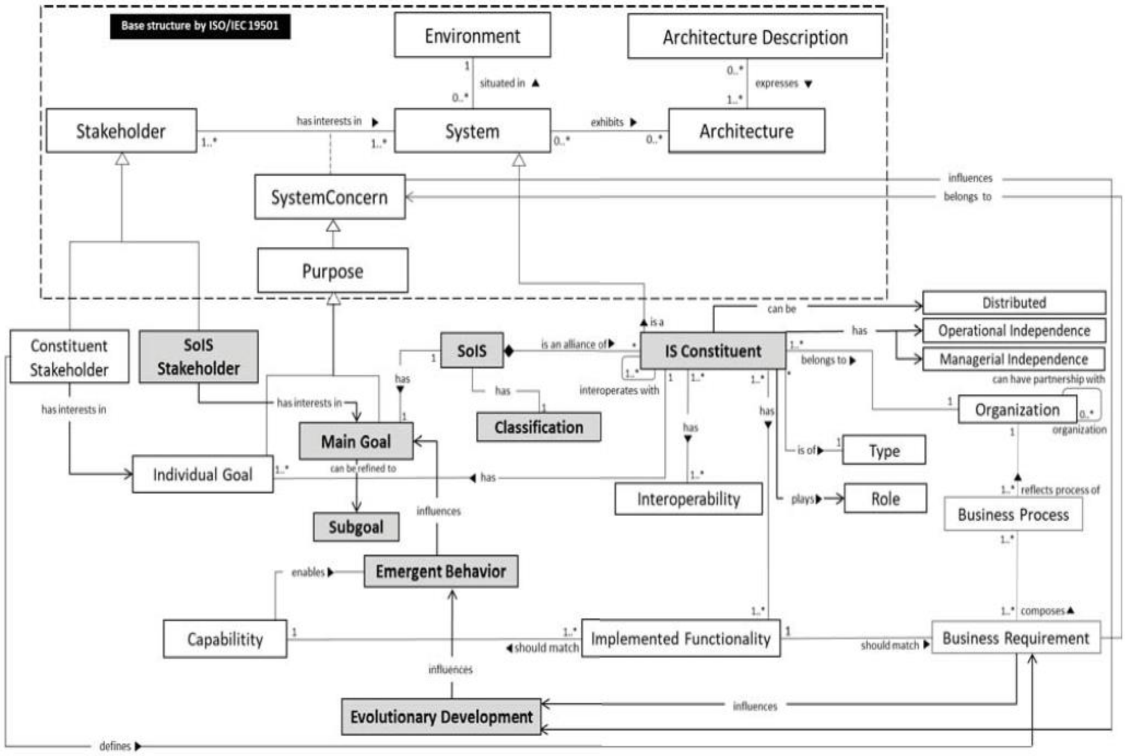

Figure 5 - SoIS model. Source: (Fernandes *et al.*, 2019).

Table 2 - Key concepts from SoIS model. Source: (Fernandes *et al.*, 2019).

Key Concept	**Definition**
Main Goal	The goal is to be accomplished by a SoIS through the interoperability of IS constituent systems.
Subgoal	A set of goals resulting from the refinement of a SoIS main goal.
Classification	SoIS can be classified into four categories, namely virtual, collaborative, acknowledged, and directed.
Individual Goal	A set of inner goals of each IS constituent.
Constituent IS	An organized combination of people, hardware, software, communication networks, and data resources collects, transforms, and disseminates information in an organization.
Type	IS category, i.e., the type of constituent IS that accomplishes an individual goal. It can be manual, informal, formal, or software-intensive.
Role	Roles are played by organizations and involve business processes and operations, decision making, and strategic competitive advantage.
Distribution	Physically decoupled constituent systems exchange information among them through some network technology.
Operational Independence	Characteristic of a constituent that does not have its operation exclusively directed to the objective of SoIS, i.e., it occasionally contributes and on-demand to SoIS goals, and also maintains its individual objectives being fulfilled as well.
Managerial Independence	Property in which one or more constituents of a SoIS belong to a company, group, organization or person/entity.
Organization	A series of interlocking routines habituated action patterns that bring the same people together around the same activities in the same time and place.
Business Process	A structured set of interdependent activities designed to produce a specified output for a particular customer or market with a start and endpoints, and clearly identified inputs and outputs.
Business Requirement	A representation of goals, objectives, and outcomes that describe why a change has been initiated and how success will be assessed. Activities of an enterprise that must be performed to meet the organizational objectives
Implemented Functionality	Behavior or action with start and end points, i.e., something executable

Table 2 - Key concepts from SoIS model. Source: (Fernandes *et al.*, 2019) (Part 2).

Interoperability	The ability of an IS to communicate with another IS. Any way to send and/or receive messages from an IS (communication channel).
Emergent Behavior	Holistic phenomenon manifested as a result of interoperability among IS constituents that produce an overall result which cannot be delivered by any of them in isolation.
Evolutionary Development	The entire SoIS evolves as a result of the evolution of its constituent systems, interoperability links, and assigned requirements, with functions and purposes being added, removed, and modified due to experience and/or emerging business needs [18].
SoIS Stakeholder	A group or person that has a mutual interest in the goals of a SoIS, and can either affect or be affected by these objectives.
Constituent Stakeholder	A person, a group of people or an organization that owns one or more constituents of a SoIS. They can be either affected by or affect IS goals.

In addition, for assessment purposes, we verified if a SoIS is classified whether they are a SoIS or not, according to the proposed model, e.g., Space SoIS Case 1. The case describes a scenario of the space domain (Graciano Neto *et al.*, 2018). The Space SoIS provides environmental data collected by satellites to organizations that develop applications and research in different fields, such as weather forecast, climatology, environment monitoring, and study on deforestation (Graciano Neto *et al.*, 2018). Moreover, Space SoIS Case 1 has a well-defined business process, i.e., a set of interdependent, structured, sequential activities to be followed to produce a specific outcome or achieve a goal.

In this context of business process modeling, SoIS is also characterized by having an internal business process that guides its operation and interoperability among its constituents (Santos *et al.*, 2020; Graciano Neto *et al.*, 2021). SoIS arises from a context of modernized business processes that encourage constituent IS to interoperate and generate value (Teixeira *et al.*, 2019). Since SoIS are oriented to business processes, such arrangements must meet business requirements, fulfilling the main goal of SoIS (Fernandes *et al.*, 2019; Li, 2021).

Business processes are interrelated events, activities, and decision points that involve a series of actors and objects, which collectively generate an outcome of value to at least one customer. Business rules govern them, and they are understood regarding their relationships to provide a view of sequence and flow. Furthermore, how processes are designed and executed affects the quality and efficiency of an organization's services, which applies to customer-driven processes and internal processes (BPM, 2013; Dumas *et al.*, 2013; BKCASE, 2018). In this sense, business process management (BPM) presents itself as an advantage and a necessity. According to Hantry *et al.* (2010), BPM emerged as a management principle and a suite of software technologies focusing on bridging diverse systems, organizations, people, and business processes.

BPM generally deals with process management scenarios to coordinate people and systems, including sequential workflow, case management, content life cycle management, collaborative process work, and value chain participation (BKCASE, 2018). It is an information technology (IT) that enables management discipline that treats business processes as assets to be valued, designed, and enhanced in their own right (Hantry *et al.*, 2010). BPM presents a set of steps that support organizations to model and manage their processes, i.e., identification, discovery, analysis, redesign, implementation, and monitoring (Oliveira, 2021)

Due to its predominantly business-oriented nature, SoIS needs specific methodologies to capture its characteristics (Graciano Neto *et al.*, 2017). Therefore, SoS and SoIS modeling is a challenge, especially for business processes that depend on the interoperability of constituents, and modeling notations, such as BPM notation (BPMN). BPMN is a graphic notation standard that describes a process's realization within any given workflow (BKCASE, 2018). Graciano Neto *et al.* (2017) argue that BPMN does not provide adequate modeling and complete SoIS adaptations. However, it can provide a starting point for SoIS managers/architects to represent constituent IS, considering that BPMN provides multiple diagrams designed for use by the people who plan and manage business processes (OMG, 2011). In this context, BPMN can provide a standard visualization mechanism for business processes associated with SoIS by defining an execution-optimized business process adapted language.

2.2.3 A Method for SoIS Generation from Business Process

Teixeira *et al.* (2019), Santos *et al.* (2020), and Oliveira (2021) discussed approaches and notations (e.g., UML and BPMN) for modeling SoIS architectures. They argue that SoIS research lacks practical support for modeling SoIS scenario understanding. As a result, it creates a gap in SoIS modeling, which becomes a considerable obstacle regarding representing interactions and activities in organizations supported by SoIS.

In this context, this thesis is motivated by the SoIS generation method from the business process (BPSoIS method, Oliveira 2021) to address organizational objectives through the lens of a business process. BPSoIS is a method based on analyzing business process models to generate an architectural model for SoIS architecture, based on

Fernandes *et al.* (2019) SoIS model. BPSoIS allows detecting interoperability needs between constituent IS in one or several organizations to achieve organizational goals. BPSoIS method is tool-supported; therefore, the tool allows the reading and analysis of BPMN files. BPSoIS is a relevant approach, as it raises general information contained in the BPMN files, providing an overview of the analyzed environment by identifying all actors who integrate the processes with their respective tasks. Furthermore, the BPSoIS tool involves a set of activities that helps to identify relationships among constituent IS: (i) analysis and extract knowledge from business process models, extracting elements related to the organization's SoIS architectural representation; (ii) identify interactions between IS from different organizational units and/or different organizations based on their business processes; and (iii) present an architecture. In order to illustrate the BPSoIS method, Figure 6 presents the macro-process method (Oliveira, 2021).

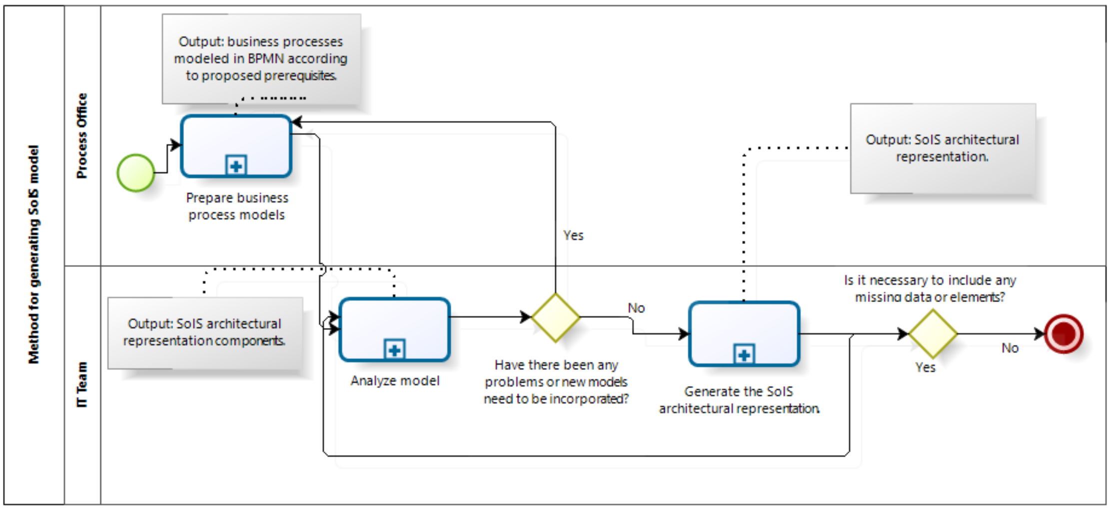

Figure 6 - BPSoIS Macroprocess Method. Source: (Oliveira, 2021).

In the macro-process, the Process Office team, or those responsible for the organization's process management, prepare the business process models, a subprocess illustrated in Figure 7. It details the process modeling phase (if this does not exist) or its checking against requirements defined by the method and necessary for its analysis. After preparation, the IT team, or the person responsible for applying the method, analyzes the models. During this step, the models have examined thanks to supporting tools, and, based on this analysis, the interoperability links between the systems are identified (Oliveira, 2021).

An interoperability link represents how interoperability is established and affected between two or more SI, that is, any way of sending and/or receiving messages between SI (Fernandes *et al.*, 2019). Figure 7 shows the sub-process referring to macro-process. If any problem occurs in the analysis during this step, or it is noticed/decided that new process models must be included, the user can return to the first step, execute it, and then execute the second step only for the necessary models. Finally, based on the results of the analysis of the models, the architectural representation of the SoIS must be generated, where the user follows a set of heuristics that guide the modeling of the resulting SoIS. The main elements of the BPMN are provided in APPENDIX I.

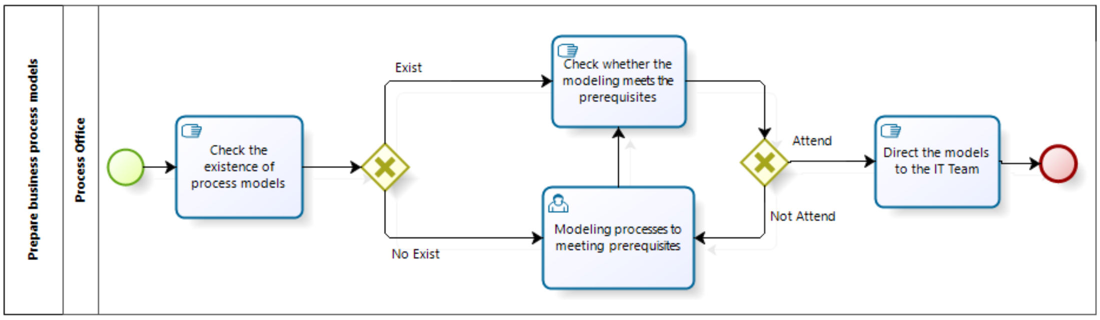

Figure 7 - Sub-process: Prepare business process models. Source: (Oliveira, 2021).

As demonstrated, the BPSoIS method and solution are based on a pre-existing conceptual model for SoIS (Fernandes *et al.*, 2019) that supports managers in identifying problems for achieving organizational goals. In short, it can be pointed that BPSoIS contributions address: (i) a better understanding of the organization's business processes and the IS that support them; (ii) understanding the interoperability links between manual and computerized IS, as well as pointing out the need for IS automation; and (iii) proposition of SoIS architecture for supporting SoIS effectiveness.

2.3 Tools for Modeling Complex Systems

Arnold and Wade (2015) assert that recognizing complex systems demands a better understanding of the deep roots of these complex behaviors to predict them better and, ultimately, adjust their outcomes. They argued that with the exponential growth of systems in our world comes a growing need for designers to tackle these complex problems. Shaked and Schechter (2017) describe that system dynamics aim to provide managers with a full understanding of their systems' feedback-loop structure to intervene in ways that ensure behaviors are maintaining the managers' goals.

For this purpose, this section presents models and modeling techniques to study complex management issues. Concerning Shaked and Schechter (2017), the modeler attempts first to identify patterns of behavior exhibited by important system variables and then build a model that can mimic those patterns. Thus, the following sections present systems thinking, soft systems' methodology, and decision maps as modeling strategies.

Finally, the following sections describe this thesis's modeling strategies to frame, perceive, and discuss SoIS scenarios for supporting the thesis solution.

2.3.1 Systems Thinking

Systems thinking (ST) has been defined and redefined in many ways. There are several definitions for ST, from the most concise as the (Sterman, 2000) "*The ability to see the world as a complex system, in which everything is connected to everything*" - to some more detailed as follows:

> "*Systemic thinking is a discipline to see the whole. It is a framework for seeing interrelationships, rather than events, to see the patterns of change rather than 'snapshots.' It is a set of general principles - distilled throughout the century, covering fields as diverse as the physical and social sciences, engineering, and administration tools and techniques, originating from two lines of thought: the feedback concepts of cybernetics and the engineering theory of 'servomechanism', dating from the 19th century*"(Meadows, 2008; Amaral, 2012).

Concerning Arnold and Wade (2015), ST consists of three kinds of things: elements (in this case, characteristics), interconnections (the way these characteristics relate to and/or feedback into each other), and a function or purpose. Moreover, through the application of ST, IS researchers may be able to "*identify the points at which a system is capable of accepting positive change and the points where it is vulnerable*" (Holling, 2001). For example, Zhang *et al.* (2015) assert that ST provides a viable alternative to mechanistic thinking (reductionism/logical positivism) to understand the interactions between factors within a system. It aims to provide a way to understand complex problems as an interconnected set of issues. In particular, ST is widely believed to be critical in handling the Complexity facing the world in the coming decades (Arnold & Wade, 2015).

Understanding interconnections are necessary for ST to achieve representative knowledge. Thus, adopting ST can complement IS researchers for problem-solving to address SoIS complex problems. For example, Chen and Stroup (1993), in a seminal work, presented strengths of General System Theory for science education, which we adjusted for SoIS (Cordeiro & Santos, 2019b) to a problem-solving:

- **Synergy**: ST can provide a set of powerful ideas in a SoIS scenario. The collection of different levels of analysis for foreign entities and individuals, ranging from the uncomplicated activity levels to the more complex hierarchical levels;
- **Engaging Complexity**: it needs to take on roles and responsibilities among system users;
- **Interconnections**: it ignores the centrality of change over time, aiming to present a picture. ST offers tools for users to build understanding based on systemic relationships;
- **Interdependence between systems:** ST offers the possibility of making explicit the complementary relation between levels of analysis of a subject;
- **Functioning in a Human-Made World**: ST has tools to design, identify SoIS goals and consider different types of interconnections, providing a theoretical foundation for investigated scenarios; and
- **Communication**: these mechanisms must be placed for SoIS to exchange relevant information regarding their environment and provide a flow of information among constituent IS.

Additionally, concerning problems understanding, ST requires group work formed by relevant stakeholders and problem owners. After specifying the system boundaries of the problem and focusing on the question, all the key variables pertinent to the question are listed (Haraldsson, 2000). Sterman (2000) points out that it is essential to distinguish between what components interact within the system (internally or externally).

Regarding the mentioned strengths, the ST approach uses a non-linear model where different elements are connected through cyclical rather than linear with feedback loops. Williams *et al.* (2017) mentioned feedbacks loops as secondary effects of a direct effect of one variable on another; they cause a change in the magnitude of that effect. Thus, positive feedback enhances the effect, and negative feedback dampens it. Additionally, the author mentioned that loops cause systems to be interconnected, and when managers do not fully understand the consequences of feedbacks loops, unpredictable system behavior can emerge. As a result, Williams *et al.* (2017) argued that systems adapt or transform in response to feedback from the external environment and have direct and indirect impacts on organizations. Sterman (2001) explains the implications of feedback loops: "*our decisions alter the state of the world, causing changes in nature and* *triggering others to act, thus giving rise to a new situation which then influences our next decision*".

From an operational point of view, causal loop diagrams (CLD) are formed by a feedback loop that describes the behavior of a system by using causal links. Causal links are built using arrows that connect different variables, i.e., evolving entities, and enable dynamic behavior analysis. It is an essential feature to assess knowledge about dynamics and impact on business performance (Schiuma *et al.*, 2012).

Moreover, it provides a language for articulating the dynamics for environment comprehension. Haraldsson (2000) argued that is essential to understand complex dynamics as developers need to be aware of presentation details. Representation is meant to show how one variable can affect another variable. The causal loop arrows are labeled with signs as follows: "+" or "–". They indicate the nature of the influence exerted by one variable on another one. In particular, the sign "+" means that the variables' changes occur in the same direction. Instead, the symbol "–" denotes a shift taking place in an opposite direction (Amaral & Frazão, 2016).

Figure 8 demonstrates positive and negative effects with three nodes. In the following example, the total enrolled student's node is positively affected by student enrollments, so if the student node increases, then the total increases. In contrast, if the student node decreases, the total decrease. Moreover, the total node is negatively affected by the school evasion node, so if the evasion node decreases, then the total increases; in contrast, if the evasion node increases, the total will decrease.

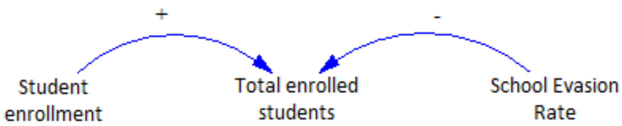

Figure 8 - Positive and negative effects.

Figure 9 presents a single closed loop regarding positive and negative cycles. Positive cycles are the fundamental structures responsible for exponential growth. The negative feedback cycles represent actions that stabilize a system (i.e., the desired state), the search for a goal, which arises whenever there is a difference between a state that we want to achieve, the desired, and the desired current state.

These examples describe causal diagrams integrating cycles to form more representative and complex diagrams. For example, assume the Coronavirus disease 2019 (COVID-19) pandemic surged in Wuhan, China, and a CLD for disease contagion. COVID-19 is a contagious disease caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). COVID-19 cause was not known: it reached all age groups, the spread took place by air, and contact between people was enough to cause transmission; consequently, the disease spread in an unbridled manner. It makes a person infected when someone breaths, coughs, sneezes, or speaks and enters another person through the mouth, nose, or eyes. It can also spread through contaminated surfaces. So, imagine that the individual, represented by the color black in the figure below, has the SARS-CoV-2 virus and had contact with others, six other people[6], contaminating them in Figure 10. As the six are unaware that they are spoiled and each may have more than one contact, the disease starts to spread exponentially. Imagine that each of them has six contacts.

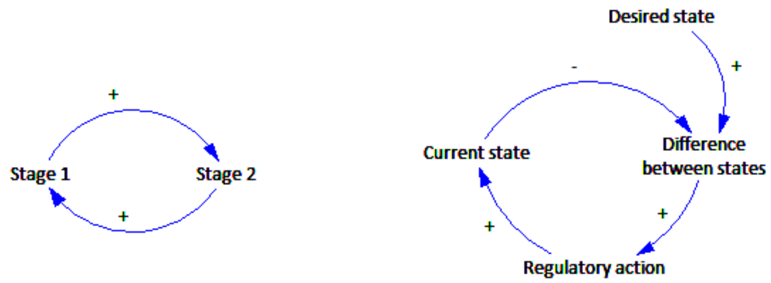

Figure 9 - Positive cycle and negative cycle. Source: (Cordeiro & Santos, 2019b).

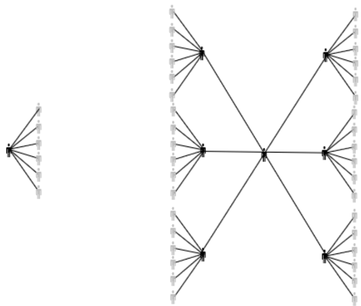

Figure 10 - Contagious spread.

The number of infected people is not due to the number of relationships or people but by the number of infectious agents' contacts. Such a scenario describes a positive cycle since the increase of contagious agents promotes more infectious agents as a contagious cycle. Figure 11 illustrates the contagious cycle represented by the snowball icon of exponential growth. The beginning of the spread of the disease had a brutal growth, with each day appearing countless new cases of contamination.

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[6] Center of Disease Control and Prevention: Rapid spread - https://wwwnc.cdc.gov/eid/article/26/7/20-0282_article

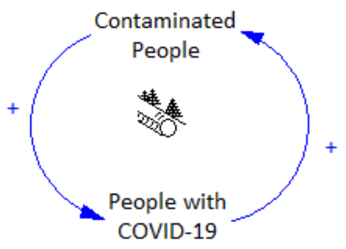

Figure 11 - Contagious cycle.

As the COVID-19 epidemic spread fast, populations were alarmed. The increase in deaths led to increasing concern about contagious, leading people to prevent themselves, reducing infective contacts. This strategy became an international recommendation where governments determined isolations and lockdowns to reduce people contact.

With the advance of the disease, several countries invested in scientific research to understand the condition and find a cure. The answer was the discovery of the contagion mechanism. Once negative feedback loop tends to offset the effects of growth generated by the positive feedback loop. Thus, the negative feedback loop has a balancing effect, as represented by the balance icon. Figure 12 presents a prevention cycle as a result of worries among people and government regulations.

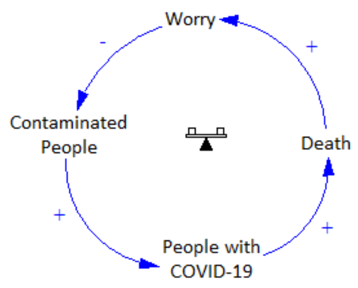

Figure 12 - Prevention cycle.

Figure 13 shows the CLD for the superposition of cycles from Figure 11 and Figure 12. Superpositions represent the integration of positive and negative cycle feedback. It demonstrates a view of the relationships between the various variables that make up the system under development. Thus, considering both COVID-19 cycles, prevention reduces the number of infective contacts, reducing the number of infected people.

Moreover, the pandemic generated worldwide commotion, affecting the way people live and directly impacting the economy, different fronts of research were carried out for finding a cure. Figure 14 presents different cycles and variables that affect the proliferation of the virus in societies, for example, the development of vaccines and their efficacy against the virus. The following model includes other forms of worry, such as masks, restrictive measures, and educational campaigns to decrease contamination.

Moreover, it shows the problem of crowded hospitals and their impacts on death. Issues with services describe many causes, such as lack of oxygen, contaminated health professionals, and the COVID-19 Test.

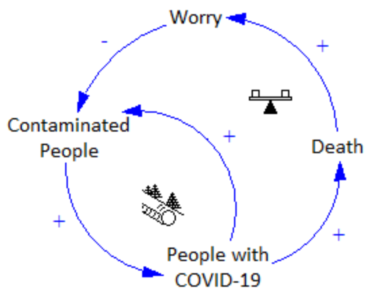

Figure 13 - Combination of cycles.

It is noticed that this model can be beneficial to assist in decision making. The strategy must involve acting in negative cycles to reduce the harmful effects of contagion, such as educational rate, restrictive measures, and the use of masks. Finally, Figure 14 demonstrates that the CLD process must be carried forward until it is possible to understand its dynamics. It allows a better understanding of the potential consequences of the actions to be taken. The next section considers a methodology for sustaining a protocol for complex situation mapping.

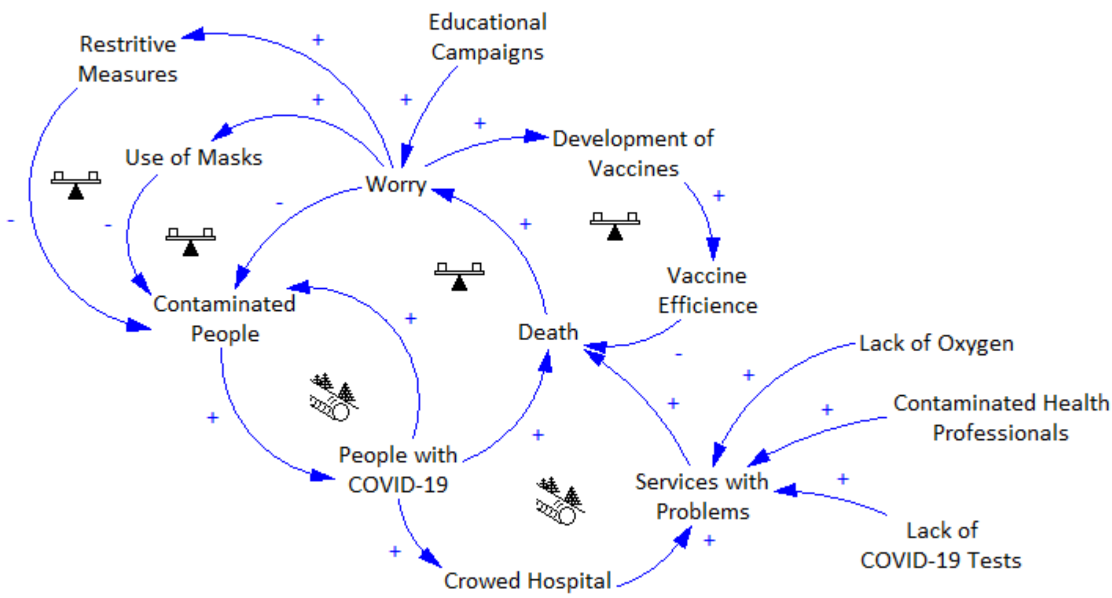

Figure 14 - CLD with several cycles addressing COVID-19 contagious.

2.3.2 Soft Systems Methodology

According to Shaked and Schechter (2017), "*soft systems methodology (SSM) does not refer to the softness or hardness of the systems themselves but rather to how people* *think about system*". SSM was designed to think about and deal with complex, often structured situations that elicit disagreement regarding what aspects are most important and how to address them. Shaked and Schechter (2017) assert that instead of reducing a situation's complexity to be modeled, SSM strives to learn from the different perceptions that exist in the minds of the various people involved in an unstructured situation.

Checkland developed SSM through a 20-year program of action research (Checkland, 2000). Reynolds and Holwell (2020) argue that the primary use of SSM is in the analysis of complex situations where there are divergent views about the definition of the problem — 'soft problems', e.g., "*How to improve health services delivery?*"; "*How to manage disaster planning?*"; "*When should mentally disordered offenders be diverted from custody?*"; and "*What to do about homelessness amongst young people?*". Authors assert that intervening in such situations, the soft systems approach uses a 'system' as an interrogative device to enable debate amongst concerned parties. Furthermore, Shaked and Schechter (2017) present the seven stages for analyzing problem situations, as seen in Figure 15:

1. entering the problem situation—gaining an initial understanding of the problem situation and the broader situation in the organization;
2. expressing the problem situation—beginning to organize ideas and understanding of the situation, to enable and facilitate the analyses that will follow;
3. formulating root definitions—describing the system in a structured way that enables modeling of the system;
4. building conceptual models—logically extrapolating a conceptual model from each root definition to show each operational activity which would be necessary to carry out the process described in the root definition;
5. comparing the conceptual models of activity with the real world—contrasting the thinking that has been done up to the relevant systems in the world;
6. defining changes that are desirable and feasible considering the results from the previous stages, to find out those that seem likely, if implemented, to have a positive outcome in the situation; and
7. recommending actions to amend the real-world situation to those with the power to make the changes.

Figure 15 shows that the SSM model is divided into two stages, depicting those that occur in the real world (Stages 1-2, 5-7) versus those that occur in the conceptual world for thinking systemically about the real-world problem situation and its solution (Shaked & Schechter, 2017). Additionally, in the context of this thesis, SSM is used to guide research around systems thinking as a strategy for data collection and analysis. Thus, considering the demand for organizing knowledge regarding complex situations, the following section presents Decision Maps.

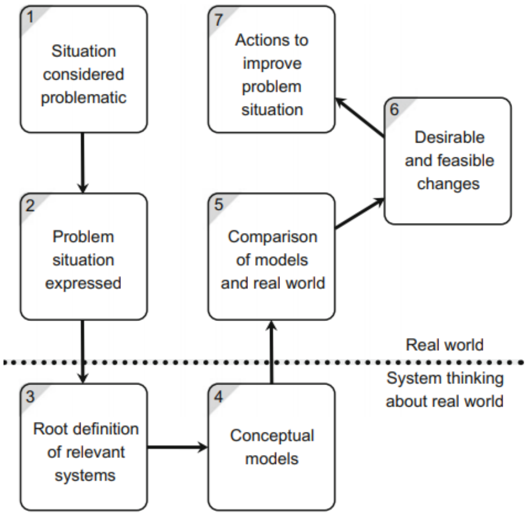

Figure 15 - The 7-stages of SSM. Source: (Shaked & Schechter, 2017).

2.3.3 Decision Maps

Lago (2019) explores the study of decision maps in software engineering in the context of software sustainability. The map is a graph representation to (i) support decision making where architectures are involved, (ii) assess the quality of architectures concerning their intended purpose, and (iii) determine whether architecture entities address their intended purpose (Lago, 2019). Such a solution provides architects with suitable instruments to make decisions that lead to some sustainable purposes. Furthermore, it has a visual notation and demonstrates factors for software sustainability.

Concerning Lago (2019), if one architecture's intended purpose is sustainability, we should provide architects with suitable instruments to make decisions that lead to stated sustainability purposes or concerns. Thus, decision maps focus on making explicit the sustainability concerns that architecture should consider. Decision map notation frames the expected impacts of software architecture on the target of sustainability. Figure 16 presents the notation, organized in different shades of grey, sustainability concerns in colored boxes, and interconnections among worries.

Although it is not the focus of the thesis to investigate sustainability concerns, it is worth highlighting the relevance of representing dimensions for sustainability (i.e., social, technical, environmental, and economic). Lago (2019) identified three types of effects among software architecture entities and concerns regarding measures, predictions, and outcomes: positive, negative, and undecided. Decision maps "*are also meant to be used and re-used across various projects. As such, incremental learning will allow effects to evolve and consolidate over time*".

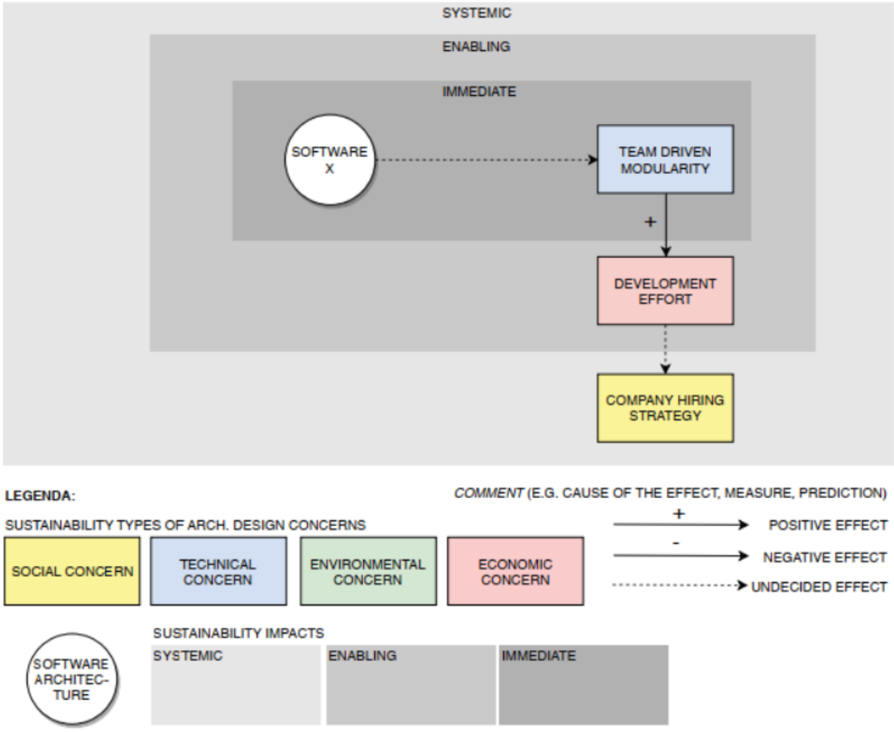

Figure 16 - Decision Maps notation. Source (Lago, 2019).

Figure 16 shows that team-driven modularity expresses a technical concern, development effort translates into economic impacts, and company hiring strategy reflects the organizational social structure and is a social concern. Concerning time effects, it presents immediate impacts, enabling impacts, systemic impacts. Immediate impacts refer to immediately observable changes. Enabling impacts arise from use over time; it includes the opportunity to consume more (or less) resources. Finally, systemic impacts refer to persistent changes visible at the macro level.

To cope with the thesis research, decisions maps were an inspiration as an initial tool for investigating connections among IS and their interconnections for SoIS. However, the research differs from Lago (2019), which focuses on constituent IS, once we are interested in accountability evaluation. For example, how IS use is affected by activities (and affect them) considering accountability suggestions. Additionally, we are exploring decision maps with causal loops to represent relationships among elements, as will be present in the following chapters.

2.4 Final Remarks

In this chapter, we first introduced accountability and presented the various concepts varying by domain. Particularly accountability characteristics in the context of IS/SoIS for evaluating the impact on business processes. Such investigation necessitates considering responsibilities within context rather than merely integrating people-process-technology them together. Besides, recommending accountability also assists in achieving successful SoIS.

Then a retrospect about context was presented. We explored definitions of context and emphasized two basic elements in constructing an accountability premise: evaluation and conceptual models. This poses challenges in defining the context of accountability and building insights. After comparing these findings, we notice the advantages of developing a systematic mapping study focusing on accountability in IS domain.

Afterward, two notions, SoIS, and tools for modeling complex systems were investigated and compared. Concerning SoIS, this chapter presents SoIS concepts, a conceptual SoIS model, and a tool-supported method for SoIS context. In addition, Section 2.3 presents an overview of core concepts focusing on ST, CLD with an example, and Decision Maps for representing a quality concern to make sense of these subjects and provide directions for thesis research. For a proper SoIS understanding based on the accountability lens, establishing an ST approach in SoIS arrangement is suitable for mapping responsibility among constituent IS and its demands. Finally, in the next chapter, we introduce two exploratory studies addressing the ST approach to generate relevant SoIS understanding.

Chapter 3 - Exploratory Study in Educational SoIS

This chapter presents two exploratory studies to identify SoIS features to help reach the objectives proposed in Chapter 1. It reflects the sixth to seventh and ninth to tenth methodology phases. Studies were published in workshops and conferences. Lessons learned are explored to find features that benefit this research by exploring SoIS scenario modeling strategies. The first study addresses Systems Thinking (ST) and causal loop in an organization supported by a SoIS. The second describes a modeling diagram for representing SoIS scenarios.

This chapter is organized into sections as follows: introduction, the first exploratory study, the second exploratory study, threats to validity, and the final remarks.

3.1 Introduction

This chapter presents two studies for contributing to the thesis body of knowledge concerning accountability evaluation understanding by mapping responsibilities. Exploratory studies are intended to illuminate the initial understating of complex scenarios in a natural and realistic setting (Bélanger & Allport, 2008). Such studies can be used for theory development or for testing the impact of some factors on variables of interest.

In this context, the purpose of the exploratory study is to help shed some light on SoIS arrangement in organizational scenarios (Cordeiro & Santos, 2019b; Cordeiro *et al.*, 2020). This research focuses on twofold: (i) identify the constituent IS that support an organization, and (ii) identify factors that contribute to SoIS analysis. To assess the nature of constituent IS, the research uses ST to explore the relationships among the constituent's IS, people, and business activities concerning an educational organization.

To this end, discussing ST in the SoIS perspective requires a concrete system (such as a specific software system) or a particular complex system (Ottino, 2007; Graciano Neto *et al.*, 2021). Therefore, we defined as a complex system the systemic aspects of daily school routines from a Brazilian case: College of Application of the Superior Institute of Rio de Janeiro (CAp Iserj) (Cordeiro & Santos, 2019b), as an organizational scenario. It is a complex school environment formed by organizational units and individuals from the school community (educators, students, and families) with approximately 2,000 students (from 2 years old to adulthood). In this context, two exploratory studies were planned and executed considering the existence of a SoIS arrangement supporting the investigated organization concerning business processes in daily school routines.

Initially, the exploratory study focused on gathering information about SoIS scenario regarding daily school routines and two main problems: (i) absence of educators; and (ii) absence of students. As a result, three CLD were developed, and CLD feedback was organized through an accountability lens concerning to ST approach. A generic accountability architecture for SoIS is presented during this research as an adaptation from Saleh and Abel (2016). Such architecture aggregates services from several constituents IS combined with accountability. It has been experienced that ST is a relevant resource for obtaining data, which helped map SoIS characteristics.

Secondly, with the body of knowledge acquired from SMS and the experience from the first study, a new exploratory study is planned and executed. This second study introduced a diagram for SoIS to represent constituent IS, actors, and processes concerning the accountability evaluation approach. The diagram results from research in ST, notably causal loops and decision maps inspired by Lago (2019). The data gathering for the second exploratory study use data collected from the first exploratory study. In addition, the proposed diagram relies on individual diagnosing and organizational accountability for providing suggestions to improve SoIS analysis and expand critical thinking skills. Finally, this chapter is organized in sections detailing both exploratory studies regarding planning, execution, results, and discussion phases.

3.2 Exploring Systems Thinking in Educational SoIS

This first exploratory study analyzes the systemic aspects of an educational organization with a particular SoIS, mainly formed by several manuals IS from the CAp Iserj educational organization. CAp Iserj comprises four major organizational subunits: Preschool, Elementary School, Junior High School, and High School; and two minors: Youth and Adult Education School and Special Education School. Each subunit has its staff, regulation, IT infrastructure, and students. CAp is part of Iserj (Superior Institute of Education of Rio de Janeiro).

The organizational context considers that each teaching modality has its respective IS and specific operating conditions. Each organizational subunit has an IS arrangement for managing daily school life. For example, in High School, there is the IS for teacher attendance control, IS for classroom management, IS for educational support, among others. In common, there are communication processes between the IS, and despite the fact that each one has their responsibilities, there is a shared mission, i.e., to seek quality in teaching on a daily basis.

In this context, an educational organization, notably a school, can be seen as an example of a complex system since it is supported by a set of IS in their business process (Cordeiro & Santos, 2019b). As an example of educational environment and SoIS, Neves *et al.* (2020) discussed virtual learning environments (e.g., Moodle) and the management challenge for facing multiple tools, courses, and operations. Authors describe the SoIS missions, types of independent systems, architecture, and implementation of the architecture. In another example, Bertolino *et al.* (2020) presented an educational domain modeled as SoS accomplishing different missions. Figure 17 illustrates the educational structures as a system: (i) regulated by-laws, rules, policies, procedures, and their interactions in inputs, (ii) process, (iii) output that should consider evaluation strategies, and (iv) feedbacks (Cordeiro & Santos, 2019b).

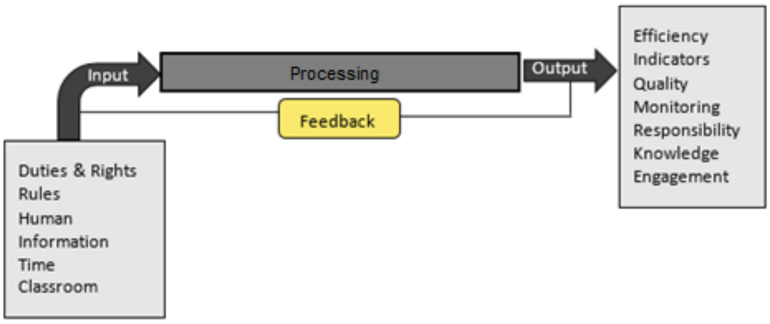

Figure 17 - Educational environment as a system.

3.2.1 Planning

The study follows a multi-method methodology that combines focus group/survey and action research. Belanger (2012) explained that multi-method in IS research tends to integrate findings from focus groups and survey or interview data to obtain a more global picture of the phenomenon of interest. Other examples of methods used combined with focus groups can be observations, logs, secondary data, and a specialist evaluation (Belanger, 2012). Additionally, the methodology includes Systemic Action Research (SAR), combined with Soft Systems methodology (Section 2.4.3) for diagnosing modeling strategies to allow a profound understanding of investigated scenarios. Bradbury (2015) defines Action Research as follows:

"*action research (AR) is a democratic and participative orientation to knowledge creation. It brings together action and reflection, theory, and practice, to pursue practical solutions to issues of pressing concern. Action research is a pragmatic co-creation of knowing with, not on, people*".

Amaral and Frazão (2016) argue that several researchers use action research to promote community-based learning by representing systems dynamics. In the context of this thesis, a system extends its understanding as a group of interconnected and interrelated components working together to achieve a purpose (Senge, 2006; Meadows, 2008) to IS, i.e., SoIS. Thus, inspired by Amaral and Frazão (2016), this planning focuses on understanding educational SoIS arrangement using ST to seek meanings in interrelationships between people-process-technology and challenges, such as accountability evaluation. Authors assert that

"*Looking at things systematically is useful because it helps us make connections that we would not otherwise make*"(Burns, 2007).

"*SAR merges systems thinking with action research. It is a participatory paradigm that seeks to create desirable change for the people involved while at the same time stimulating their learning*"(Vasstrøm *et al.*, 2008).

Therefore, the study uses SAR with two complete cycles (see Figure 18). A general SAR is cyclical with phases (planning, developing, observing, and systemic reflection) (Amaral & Frazão, 2016). Planning starts with diagnosing a situation, which leads to the definition of the intervention's goals. Developing executes the research. Observing collects results. After that, a reflection of the whole cycle is accomplished, as two systemic reflection graphs complete it. This work was published at *2019 IEEE/ACM 7th International Workshop on Software Engineering for Systems-of-Systems and 13th Workshop on Distributed Software Development, Software Ecosystems and Systems-of-Systems* (SESoS/WDES 2019), available in (Cordeiro & Santos, 2019b).

Figure 18 details the multi-method methodology phases (Cordeiro & Santos, 2019b), adapted from (Amaral & Frazão, 2016). First, regarding diagnosing, it evolves focus groups combined with a survey. Jarvenpaa and Lang (2005) define focus groups as a qualitative research method that uses the interaction among the participants to emerge shared reactions, issues, experiences, and opinions on the topic of the study. In particular, focus groups are helpful in evaluation research or in understanding how people regard a specific occasion or event (Krueger, 2014).

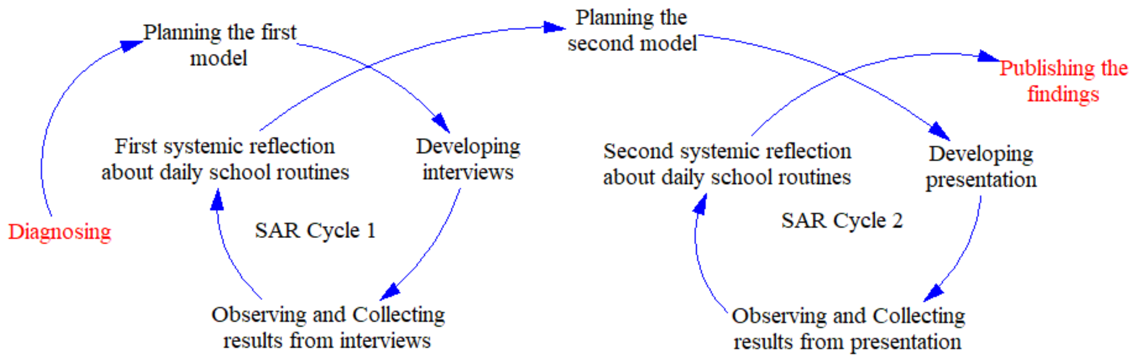

Figure 18 - Methodology phases.

Furthermore, the preparation for the investigation encompassed three distinct moments. First, a composition of focus groups with participants from the investigated scenario, selected by convenience, as the thesis author work at the educational organization. Once data gathering is complete, the first CLD is designed. Second, a programming meeting is planned with IS researchers in complex software engineering, who evaluate the first CLD. Third, after analyzing IS researcher's feedbacks, a second CLD is designed. Finally, the CAp principal evaluates a final version of the CLD. As instrumentation of the study, a questionnaire is planned in Portuguese, allowing the participants to provide information about themselves and the organization. Filling out the questionnaire, which is available in APPENDIX II organized with four forms, as follows:

- **Causal Loop Background**: before starting the study, participants should submit a short training on the causal loop and key concepts of accountability;
- **Informed Consent Form**: informs the study objective and participant's rights and responsibilities. It also reports that collected data should not be used to evaluate participants' performances and explains confidentiality terms;
- **Characterization Form**: allows the researcher to analyze participants' profiles; and
- **Execution Form**: presents the context of the work and the four open questions. In addition, the participants are asked to detail daily school routines in high school.

Two roles who conducted the study: moderator and collaborator. According to Kress and Shoffner (2007), the role of the moderator is to promote interaction, probe for details when necessary, and ensure that the discussion remains directed toward the topic of interest. The role of the collaborator is to record meeting minutes. The employee is an actor of the organization who is responsible for recording data in minutes. Next, GQM (Goal-Question-Metric) approach (Basili *et al.*, 1994) is suggested to guide the specification of ST analysis as SoIS measures in Table 3.

Table 3 - Study goal.

Analyze	a SoIS infrastructure at an educational organization considering accountability
With the purpose of	identifying interrelated SoIS parts
With respect to	exploring SoIS scenario understanding based on systems thinking
From the point of view of	organizational SoIS user
In the context of	organizations that operate with SoIS

The following questions organize the study:

Q01. Who are the stakeholders and their responsibilities? It aims to identify daily routines by mapping stakeholders, constituent IS, processes, and responsibilities to gather participants' backgrounds.

Q02 - How is the systems thinking in daily school routines? It aims to gather information on cases of daily school routines that affects the quality of education. It has been refined into the following sub-questions that help to explain the environment dynamics concerning stakeholders, daily routines, and quality of education:

- Tell us about your professional background and your experience in daily school routines;
- Tell us about school dynamics; and
- Tell us about what happens in the daily school routines that influence the quality of education.

3.2.2 Execution

The execution starts by defining the participants. At this time, a meeting was scheduled with Cap Iserj's principal to explain the exploratory study. With execution authorized, a second meeting was planned with professionals who directly work in daily school life. These professionals were organized into two focus groups: (i) Group 1 formed by 13 participants and (ii) Group 2 formed by 13 participants. Each focus group lasted for 1 hour, conducted in the local language. It is worth mentioning that participants represent educators from all disciplines and team managers, such as coordinators and principals. The session was registered in the records meeting by the collaborator. Concerning the execution, the research was explained to participants, and then participants were distributed into groups. It is worth mentioning that the focus group strategy is based on the soft system’s methodology (see Section 2.3.2) for highlighting how the professionals have seen individual behaviors and the impact on quality education.

Initially, participants identified several issues in daily routines, such as lagged salaries, disinterested students, lack of teaching materials, cleanliness of classrooms, lack of adequate refrigeration in classrooms. After iterations of regrouping data, participants mentioned three main problems concerning daily school routines: (i) absence of educators, (ii) absence of students, and (iii) absence of classes motivated by the school.

Finally, based on the definition of the main problems, the moderator asked about the relationship between IS area (people-process-technology) that influences school routines to be detailed. Participants described that the IS are manual and that there is no transparency about the daily records. In addition, participants mentioned that the absence of educators provides a symptom of classes being dismissed, as the classes are released earlier than predicted. Once the focus groups study is completed and record meetings analyzed, the data were organized so that participants' responses were grouped by questions, reviewed, and organized into subjects related to the questions. With this feedback, the CLD 1 was built.

The second part of reflection emerged from meeting with IS researchers, namely complex software engineering researchers, who investigate complex systems at UNIRIO. The researchers (12) were selected for convenience, and the analyses took place collectively, based on the presentation of the diagrams. At this point, a presentation with CLD1 was conducted, and the IS researchers provided feedback for evaluating CLD 1. During the execution, new feedbacks were incorporated, and the CLD 2 was built. Finally, a final meeting was scheduled with the CAp Iserj principal, who evaluated the final CLD version.

3.2.3 Results and Discussion

This section summarizes key findings from the methodology. First, focus groups provided rich information about why things happen and how they should occur. For instance, a common theme in-group members mentioned is that an institution such ours should receive investments and offer better conditions to students and professors. This information might help inform school counselors about topics that should be addressed with the school community as part of managerial decisions.

3.2.3.1 Demographics

Demographics present data collected from a survey regarding participants' professional backgrounds. Results focus on characterizing form as a strategy for collecting data from the user's profile. It considers basic questions and knowledge about the study topics (i.e., SoIS scenario understanding). Figure 19 shows distributions of participants by their functions, e.g., course coordination, supervision. It describes teachers with almost 50% and other professionals working at a managerial level, e.g., course coordinators, principals, supervisors, shift teams. Another exciting aspect was understating accountability, IS, and complex IS through participants' lens.

Figure 19 - Distribution of participants by activity.

In addition, Table 4 shows the participant background: (1) Strongly uncomfortable; (2) Uncomfortable; (3) Neither uncomfortable nor comfortable; (4) Comfortable; and (5) Strongly comfortable. Moreover, it shows that accountability is not a subject for educators. In contrast, it is focused on the managerial level, i.e., coordinators, supervisors, principal, inspectors. Additionally, complex IS is an unknown subject for most participants, with only two participants knowing the subject (i.e., IT knowledge).

Table 4 - Participants subject background.

Professional Activity	**Knowledge about accountability**					**Knowledge about Information Systems**					**Knowledge about complex Information Systems**				
	1	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Coordination	1	-	3	1	-	-	2	-	1	2	3	-	-	1	1
Principal	-	-	1	-	-	-	-	-	1	-	1	-	-	-	-
Shift Coordination	3	-	-	-	-	3	-	-	-	-	3	-	-	-	-
Shift Inspection	2	-	-	-	-	-	-	2	-	-	2	-	-	-	-
Supervision	-	-	3	-	-	-	-	3	-	-	2	1	-	-	-
Teacher	12	-	-	-	-	-	-	6	6	-	12	-	-	-	-

These results are an exciting starting point for research since it is a universe of participants unaware of the interdependence of the IS area and influences of accountability in the educational organization routines. Thus, the following section addresses the daily school routines, representing participants' feedback regarding problems and potential insights for improving problem-solving concerning to ST approach.

3.2.3.2 Who are the stakeholders and their responsibilities?

To answer Q01, the responses from participants detailed eight organizational actors in school routines (Cordeiro & Santos, 2019b). Table 5 describes these actors, their definitions, and the total of members in each organizational actor. According to participants, each IS has its routine and procedures, and only the academic department has an automatized IS. Additionally, participants highlighted the IS use, their dynamics, and IS impacts in daily routines on the quality of education. Figure 20 briefly describes a conceptual model of SoIS, their goals, and their associations, i.e., Shift Coordination (SC IS), Educational Guidance (EG IS), Pedagogical Guidance (PG IS), Coordination (Coord IS), Principal (SP IS), and Frequency Management (FM IS).

Table 5 - High school actors and responsibilities.

Actor	Definition	Total
Principal	User supervises the integration of subunits and their demands.	1
Student	Who learns and informs daily attendance to educators.	1200
Educator	Who teaches and reports the student's daily attendance. In addition, educators inform the Educational Guidance of the recurrent cases of student absence and indiscipline.	
Educational Guidance	Team of users who assist students involved in student affairs.	4
Pedagogical Guidance	The team of users Who assists educators. They are involved in educator affairs. Pedagogical Guidance reports students and the responsibilities of educators.	6
Shift Coordination	Team of users who organize the school space, organize class entry and exit times, and report the Educator's daily attendance.	3
Coordination	Group of users who coordinate an organizational subunit, reporting monthly attendance of educators to principal and coordinating interaction between all community individuals and other IS.	2
Responsible	Often a student relative, such as mother, father etc.	>2000

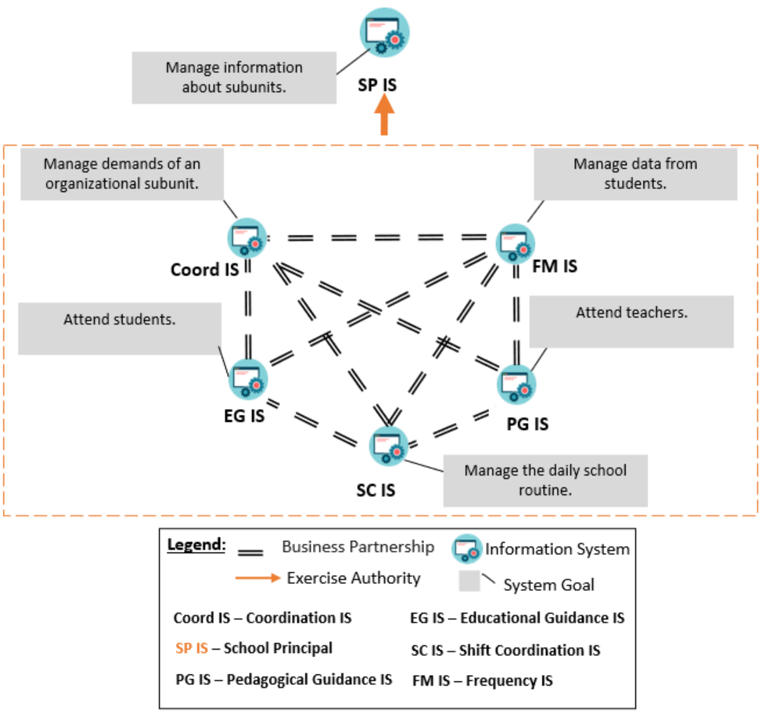

Figure 20 - Interoperability links in educational SoIS.

In addition, it focused on highlighting how SoIS users have seen individual behaviors and the impact on quality education. The information collected also helped to identify SoIS scenario. Furthermore, both groups mentioned external problems that affect routines, such as lagged salaries, disinterested students, lack of teaching materials, cleanliness of classrooms, and adequate refrigeration.

Additionally, Group 1 argued that the most significant problems faced by daily routines emerged from students, educators, and in some scenarios, resulting from dismissed classes, which is a consequence of some organizational issues (strike, lack of water, external event). At this point, both groups agreed that the main issues were related to different absences and their influences on school routines: (i) educators, (ii) students, and (iii) absence of classes motivated by the school. In common, these problems highlighted challenges to improving accountability, ranging from lack of engagement of educators and students to lack of transparency regarding the registration of frequencies.

3.2.3.3 How is the systems thinking in daily school routines?

CLD and descriptions presented on the following topics refer to answers for Q02 (Cordeiro & Santos, 2019b). It describes participant' feedback (i.e., P01 defines Participant 01) and systemic relationships among elements. Diagrams reflect the daily school routines on an ST approach and describe the instances and the impacts of the absence of educators and students in the school environment, namely consequence of absence of educators and consequence of absence of students. In both problems, ST variables and associations are related to school daily processes concerning class flow management and considering participants' feedbacks. Checking feedback is a fundamental concept in ST, as it is a mechanism to comprehend the cause of systems failure (Meadows, 2008).

A. Consequence of absence of educators

One of the problems that influenced school dynamics and, consequently, constituent IS's dynamics was the absence of educators in the daily schools. It increases the workload of the SC IS, which must communicate the lack of the educators in their absent daily list to coordination, which impacts the release of classes before the regular period. Participants from both groups related cases of educators missing class for different reasons (i.e., health problems, unjustified absences, and other commitments that conflict with work). P01 states that "*educators missing jobs without communicating with us generate chaos, since we have to organize the flow of at least three classes, which represent almost 100 students*". Other participant's comments are summarized next:

> "*we have several cases of educators who miss jobs, and it impacts on quality of classes*" (P05);

“*we understand that night classes have been released earlier since they are tiring from work; however, we should be able to evaluate how to mitigate classes dismissed earlier and potential effects on education*” (P07)*;* and

“*almost all educators adhere to strikes, and in these cases, many classes do not even show up at school, and the few educators who do not adhere to practically cannot teach, due to lack of quorum*” (P05).

As a result, participants agree that the quality of teaching is affected by recurrent cases of absence. Additionally, P15 states “*it doesn't happen in private school*”, which was rebutted by another participant who cited, “*but there they have better conditions; besides, if you miss in private, you are sent away*”. On the other hand, P15 mentioned that “*not everyone who is missing has their absences recorded*”*,* at this point, the researcher asked for more details.

Then P08, P09, and P15 explained that all registration of fault occurrences is a manual process, and there is discretion about the roles, which leads to a problem where some educators are protected, and others are not. For those who are informed, there is financial loss; for others, there is no. Other participant’s comments are summarized, as follows:

“*this protection affects everybody*” (P15);

“*the school must have a system to demonstrate daily school routines for parents*” (P09); and

“*there are professionals that do not know school norms*” (P02); and “*What are the incentives?*” (P01).

Furthermore, participants explained the information flow when an educator misses a job among constituent IS: (i) SC IS registering educator presence and communicates to Coord IS; and (ii) SC IS organizing the daily school flow and if a class must be released earlier. In contrast, in cases without some component (i.e., lack of chemistry classes), students start to call shift coordination for earlier classes to dismiss. When these cases are not resolved, those responsible begin to question why the situation remains unresolved. As P04 states:

“*classes without activities start with everyone satisfied, educators advance classes and leave earlier, students leave earlier, but there comes a time when students start to realize how much they are missing, so parents demand measures*” (P04).

In specific cases, the classes tend to accept the loss of classes, motivated by the lack of a teacher. However, when there are recurrences, there is a movement to face the problem. Such an example represents the following flow detailed by SC staff: (i) SC IS communicating those classrooms that are systematically complaining about missing classes to the EG team; (ii) EG IS schedules meetings with Coord IS, as a strategy to obtain answers to be informed to students and responsible; and (iii) Coord IS schedule a meeting with the principal as a strategy to finding a solution. At this point, P04 noted that "*finding a solution is complex because when a class starts with an incomplete component, the individual grids are already ready*". Usually, it happens as a consequence of a tenured educator or because the educator is acting as a discipline coordinator.

Once the resulting phase is completed, feedback reveals information sources for developing the Absence of Educators CLD in Figure 21. It represents the understanding of interrelationships between process activities focusing on the educator's absence. The analysis helps demonstrate the markings' absence cycle; as a result, a problem considering that the absent variable list is affected by a variable friendship among professionals. The MA cycle affects the activity markings educator's absence by the CS IS, then affects a school's performance,

On the other hand, since the reports are manual, it is up to the SC IS to assess whether to communicate the educators' absences because, according to the educators' justifications or the degree of friendship between them, this communication may not occur. It explains how educators are encouraged to miss work (decreasing the number of classes, impacting the quality of teaching, and decreasing school performance) because the system caused by flexible rules protects them. The stress cycle describes pressures on SC team and the need for demanding solutions, as some teachers are registered and others are not. In such a scenario the principal acts by demanding more daily control.

Additionally, answers suggested another problem is space management (SM), which is the SM cycle encompassing that class released earlier generates authorizations, impacts performance, and the organizational quality of education rates in the future. Consequently, students end their course without achieving the knowledge predicted to, then impacts the opportunities cycle for students.

However, as demonstrated in the stress cycle, the system tends to balance when complaints and pressure from the school community (students, family, ES or PS, other educators). This cycle describes situations, such as (i) coordination interacting with SC

IS and requiring more efficiency on daily reports registers, which impacts demands for a solution. Usually, it produces positive impacts since the educator tends to miss work less: the environment rebalances itself.

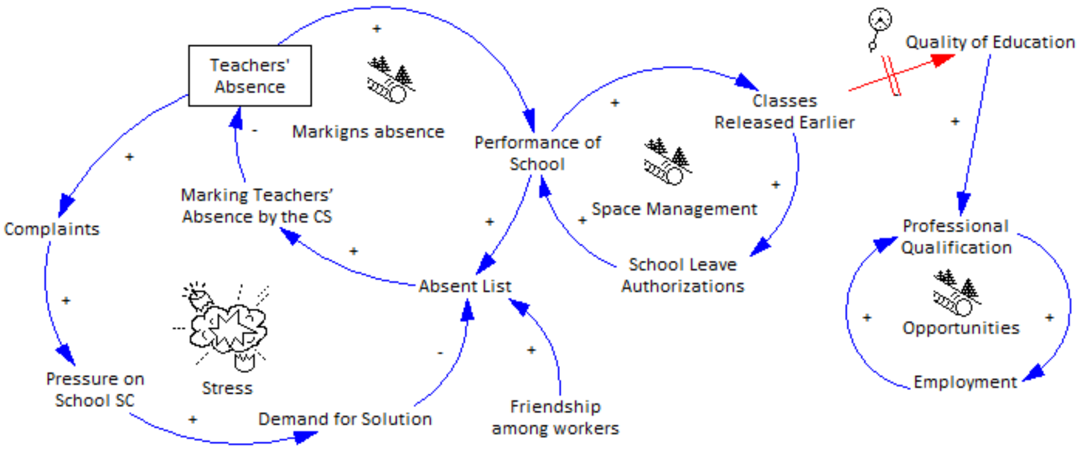

Figure 21 - CLD for the absence of educators.

B. Consequence of absence of students

Concerning participants, students' absence directly influences their achievements and approvals in the disciplines, which affects student motivation. This discouragement is also reinforced by classes without educators, impacting the daily control of school attendance (fewer reports). Other participant's comments are summarized as follows:

"*as educators, we must persist in mitigating evasion rates*" (P07); and

"*empty schools are imminent risks for education professionals*" (P05).

In this context, a course coordinator argued that an efficient, accountable system would have educators reporting students' absences to educational guidance. P04 states that "*it is up to education guidance in the goal of intervening and identifying reasons for the student absence and seek the best conditions for keeping students at school*".

However, the study suggested that not all educators comply with this routine focused on informing EG. P01 states "*we have different types of professionals and different types of engagement*". Therefore, all participants agreed that EG IS only addresses infrequency when engaged educators report absences of students as a standard responsibility. In this scenario, the student's absence control evaluation occurs in three semesters throughout the year, so the absence of systematic control entails two risks: school failure and increased school dropout. P09 states "*I believe that waiting a semester is not the best strategy; we should have better mechanisms for supporting students*".

Another analysis evolved the risk of school dropout, which is a factor that motivates the school community to seek a mechanism for intervention because by reducing the number of students in the classroom, there is concern about class optimization. P09 states "*optimized classes reflect in a fuller classroom, busier educators, and also generate a loss of job vacancies, motivate the joining of classes*".

Figure 22 shows the CLD designed for the Absence of Students. It shows the risk cycle details positive loop addressing school evasion, students 'absence, and class optimization. In addition, this cycle shows the general fear among educators considering replacements of educators. Another problem that stimulates the absence rate is the Discouraged cycle, a positive cycle of missed content and discouraged students. In addition, it describes the feedback cycle as a negative cycle for addressing strategies, namely, educators acting to stimulate an educator's presence, with roll call related to activities. The feedback cycle fulfills the function of rebalancing the system, motivated by the reports from the school community looking for managing mechanisms.

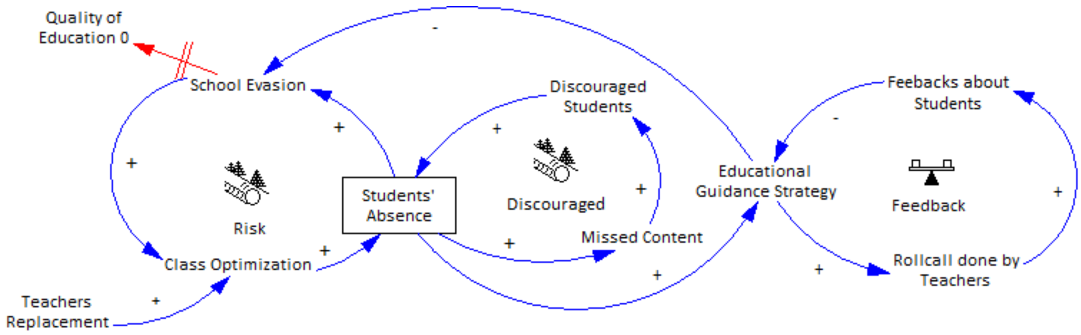

Figure 22 - CLD for the absence of students.

3.2.4 Towards Accountability Evaluation in SoIS

The main findings address unwanted symptoms such as school evasion rate, low academic results, discouragement (in the case of students), complaints, recurrent absences, selective protection (in educators). Analysis suggests that the decision-making process is susceptible to interpretations, which creates an environment of privilege for some and a sense of persecution for others. Several professionals mentioned the lack of accountability, which indicates that it is necessary to rethink business processes, as follows:

> "*the school must invest in the sense of responsibility*" (P07);
>
> "*Unfortunately our systems are manual, and we face human errors*" (P14);
>
> "accountability can demonstrate transparency and effects on educational rates" (P17); and

"*engagement is a power that should be considered; thus, the school must invest in this type of strategy for increasing participation of students and educators*" (P18).

Thus, Figure 23 presents a smaller version from CLD Absence of Educators, adapted to accountable feedback from systemic reflections. The accountability mechanisms emerged as SoIS characteristics that need to be improved. This approach describes participant's suggestions: (i) improve managerial mechanisms and inform user starts, as part of management strategy; (ii) stimulate engagement, as part of engagement strategy; and (iii) awards policies, as part of new norms for management results, as part of a regulation strategy. Thus, concerning CLD results, the exploratory study experience served to understand systemic aspects of an educational organization with a particular and complex structure, mainly formed by several manuals IS. In addition, it highlights the importance of supporting the evaluation of the business process as a strategy to improve organizational accountability.

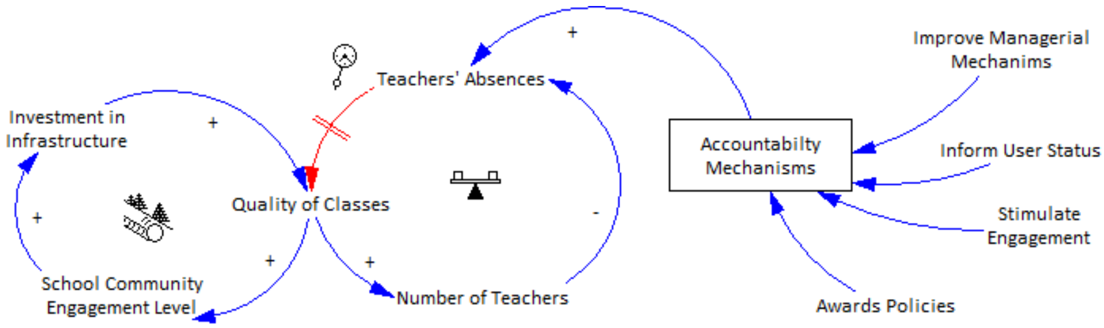

Figure 23 - CLD for the absence of educators considering accountability feedbacks.

Concern to the proposed diagram, the final CLD version was evaluated by the CAp Iserj principal. It motivates some accountability suggestions identified to be addressed by IT and pedagogical teams. Therefore, the study focused on adapting a SoIS architecture from Saleh and Abel (2016) towards an accountability evaluation approach. Figure 24 demonstrates a SoIS connecting several IS (e.g., A IS, B IS). Each constituent IS has its services, databases, and works separately. To this end, we proposed a SoIS architecture combined with accountability evaluation (Cordeiro & Santos, 2019b). Such an approach aims to explore the three concepts that we assume relevant to accountability evaluation in the context of SoIS: engagement, management, and regulation. As an example, Figure 24 carries a set of services related to each dimension.

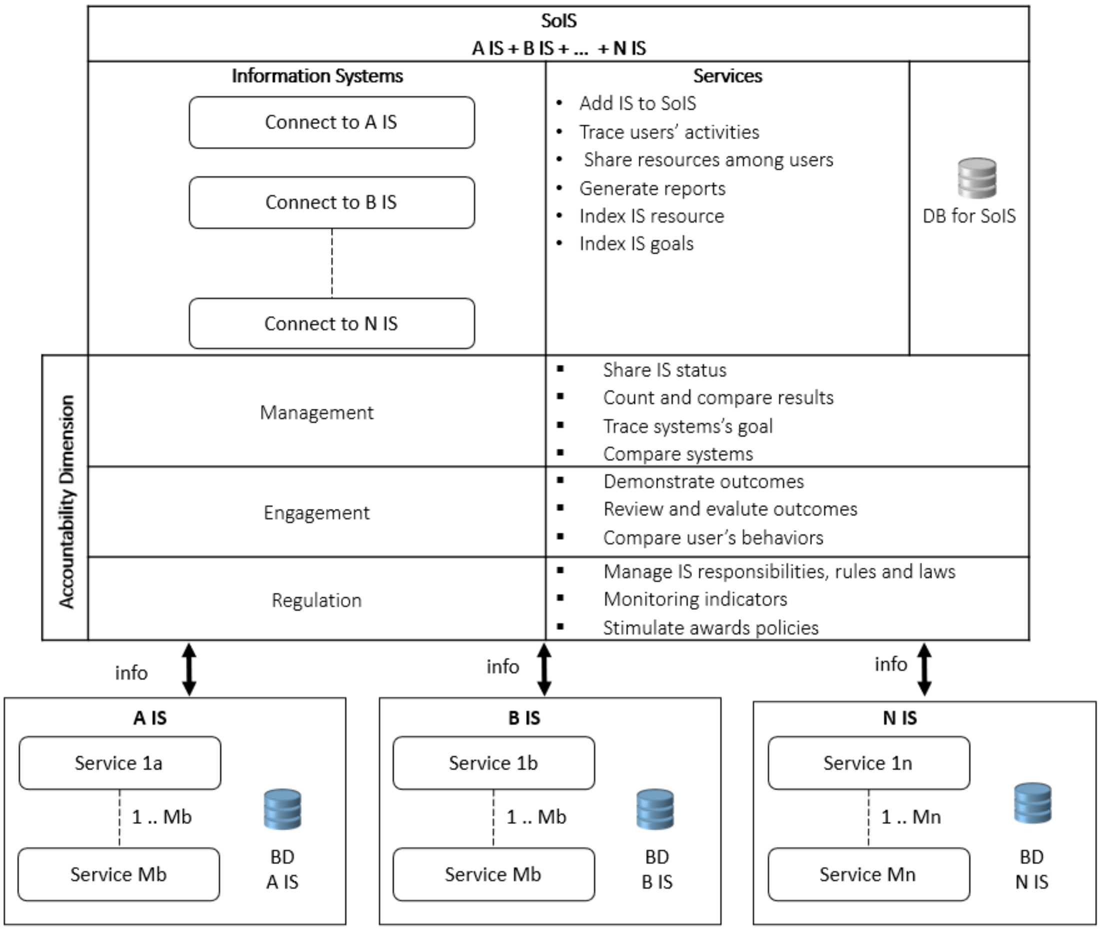

Figure 24 - SoIS architecture combined with accountability dimension.

Management addresses the needs of sharing the status of the constituent information system, calculation, and comparison results, tracking system goals, and comparing systems. For example, changes in share IS status requires more integration between different IS, e.g., EG IS must be a more integrated FM IS. Instead of waiting for individual educators to report, it should receive automatic data from the education secretary.

Engagement focuses on demonstrating outcomes, review, and evaluating outcomes, compare users' behaviors. For example, display outcomes demands focusing on transparency, e.g., each constituent IS must focus on feedbacks mechanisms aiming to encourage participation in the educational community.

Regulation details managing IS responsibilities, rules, and laws, monitoring indicators, and stimulating awards policies. For example, new regulatory strategies are incorporated to support educators and students, e.g., improve the monitoring indicators with online resources since all the institutional records depend on paper (management and rules).

In addition, the study promoted a better understanding of SoIS related constituent IS dynamics by comprehending demands and solutions through ST approach. First, modeling ST worked as a resource to evidence the big picture associated with the SoIS scenario. Second, it was a way to understand how the different components interact, helping to indicate problems and solutions by studying the relations between IS. Third, the generated CLD allowed the participants to discuss and share insights to maintain continuous improvement regarding the need to look to the future and invest in computational IS.

It is worth mentioning that ST takes time (Shaked & Schechter, 2017), as it demands understanding complex scenarios. However, in the long term, someone saves time compared to treating each problem as an isolated issue. CLD evidenced an opportunity to insert accountability resources to help the educational processes, acting mainly in the changes of SoIS behaviors, privileging equality of conditions, unifying the means of communication and control. The impact of accountability on this SoIS is not trivial precisely because of the complexity, cultural aspects, and quantity of actors involved.

Finally, the principal feedbacks confirm that developing SoIS architecture involves attention beyond the technical issues. In this sense, ST can assist SoIS architecture, moving from a technically centered perspective to a socially responsible system design, as mentioned, as one IS challenge in the Grand Research Challenges in Information Systems in Brazil 2016-2026 (Araujo 2016; Graciano Neto *et al.*, 2016).

3.2.5 Implications

Reflecting on the experience, we consider that ST allowed revealing the systemic aspects in the educational SoIS. Moreover, the mapping achieved its goals of providing high-quality information, fostering the development of future research. It seems to us that it brought highlights to indicate ways to develop accountability for SoIS. Additionally, this exploratory study brings to the surface SoIS that are not software-intensive but have their business process, actors, and conditions analyzed. Furthermore, it helped to comprehend the ST modeling process and demonstrated that accountability measures could promote process changes related to people-process technology activities. Finally, the study points to the need for causal loop representation adapted to constituent IS and effects through time. In this context, the following section addresses a second exploratory study based on data collected with this first study, which adopts an approach for accountability evaluation for SoIS scenarios.

3.3 Exploratory Study in an Educational Systems-of-Information Systems.

As discussed, perceiving and analyzing relationships among SoIS and different actors can be challenging to decision-making in SoIS scenario understanding. The first exploratory study demonstrated that ST can be used for SoIS modeling. However, especially in SoIS with accountability, some requirements are needed beyond ST tools. Therefore, this section proposes the Accountability Suggestion Map (ASM) (Cordeiro *et al.*, 2020) to cover users' feedback, aiming to promote accountability in SoIS understanding. Such an approach incorporated ST causal loops tools (Amaral & Frazão, 2016) and a template (Lago, 2019) as an initial layout.

Thus, this section (i) presents ASM as a layout for representing systemic behaviors over time combined with an accountability evaluation approach that consider causal loops and ST analysis as a resource for modeling SoIS scenario, and (ii) reports the application of ASM in an organizational scenario in the education domain. Therefore, two diagrams are planned and developed to address daily issues regarding the absence of educators and school evasion rates.

3.3.1 Planning

In the previous exploratory study, the research focuses on investigating causal loops in SoIS context. However, it is worth mentioning that modeling and simulation for SoIS lack analysis for formal modeling and verification techniques to deal with complexity, mainly those related to business processes (Graciano Neto *et al.*, 2021). In this context, the ASM study extends the previous modeling approach by proposing a diagram for investigating systemic dynamics, considering business process and SoIS, as shown in Figure 25.

ASM is a proposed layout for representing SoIS behaviors and suggestions to support SoIS evaluation; notably constituent IS, process, and people feedbacks (Cordeiro *et al.*, 2020). ASM solution differs from Lago (2019) once the approach stimulates individual and organizational accountability (Cordeiro *et al.*, 2020) for supporting SoIS scenario understanding. Furthermore, ASM relies on how accountability suggestions combined with causal loops can express suggestions to IS practitioners and researchers to support decision-making driven to SoIS understanding and improvements. For example, an accountability suggestion can address several SoIS management insights: (i) stimulating user participation; (ii) re-defining regulations that are not working; (iii) upgrading software; and (iv) defining a business strategy.

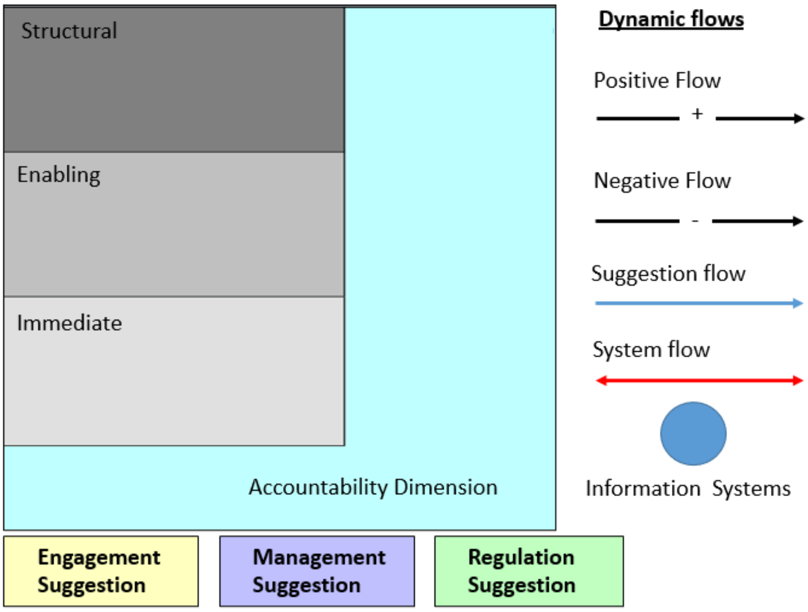

Figure 25 - ASM layout.

Additionally, the ASM solution relies on diagnosing individual and organizational accountability for providing suggestions to expand critical thinking skills for supporting SoIS modeling. Individual accountability refers to perceptions of someone's accountability, while organizational accountability refers to the perception of organizational units' accountability (Frink *et al.*, 2018). We argue that the lack of accountability may lead individuals, groups, and organizations to act without consequences imposed by others. Moreover, Hall *et al.* (2017) define that the lack of accountability implies that "*to coordinate activities would be difficult, and organizations would find it challenging to operate efficiently*". Therefore, ASM layout (see Figure 25) aims to represent modeling information from SoIS scenarios regarding accountability suggestions for supporting SoIS modeling, based on the following layouts:

- **Time impacts** refer to environmental changes that are observable over time, which affects the creation of products, services, and user decision-making (i.e., immediate, enabling, and structural in different shades of gray), as shown in Table 6;

Table 6 - Time impacts.

Time Impacts	Description
Immediate impacts	It refers to some activities close to, or a cause of, or even an effect of something. These impacts are felt without any delay and include self-reacted behaviors (Lago, 2019).
Enabling impacts	It arises from the use over time. It represents the impacts that different types of monitoring must report on demand when activities are coordinated. Such impacts are felt by the dependency of events/behaviors (Lago, 2019).
Structural impacts	It refers to some facts in an extended period and summarizes systemic actions that had grown in an environment. Usually, structural impacts are not open to changes (Lago, 2019).

- **Accountability dimension** demonstrates a way for characterizing accountable behaviors from stakeholders in an organization, given accountability criteria: engagement suggestion, management suggestion, and regulation suggestion, i.e., light blue area that has colored boxes of concerns, as shown in Table 7; and

Table 7 - Accountability dimension.

Criteria	Description
Engagement Suggestion	It involves participating in an activity, event, or situation and contributing to actions to achieve shared objectives (ISO/IEC 9000, 2015).
Management Suggestion	It involves the exercise of control and supervision within the authority and accountability established by governance. The term management is often used as a collective term for those responsible for controlling an organization or subunits (ISO/IEC 38500, 2015).
Regulation Suggestion	It involves meeting the organization's requirements to comply with (and enforce) legal and regulatory standards (e.g., policies, guidelines, laws, and rules). It aims to support regulation activities (either formal or informal) in systems' processes. It means addressing parameters for sanctions/obligations (ISO/IEC 9000, 2015).

- **Dynamic flows** organize the primary forms from the diagram. It encompasses accountability links among elements, which reflects responsibility among elements. It considers the behaviors in causal loop relationships, i.e., a positive or negative effect and the interoperability between systems (arrow links), as shown in Table 8.

Table 8 - Dynamic flows.

Primary Forms	Description
Positive flow	It signs that variables' changes occur in the same direction (sign +) (Cordeiro & Santos, 2019b).
Negative flow	It signs that variables' changes occur in the opposite direction (sign -) (Cordeiro & Santos, 2019b).
Suggestion flow	The blue arrows associate accountability with suggestions from managers, developers, and users to indicate accountability interventions.
System flow	The red arrows associate systems. The system icon is associated with a system goal.
System icon	It represents "IS" icon.

Furthermore, the accountability suggestions approach aims to perform accountability evaluation. The study goal is the stimulation of organizational interest and the demand for better products and services. It involves identifying issues regarding people-process-technology for supporting systemic understanding aiming to support organizational activities. This study reports an interview plan conducted with the organization leader that was chosen for convenience, as a respondent to frame ASM in a real scenario. Figure 26 summarizes the method, as adapted from Belanger (2012).

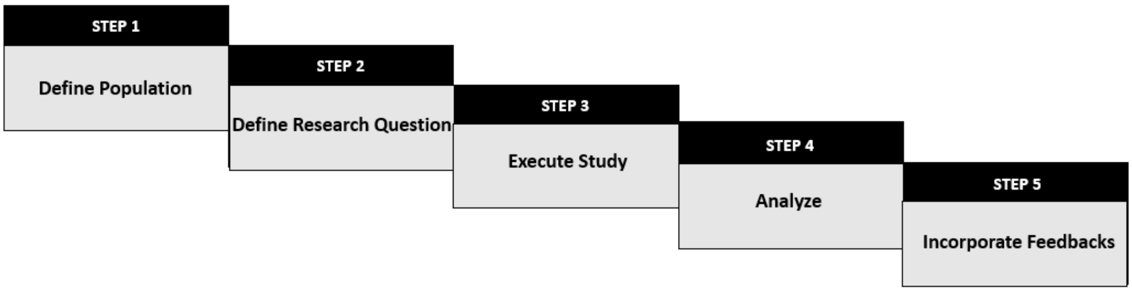

Figure 26 - Method.

Step 1 contains the problem or research question of interest definition. Step 2 involves selecting the appropriate population for the interview that is relevant to the research question. Step 3 consists of developing the discussion and selecting the complementary feedbacks about the SMS presentation. Step 4 involves analyzing feedbacks and allowing new insights to be incorporated into the ASM. Finally, step 5 includes improvements to the ASM notation. Additionally, the study goal is defined accordingly to the GQM paradigm (Basili *et al.*, 1994), as presented in Table 9.

Table 9 - Study goal.

Analyze	ASM diagram and its infrastructure at an educational organization
With the purpose of	characterizing
With respect to	usefulness
From the point of view from	organizational manager
In the context of	organizations that operate with SoIS

3.3.2 Execution

The following topics describe the execution steps.

- **STEP 1 - Define Population**: For this second exploratory study, the CAp principal was invited to participate as a result of a partnership developed during the previous research. It is worth mentioning that the principal is responsible for the institution's expenses and authorizes resources. Moreover, differences between the exploratory studies and the ASM's focus on individual diagnosis and organizational accountability for supporting SoIS;
- **STEP 2 - Define Research Question**: Participant defined two problems to be designed on ASM: (i) absence of educators and (ii) evasion rates. Asked about problems, the principal states "*the daily school is directly affected when educators miss work, and we worry about releasing classes, on the penalty of creating evasion*". Thus, three open-ended questions are provided:
    - **Q01. Do you think that the ASM helps characterize scenarios?**
    - **Q02. Do you think that the accountability suggestions strategy helps to support accountability evaluation?**
    - **Q03. Do you think that the ASM layout evolved from previous diagrams?**
- **STEP 3 - Execute Study**: It aims to capture data from daily school routines, the constituent's IS, their goals, and interoperability links grouped for modeling ASM. Figure 27 shows the interoperability between constituent IS for the investigated problem and constituent IS descriptions. It demonstrates that each IS has its concern (i.e., gray box), alternating between inputs and outputs. Furthermore, each IS is

related to others. For example, SP IS exercises authority over others (Coord, EG, and SC), while Coord IS interoperates with SC IS. The investigation was developed by the researcher for a week and evaluated by three researchers with experience in process modeling. Afterward, a meeting was scheduled with the participant where the two diagrams and research questions were presented. Thus, two scenarios were designed by the CAp Iserj principal to address daily school routines: (i) Problem #1: Absence of Educators; and (ii) Problem #2: Evasion Rates;

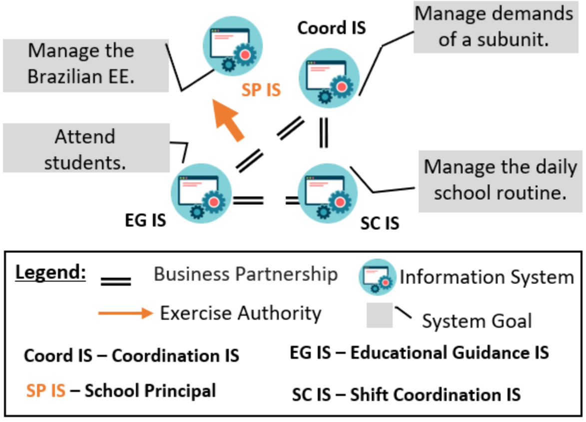

Figure 27 - Interoperability links in educational SoIS.

- **STEP 4 - Analyze:** After data gathering, ASM diagrams are created. It encompasses causal loop relationships and elements considering immediate, enabling, and structural effects over time. Furthermore, accountability suggestions represent feedbacks when evaluating the created diagrams. In the investigated scenario, accountability suggestions result from IS users' feedback, mainly from the CAp Iserj principal's first exploratory study (see Section 3.2). As a result, a scheduled meeting was planned and executed with the researcher and principal when diagrams were presented and the interview occurred. Answers were organized for evaluating the ASM solution; and
- **STEP 5 - Incorporate Feedbacks:** This final step analyzed the participant's feedbacks for improving ASM, such as: (i) incorporating organizational subunits and (ii) generating a textual report. The researcher organized a meeting with two modeling specialists aiming to discuss strategies for ASM layout.

3.3.3 Results and Discussion

This section describes ASM diagrams and discussions. The following diagrams are created: (i) Problem #1: Absence of Educators; and (ii) Problem #2: Evasion Rates.

3.3.3.1 Problem #1: Absence of Educators

Problem #1 was previously detailed in Section 3.2.3, so this section omits details about the problem but shows how the problem was incorporated into the ASM diagram. Figure 28 demonstrates the absence of educators through the lens of the shift coordinator, who must communicate the lack of educators in the absent daily list to Coord IS and must create a class release report. Concerning to IS users, the shift coordinator uses SC IS, and the high school coordinator uses SP IS. This scenario details, as follows:

SC IS must manage the daily school routine as an IS goal in the red arrow. It comprises the following cause and effects activities: (i) mark educator absence (a consequence activity from educator missing work); (ii) classes released earlier; (iii) students without classes (unwanted behavior in a school environment); and generates (iv) complaints from families; followed by (v) pressure on school principal.

SC IS interoperates with Coord IS, which has the report absence of educators as an IS goal. This goal represents the administrative fault of educators. SC ranges the following effect IS: Pressure on school principal. It shows new strategies: (i) engagement - encouraging immersive participation of educators by stimulating rewards, (ii) regulation - making new educational campaigns by defining performance campaigns, and (iii) management - replacing the manual systems with automated IS.

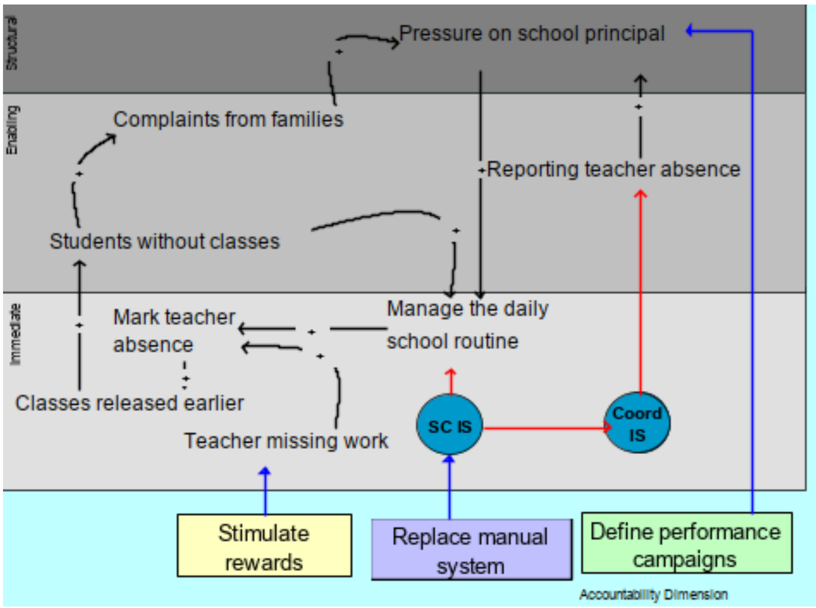

Figure 28 - ASM diagram for the absence of educators.

Lessons learned: after the causal loop analysis when evaluating the ASM diagram; three accountability suggestions were defined to the scenario:

- Regulation Suggestion - Define performance campaigns (i.e., generate a new strategy to motivate educators and their influence in the school community);
- Engagement Suggestion - Stimulate rewards (i.e., an engagement action taken by the school towards the successful cases); and
- Management Suggestion - Replace manual system (i.e., replacement of manual IS to computational IS).

3.2.3.2 Problem #2: Evasion Rates

The absence of students entails the risk of school evasion. Such risk affects the whole organization, decreasing the number of students in the classroom and requiring class optimization. Class optimization occurs when two classes are grouped to form a new class, and the previous are excluded, which directly impacts fewer educators working and empty classrooms. This problem reveals complex relationships precisely because they are unwanted symptoms for any school. Figure 29 shows Problem #2, demonstrating relationships among EG IS and SP IS.

EG IS has (i) compiled educational rate is an IS mission, which is part of the IS goal (i.e., attend students). It comprises the following cause and effects activities: (ii) students' absence (e.g., students missing classes); the absence situation affect (iii) School evasion (e.g., a student who abandoned the studies) and (iv) compile educational rate; (v) Class optimization (e.g., an enabling state that reduces school classrooms); (vi) students' absence (unwanted behavior related to students who abandoned studies); and generates (vii) pressure on school principal; which is followed by (viii) pedagogical reunion (e.g., staff meetings to investigate rate issues).

SP IS must (i) manage the subunits as a goal (i.e., it focuses on sustaining the whole high school environment); it interoperates with EG IS. SP IS is ranged by (ii) pressure on the school principal, which is followed by (iii) pedagogical reunion (i.e., investigation on rate issues). Thus, Figure 29 presents accountability suggestions indicating new processes (i) developing a new routine for the educational guidance team by improving EG IS aligned with responsible participation and technology (ii) exploring IT solutions to improving students' feedback, which may contribute to IS management.

Lessons learned: during the systemic reflection and evaluation of ASM diagrams, four accountability suggestions were defined to improve the organization:

- Regulation Suggestion - Define visiting protocol (i.e., an agenda for visiting students' homes and discuss on their absence) and Socialize reports (i.e., support a new culture linked with absence rate and issues);
- Engagement Suggestion - Stimulate individual conversation with responsible (i.e., increase individualized social service aiming to improve the sense of ownership); and
- Management Suggestion - Create a mobile communication system (i.e., use an IT platform to support communication, such as WhatsApp).

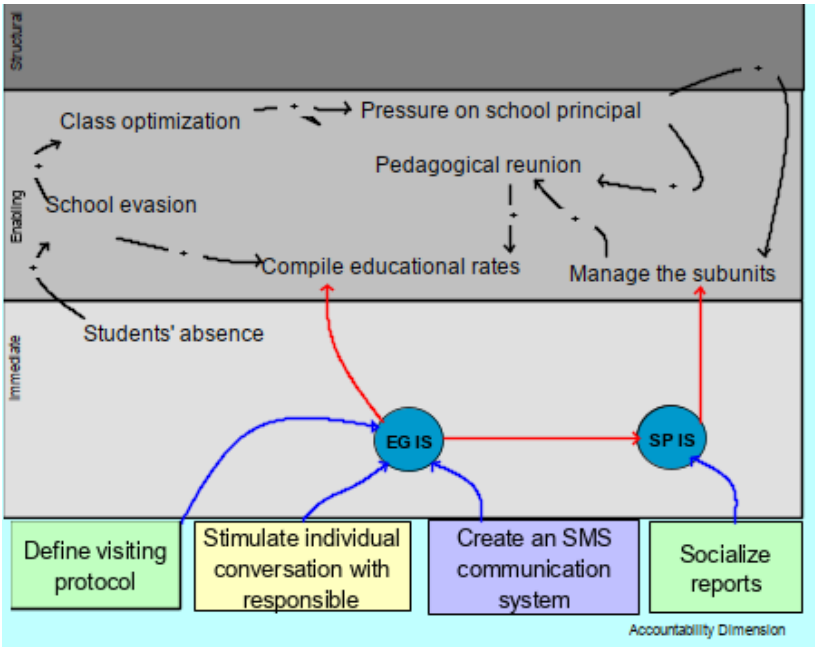

Figure 29 - ASM diagram for evasion rates.

3.2.3.3 Investigated Questions

Considering that the participant was involved in both exploratory studies, this section summarizes the comments that emerged in the study.

- **Q01 - Do you think that the ASM helps characterize scenarios?**

Overall, the participant mentioned that the new diagram has more elements than the previous diagrams. For this reason, it has become more evident that certain activities are more sensitive to managerial interventions. Participant states "*the elements have increased from the last time, and the diagram is more colorful*" and "*now I understand the layout of effects of time*". On the other hand, the participant criticized the quality of the layout.

Another positive point concern IS directly in modeling. The participant states "*I enjoyed seeing the IS represented; it is a good strategy for evaluating the infrastructure*".

At this point, the participant asked whether the systems communicate with each other or only in one direction, e.g., "*why does the arrow between SI only go in one direction?*". Another question involved the layout of the people who interact, e.g., "*couldn't the professionals be represented*?". These comments were helpful as they highlighted the need to include new elements and revise others.

As a result, the participant approved the diagram usability and signaled that it would be interesting to have a tool to automate ASM. At this point, the researcher informed that this is one of the next steps in the thesis research. The participant mentioned that the academic department had an IS operating, and we should contact them if we have an interest. As a result of this feedback, the secretary was reached, and he expressed interest in participating in future research.

- **Q02 - Do you think that the accountability suggestions strategy helps to support accountability evaluation?**

The participant was excited to realize that the manager has tools to assess engagement, management, and regulation. Participant comments are summarized as follows:

> "*we depend too much on the professionals' engagement, as we have cases that some professionals do the basics; that is, we have a good community in our school, but it could be much better if they participated more actively*"; and
>
> "*I believe that control mechanisms need to exist; otherwise, the manager cannot plan correctly, and this affects quality*".

Valuable feedback was on the effort the manager needs to put into finding solutions to everyday problems. The participant states:

> "*It's tiring to be always looking for solutions; I know we don't have a manual for the school environment, but it would be beneficial to have some solutions to help, that's because engaging is too difficult, sometimes we have rules and people just ignore it. Not to mention that I'm often the hangman because I need to charge; it's my job*".

At this point, research explained to the participant that part of the accountability evaluation study comes precisely from this analysis of what works (or not) and how this knowledge can be used for future decisions. I agree with the participant that the manager's life needs to be simplified, even more in public educational organizations that deal with enormous challenges related to their target audience. In addition, the participant reaffirmed that business processes are not automated and that it would be a big step to improve their integration through technology.

- **Q03 - Do you think that the ASM layout evolved from previous diagrams?**

About this question, the participant commented that the current study involves a diagram with greater explanatory power and that it provides opportunities for thinking about evaluation strategies. In addition, the participant states that "*just the fact of having a colored element calling attention to an activity is already attractive*". Furthermore, "*I believe that an automated version can contribute a lot, especially in brainstorm meetings*".

3.3.4 Implications

This exploratory study proposed, planned, and executed an accountability evaluation approach focusing on ST to improve decision-making in educational organizations. It presents the ASM for diagnosing investigated problems to enhance SoIS understanding and expand critical thinking skills. In addition, it demonstrated some initial indications of providing high-quality information to support SoIS modeling, based on its application in a real scenario in the education domain.

As a result, some improvements will be addressed in the ASM layout, including new elements and a better visual presentation. In addition, it considers an upgrade on accountability criteria, as it can be related to an accountability suggestions database to support SoIS managers in their decision-making process.

3.4 Threats to Validity

Some possible limitations of both exploratory studies conducted in this research consider best practice on focus group research, as proposed by Freeman (2006):

- **Group membership**: pre-existing groups should be avoided, given their potential for bias, and random sampling of participants is recommended. Participants were divided into two groups to mitigate this threat, which allowed exchanges between participants from different areas at the first exploratory study. For example, a group formed by coordinators, shift teams, and educators with diverse specialists. Another limitation relies on opinions that may reflect the national scenario of accountability for SoIS, as Brazilian researchers and practitioners answered it. To mitigate that, one international researcher evaluated the generated diagrams. In addition, the researcher's factor working in the organization can drive the process. To avoid this error, the investigation was conducted with participants who do not have a functional relationship with the researcher;

- **Homogeneity:** it concerns inferences drawn from sample to population segmentation to increase the likelihood of uncovering a pre-existing reality. As a strategy to share perceptions of the population, participants were invited to share issues about daily routines, addressing and selecting those more relevant. The selected participants represent several members from the school environment (such as Mathematics, Portuguese, Chemistry, coordinators). It is worth mentioning that the second exploratory is based on pre-existing data from the first study;
- **Heterogeneity**: it details that too much heterogeneity will inhibit discussion, especially regarding status distinctions between participants**.** Feedbacks were collected to reach a consensus among participants regarding problems that significantly impact routines to mitigate heterogeneity. Such an approach was verified in both studies;
- **Interaction:** it describes instruments for supporting data gathering. It included forms for collecting and collectively building a database. The forms were made available to both groups, and the answers were collected, based on the consensus of the participants; and
- **Generalizability** defines the extension of research findings and conclusions from a study conducted on a sample population to the population at large. Thus, it included the population (from the first study) and principal (from the second study). For example, the data collected from the first exploratory study was used as an input for the ASM layout analysis. Participants represent members of disciplines, for example, present from teachers of Mathematics, Portuguese, and Philosophy.

3.5 Final Remarks

Reflecting the whole exploratory experience, we consider that ST tools combined with quality studies, i.e., focus group, survey, and interview, are relevant for SoIS scenario understanding and indicate a way for sustaining accountability evaluation. Using causal loops as tools from ST allowed revealing systemic aspects of SoIS scenarios involving daily school routines as an initial attempt for SoIS modeling for its demands and solutions.

Initially, it enabled to bring to the surface the diagnosis from scenarios dynamics, making it easy to understand the complex relationships among people-process-technology and encourage feedback for sustain business processes. Additionally, it achieved the study goals of providing problem presentations, allowing participants to discuss the difficulties and suggestions for improvements. Furthermore, it evolves a previous SoIS architecture by including accountability as a resource to support SoIS scenario understanding. Finally, the second exploratory study incorporated findings from the previous one, as it proposes the ASM diagram for supporting SoIS modeling, which involved the participation of the high school manager.

The experience brought benefits to the accountability research, as it discusses the need for evaluation as a strategy for better SoIS management. Moreover, the layout proposal demonstrated benefits for mapping the relationships between business processes, people involvement, and constituent IS.

In the next chapter, we present an SMS that assists us in defining and implementing the accountability evaluation research in IS/SoIS domain. It includes analysis of IS arrangement as SoIS. Furthermore, it proposes some accountability criteria to support evaluation and accountability research challenges to IS/SoIS research.

Chapter 4 - Accountability in Information Systems

This chapter reports on an investigation of accountability in IS/SoIS from the state of art and points out research challenges, obtained from the eighth methodology phase. The research method comprises an SMS for selecting, classifying, and analyzing relevant publications. As a result, three accountability criteria are proposed to support evaluation: engagement (effects on people), management (acts on the process), and regulation (the process of regulating).

This chapter complements the theoretical thesis background, and it is organized as follows: planning, execution, results, and discussion covering accountability evaluation criteria, implications of the study, threats to validity, and the final remarks.

4.1 Planning

After an initial literature review presented in Chapter 2, an SMS was planned and conducted to investigate the thesis subject, with no time or area restriction, covering until mid-2020. In addition, it presents a list of IS research challenges as a result of three accountability evaluation criteria identified in SMS. Such an approach aims to propose and evaluate strategies to sustain accountability in IS domain, namely complex IS arrangements, such as SoIS.

As introduced in Chapter 2 and discussed in Chapter 3, accountability is challenging in several domains, IS domain included. Thus, this chapter presents an SMS for characterizing accountability state of the art and provides further investigation directions in IS domain. Furthermore, in order to manage the SMS, a protocol was defined to guide research objectives and explain how the literature review was performed (Figure 30).

The SMS protocol is an adapted version of Bandara *et al.* (2011) and Petersen *et al.* (2015). Bandara *et al.* (2011) proposed a method for conducting an IS tool-supported literature review. Thus, this protocol detail three tools for supporting SMS: a free collaborative reference database (Zotero[7] 5.0.74), a free qualitative data management tool

[7] Zotero - https://www.zotero.org/

(StArt tool[8] 2.3.4), and a free online tool for analyzing keywords frequency in documents (EvidenceSET[9]). Tools were chosen as researchers had access to software and prior experience using them in other studies. Besides, the process level described principles from Petersen *et al.* (2015) with five steps, as follows:

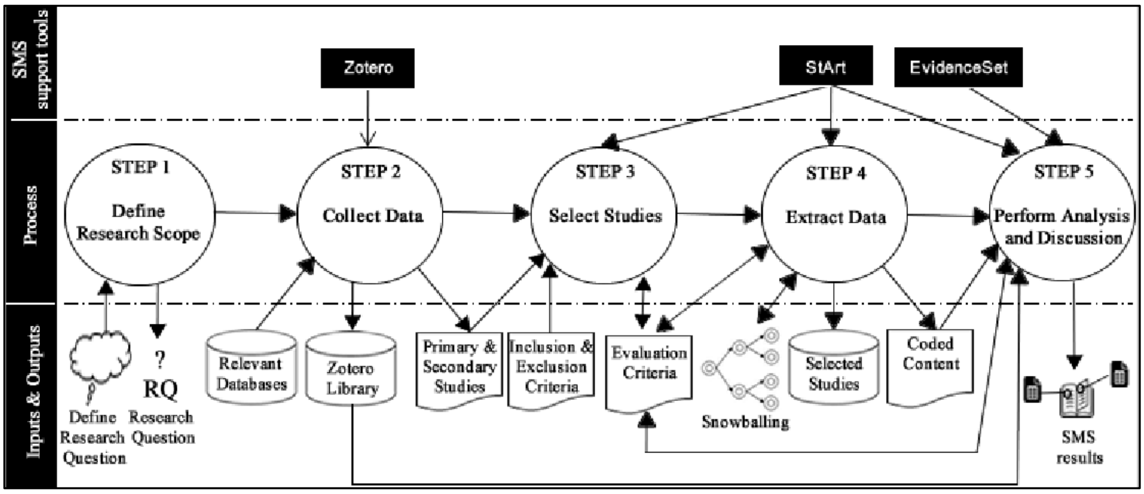

Figure 30 - Protocol adapted from Bandara *et al.* (2011) and Petersen *et al.* (2015).

- **STEP 1 - Define Research Scope**: for the sake of scope delimitation, the main question is "**Which topics related to accountability in information systems have been investigated, and to what extent?**". It has been refined into the following sub-questions for this phase (conceptualizing), referred to as Q*ii*:
    - **Q01: What does the scientific literature say about accountability in Information Systems?**
      Rationale: IS has supported parts of organizations, entire organizations, or groups of organizations. Thus, accountability tends to be different since it depends on organizational objectives and how it is supposed to be achieved. Q01 is on aspects of accountability developed over time (and still unclear) encompassing complex IS arrangements, such as SoIS.
    - **Q02: What are research challenges related to accountability in Information Systems?**
      Rationale: Q02 focused on establishing how far IS researchers have investigated accountability in IS domain. Moreover, it considers

[8] StArt tool - http://lapes.dc.ufscar.br/resources-and-downloads/tools

[9] EvidenceSET - http://evidenceset.com.br/html/site/

accountability elements for supporting IS operation and maintenance, aiming to put efforts into accountability evaluation and where the potential for further research challenges lies.

- **STEP 2 - Collect Data:** the search strategy used the Zotero tool as a repository to manage studies from the principal six databases sources with IS/SoIS publications (see Table 10), covering until mid-2020. To ensure that studies were not cut, two approaches were applied: (i) including synonyms "accountable" and "*responsibility*" to accountability, and (ii) to each digital library a publication topic was applied a filter (information system or computer science). The following search string was run in each digital library: ("accountability" OR "accountable" OR "responsibility") AND ("information systems"). At this point, as a result, the StArt tool (Fabbri *et al.*, 2016) excludes duplicated studies.

Table 10 - Database sources.

Source	Url	Source	Url
ACM	http://dl.acm.org	Science Direct	http://www.sciencedirect.com
Engineering Village	http://engineeringvillage.com	Scopus	http://www.scopus.com
IEEE Xplore	http://ieeexplore.ieee.org	Springer	http://link.springer.com

- **STEP 3 - Select Studies**: after step 2, StArt helps researchers execute a literature review protocol based on planning, execution, selection, extraction, and summarization. Initially, the list of retrieved was attached to StArt. At this step, it is applied SMS filters: "*1st filter: Reading titles, abstracts and keywords*" and "*2nd filter: Reading introduction and conclusion*".

Petersen (2015) claims that to reduce the threat, some actions must be taken to evaluate the final set of articles included, which was done by the author of this thesis (see further below). If a very large number of studies is obtained and many of them are clearly identifiable noise the process may be conducted individually. We assumed the need for full-text reading studies when in doubt. Table 11 presents the inclusion and exclusion criteria applied to titles and abstracts. It is worth mentioning that the query with IS brings results regarding SoIS. The selection of the studies was developed by one research.

- **STEP 4 - Extract Data**: it considers the "*3rd filter: Full reading of studies*". It applies quality criteria (QC) from Table 12 to evaluate whether a study is relevant for research. Concerning results and extracting additional information, the snowballing technique is applied. Snowballing is a strategy to add new studies based on retrieved results from references to identify other items and ensure broad coverage. During full-text reading, it became obvious that further studies should be removed as they were not in the scope based on the inclusion and exclusion criteria.

Table 11 - Inclusion criteria (IC) and exclusion criteria (EC).

Index	Criteria Definition
IC	1. The study is available for download. 2. The study reports accountability in the information system domain. 3. The study addresses the impacts of accountability on the information system domain. 4. The study describes accountability in other disciplines supported by information systems.
EC	1. The study does not mention information systems. 2. The study does not mention accountability. 3. The study is a book or chapter. 4. The study is not written in English.

Table 12 - Quality criteria.

Index	Question
QC1	Does the study provide a clear definition of accountability?
QC2	Does the study present the context in which the accountability solution was applied?
QC3	Does the study report a factor that influenced the proposed accountability solution?

- **STEP 5 - Perform Analysis and Discussion**: studies are classified using the EvidenceSET tool (Barbosa *et al.*, 2017). EvidenceSET requires uploading PDF files analyzed by different code extracting visualizations. Studies were thoroughly read and organized findings.

4.2 Execution

Initially, duplicated studies were removed. In addition, we excluded studies based on "*1st filter: Reading titles, abstracts and keywords*", "*2nd filter: Reading introduction and conclusion*", as well as the "*3rd filter: Full reading of studies*" and quality assessment. Studies also have been added through backward snowball sampling (Petersen *et al.*, 2015). The application of inclusion and exclusion criteria to titles and abstracts was conducted by one researcher. Thus, each study was only reviewed by a single author, which poses a threat to the reliability of the SMS (see also the discussion of threats to validity in Section 4.5).

Figure 31 shows an overview of the execution process, as it starts by identifying duplicated titles, which describes the initial base of 863 studies; 713 remained after excluding duplicate studies. Next, inclusion and exclusion criteria are applied, and 141 studies remained based on the "1st filter" (Step 2 to Step 3). After using "2nd filter", 23 remained (Step 3 to Step 4). Finally, 23 studies are considered and evaluated with quality criteria in the data extraction step with a "*3rd filter*" (Step 4).

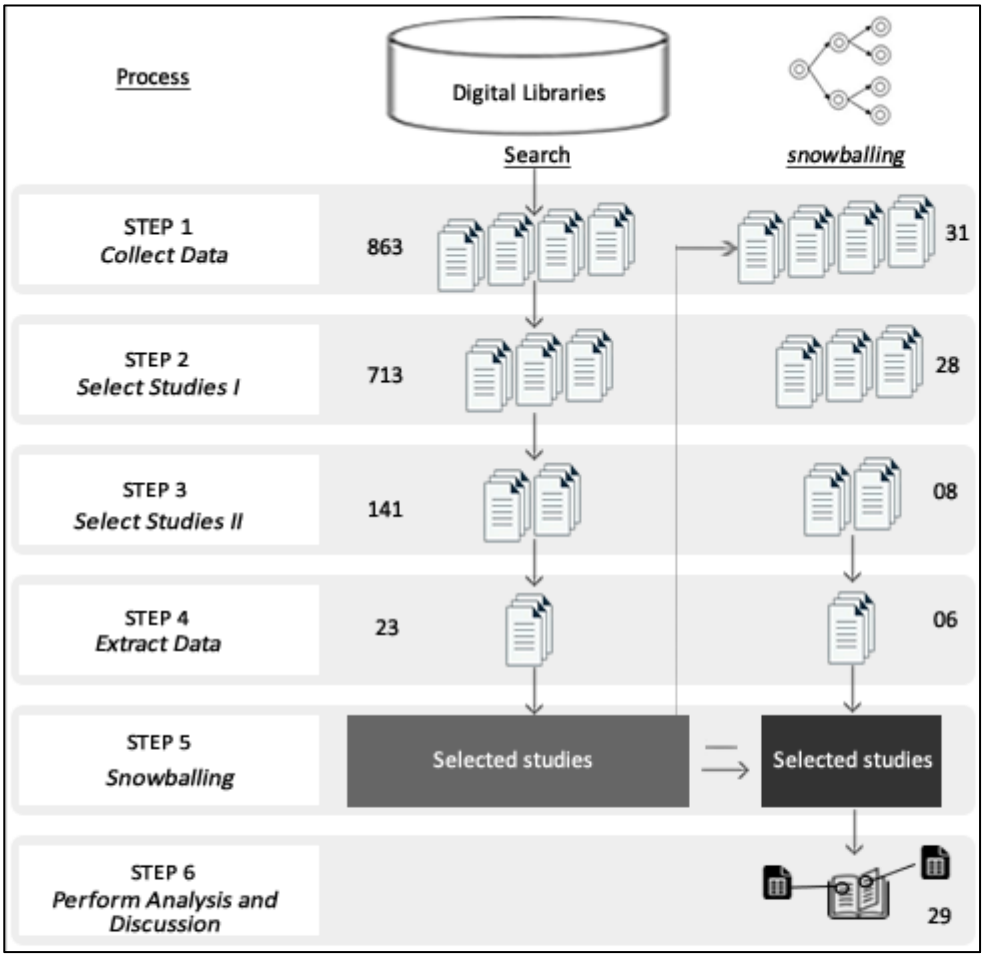

Figure 31 - SMS evaluation process.

At this point, a backward snowballing technique is applied in the 23 selected studies, and 31 new studies were added to the final analysis (Step 5). Therefore, all related studies were incorporated to be analyzed considering the SMS evaluation process and starting at Step 1. It summarizes an overview of steps and outputs. In the end, a total of 29 were selected for study (Step 6); such result incorporates the 23 studies previously selected and six news studies (snowballing selection results). Thus, each study is called S*xx*, where *xx* is a numerical ID, e.g., S01. Table 13 describes SMS results from Step 5. In the end, a total of 29 were selected for study (Step 5). Thus, each study is called S*xx*, where *xx* is a numerical ID, e.g., S01.

Table 13 - Selected studies.

Index	Title	Source
S01	A Metamodeling Framework to Support Accountability in Business Process Modeling	(Zou *et al.*, 2009a)
S02	Accountability and Reflective Responsibility in Information Systems	(Stahl, 2006)
S03	Accountability in Cloud Service Provision Ecosystems	(Pearson, 2014b)
S04	Accountability issues in multihop message communication	(Bhattacharya & Paul, 1999)
S05	Accountability of Electronic Cross-Agency Service-Delivery Processes	(Gortmaker *et al.*, 2005)

Table 13 - Selected studies (Part 2).

S06	Adaptability and accountability of information architectures in inter-organizational networks	(Janssen, 2007)
S07	An agent-based framework for identity management: The unsuspected relation with ISO/IEC 15504	(Gateau *et al.*, 2008)
S08	An Online Transparency for Accountability Maturity Model	(Lourenço & Serra, 2014)
S09	Being ethical in developing information systems: an issue of methodology or maturity in judgment?	(Rogerson *et al.*, 2001)
S10	Cross-boundary e-government systems: Determinants of performance	(Chen *et al.*, 2019)
S11	Descriptions of responsibility for implementation: A content analysis of strategic information systems/technology planning documents	(Gottschalk, 2001)
S12	Designing for accountability	(Eriksén, 2002)
S13	Designing the Accountability of Enterprise Architectures	(Campagnolo & Jacucci, 2006)
S14	Discriminative effect of user influence and user responsibility on information system development processes and project management	(Chen *et al.* 2011)
S15	Discussions about perfecting chinese system of official accountability for mining disasters	(Chuan-hui & Bing, 2011)
S16	Expanding citizen access and public official accountability through knowledge creation technology: one recent development in e-democracy	(Shires & Craig, 2003)
S17	Health information systems, decentralization, and democratic accountability	(Madon *et al.*, 2010)
S18	Information technology, responsibility, and anthropology	(Stahl, 2002)
S19	Information, not technology, is essential to accountability: electronic records and public-sector financial management	(Barata & Cain, 2001)
S20	Privacy by information accountability for e-health systems	(Gajanayake *et al.*, 2011)
S21	Probable Influence of E-government on Financial Accountability in China	(Chen *et al.*, 2010a)
S22	Public sector information management in east and Southern Africa: Implications for FOI, democracy, and integrity in government	(Mutula & Wamukoya, 2009)
S23	Sharing with Care: An Information Accountability Perspective	(Gajanayake *et al.*, 2011a)
S24	State Education Agencies, Information Systems and the Expansion of State Power in the Era of Test-Based Accountability	(Anagnostopoulos *et al.*, 2013)
S25	Systems Thinking as a Resource for Supporting Accountability in System-of-Information-Systems: Exploring a Brazilian School Case	(Cordeiro & Santos, 2019b)
S26	Toward accountability in the cloud	(Pearson, 2011)
S27	Towards a formal model of accountability	(Feigenbaum *et al.*, 2011)
S28	Towards Accountable Enterprise Mashup Services	(Zou & Pavlovski, 2007)
S29	Using Accountability to Reduce Access Policy Violations in Information Systems	(Vance *et al.*, 2013)

4.3 Results and Discussion

4.3.1 Demographics

This section presents SMS demographics results. Results focus on three perspectives - publication venues, contribution type, and preliminary analysis. Disagreement regarding SMS findings was resolved through a discussion between authors that refined the classification scheme. Publication venues describe items organized by studies per year. Contribution type addresses different contribution types (method, model, process, and tool) per year. Preliminary analysis shows visual representation based on keywords' frequency.

Considering **publication venues** until mid-2020, distributing literature base was published in journals or conferences/workshops in 1999-2019 (see Figure 32). Petersen *et al.* (2015) argue that identifying venues is a strategy that must provide an overview of studies distribution and suggestions for submissions. Thus, the venue's characterization information shows 62% of studies were published in conferences/workshops (18) and 38% in journals (11). Results indicate a graph curve with publication distributed from 1999 until 2019.

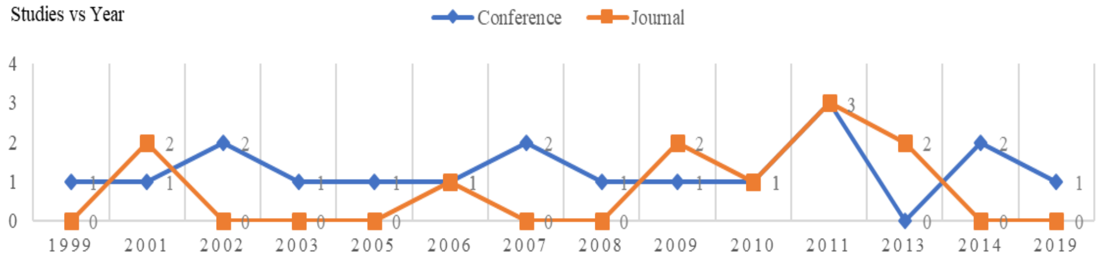

Figure 32 - Distribution of studies by publication venues.

Contribution type is organized as (i) method; (ii) model; (iii) process; and (iv) tool. Contribution to a precise method (61%) and model (19%), compared with a few studies on a tool (13%) and process (7%). Each of the contribution types is described in Figure 33.

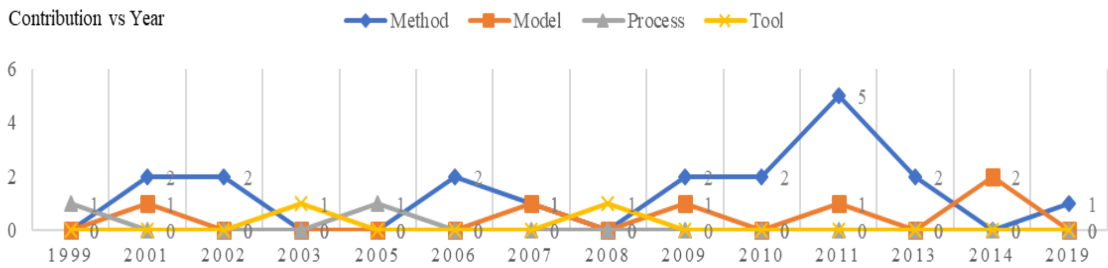

Figure 33 - Contribution type by year.

Method refers to research concerning approaches describing rules of accountability in IS and how they can be implemented (S02, S06, S09, S10, S11, S12, S13, S14, S15, S17, S18, S20, S21, S22, S24, S25, S26, S27, and S29). S09 highlighted accountability through IS lens concerning development professionals' responsibilities by constructing and comparing ethical challenges in activities and performance in IS development. S10 developed a framework for evaluating performance measures in an e-government system, including accountability and other requirements to understand shared goals and inter-agency trust.

Model refers to research that discusses concepts, makes comparisons, explores relationships, identifies challenges, and makes classifications (S01, S03, S08, S19, S23, and S28). They suggest that accountability is used to explore transparency, social participation, and pursuing results. For example, S28 proposed a framework that includes a service or content creator and a new mashed-up service owner to add more disclosure, trust, and non-denial. S03 discussed data protection and risk (e.g., lack of availability, integrity, isolation).

Process refers to actions or activities associated with workflows (S04 and S05). S05 presented a cross-agency service-delivery approach for reallocating responsibilities and change processes to create accountability relationships (an organization, an individual, or both). Finally, **Tool** refers to research presenting software to support IS accountability (S07 and S16). S16 focused on neural network-based applications and algorithms to access public information. It handles access to public records and enables users to evaluate public actions to improve public services. S07 proposed a tool for aligning business objectives with an access policy and deploying policies associated with IT infrastructure and multi-agency architectures.

4.3.2 Preliminary Analysis

The preliminary analysis encompasses Step 5, pre-classified using EvidenceSET to support analysis of keywords and synthesis of studies. EvidenceSET setup was configured to cover: (i) automatic rename of files, and (ii) at least four occurrences at the same file. The following two EvidenceSET visualizations are explored:

- **Look for a keyword visualization** that presents a link between keywords. As shown in Figure 34, the visualization result confirms that the choice of keywords (and synonyms) was correct, i.e., responsibility (83) and accountable (42) are top terms associated with accountability. Another insight considering top-rated terms are management (50), users (21), technology (31), and process (45), which demonstrate that accountability is related to IS area;

Figure 34 - EvidenceSET presenting keywords visualization.

- **Graphviz visualization** is configured for displaying terms with 40 connections or more. It contains a finite set of nodes relating to relationships among keywords (see Figure 35). Nodes highlighted in blue show the most common keywords. Frequent keywords associated with accountability are management (23 files), process (80 files), responsibility (14 files), and records (6 files). This visualization uses references considering the number of occurrences and the number of files (accountability was found 1,540 times in 25 files). Thus, the most frequent keywords associated with accountability are management (23 files), process (18 files), responsibility (14 files), and records (6 files). The link between nodes means many times that both keywords were found in the same statement, e.g., management and accountability, equal to 50.

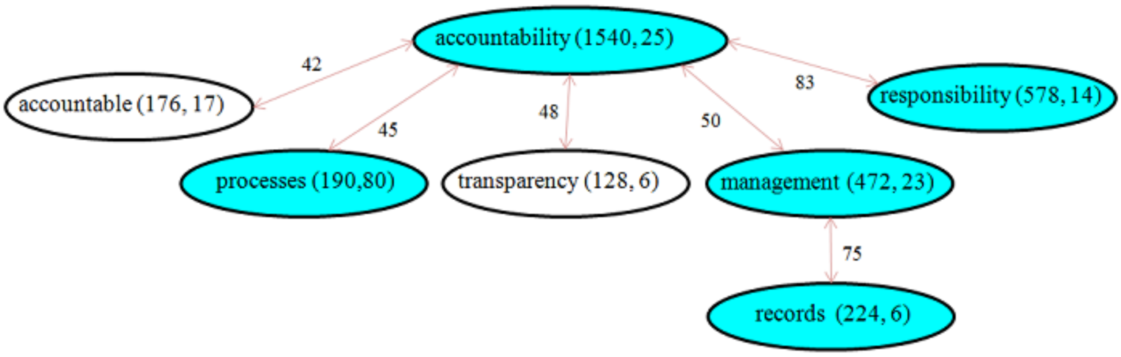

Figure 35 - Graphviz visualization.

4.3.3 What does the scientific literature say about accountability in IS?

In this section, we summarize seven findings addressed by Q01. The following topics organize influential topics of accountability in IS/SoIS, based on a review and systematization of literature, founder of the area. In particular, the creation of coherent categories of analysis, adapted from (Carlomagno & Rocha, 2016): (i) there must be clear inclusion and exclusion rules in the categories; (ii) the categories cannot be too broad, and its homogeneous content; (iii) categories shall include all possible contents and "other" must be residual; and (iv) the classification should be objective, not likely to be coded differently depending on the interpretation of the analyst.

4.3.3.1 Definition of Accountability

We found the term used more as a buzzword than to describe accountable initiatives in IS domain, most studies do not state any definition, and it is closely related to responsibility. We noticed that SMS findings explained accountability in two perspectives: direct (a quotation) or example. Larsen and Eargle (2015) organize a wiki with several IS theories[10]; one of them is an accountability theory. We realized that the theory's definition was only cited in S29 - the same authors who wrote the theory. Difficulty in finding a universal purpose was also highlighted in S01, S06, S25, S27, and S29. Authors argue that the challenge of studying accountability is that it is widely used in various contexts.

We assert that the core of definitions refers to something/someone responsible for, something/someone considered to be analyzed, and some judgment criterion to cope with the difficulty of characterizing accountability. For completeness purposes, S6 states that accountability is a multidimensional concept, it is not technologically oriented, and it can only be reached at significant expenses and long-term efforts. Table 14 shows the accountability definitions from SMS.

Table 14 - Accountability definitions.

ID	Definition
S01	It is an obligation to inform other parties about actions and decisions, or justify them and to be punished in the case of misconduct" "answerability" or an "obligation to account for how well resources used to meet specified outcomes," others argue that Accountability is either "credit or blame" or "corporate scapegoating".
S02	It is one aspect of responsibility, which refers to the entire process of ascribing an object to a subject; Accountability is concerned with how this relationship can be established and verified, which allows tracing of causes, actions, and events.
S03	It is a type of non-functional requirement, a quality that defines how a system is supposed to be, as opposed to functional requirements, which define what a system is supposed to do.
S04	Accountability refers to being able to prove what a user did do, as well as did not do.
S05	Accountability is a relationship between two parties in which an individual or agency is held to answer for a performance that involves some delegation of authority to act. Accountability always consists of an actor with the duty to render an account and another actor with the power to judge or impose sanctions.
S06	It is answerability for one's actions or inactions and to be responsible for their consequences.
S07	It describes the state of being answerable about the achievement of a task.
S08	The concept may be understood from many different perspectives, such as "the obligation to explain and justify conduct"), and proposes several viewpoints from which the concept of Accountability may be analyzed. From the "To Whom is Account to be Rendered" perspective emerges the concept of political Accountability, whereby citizens (among others) are the recipients of governmental disclosure efforts as a counterpart for the power delegation, which characterizes representative political systems.
S09	Accountability is a term of responsibility that focuses on work attitude when considering being accountable for actions in professional domains.
S10	Accountability is a complex and multi-dimension construct for measuring performance and is closely related to transparency.
S11	Accountability is a result of responsibility, which can emerge, considering moral or legal obligations to be held responsible for actions and results.
S12	It is the quality or state of being accountable, which is defined, on the one hand, responsible for giving an account (as of one's acts): answerable.
S13	It is a visibly-rational-and-reportable-for-all-practical purposes'.

[10] This site is maintained as an ongoing project of the Human Behavior Project at the University of Colorado and the Information Systems PhD Preparation Program of the Marriott School of Management of Brigham Young University. Available at: https://is.theorizeit.org/wiki/.

Table14 - Accountability definitions (Part 2).

S14	It is associated with responsibility, and it refers to the assignments and activities reflecting user responsibility.
S15	It is a strategy for evaluating systems, laws, regulations aiming to investigate responsibilities and call to account for.
S16	It reflects abilities and powers to elected officials that allow officials and their agents to restrict individuals' actions and seize property and resources from them.
S17	It refers to who one is accountable to because of their power to impose sanctions.
S18	Accountability can be defined as the social side of responsibility, as "a feature of systems and social institution: It means that strategies are in place to determine who took responsible action, who is responsible".
S19	It is a fundamental requirement of good government. It ensures that the political, social, and economic "contract" existing between the government and the people is fulfilled.
S20	It entails procedures and processes by which one party justifies and takes responsibility for its activities.
S21	It reflects the relationship in which one party, the accountor, recognizes an obligation to explain and justify their conduct to another, the accountee, mainly as a requirement for an individual's participation in any social world.
S22	It is a principle of good governance that depends to no small extent on the free flow of information within the government.
S23	It focuses on providing means for verifying, analyzing, and investigating users' actions, with multiple actors should have access to information about accountable parties, but at different levels based on the actors' purpose.
S24	It focuses on holding individuals accountable for performance; such reliance will increase, and it extends the power of testing companies, computer firms, consultants, and researchers who create the metrics and models.
S25	The concept of accountability needs to emerge from three fundamental: frequent improvement on management processes, a frequent improvement in the sense of responsibility by engagement, and frequent respect to compliance (laws, regulations, or policies).
S26	Accountability is associated with complying with measures that give effect to practices articulated in given guidelines.
S27	An element is accountable concerning some policy (or accountable for obeying the policy) if, whenever the element violates the policy, then with some non-zero probability, it is, or could be, punished.
S28	It refers to the obligation a person, group, or organization assumes to execute authority and/or the fulfillment of responsibility. This obligation includes: answering—providing an explanation or justification—for the execution of that authority and/or fulfillment of that responsibility, reporting on the results of that execution and/or fulfillment, and assuming liability for those results.
S29	As a virtue, accountability is seen as a quality in which a person displays a willingness to accept responsibility, a desirable trait in public officials, government agencies, or firms; hence, in this use, Accountability is a positive feature of an element. As a strategy, accountability is seen as a process in which a person has a potential obligation to explain his/her actions to another party who has the right to pass judgment on the actions and subject the person to potential consequences for his/her actions.

4.3.3.2 Accountability versus Responsibility

We noticed that most results focus on making people-process-technology more accountable, improving participation, and creating a safe environment through responsibility. SMS demonstrates that the term responsibility appears without mention of accountability. Studies of this kind were excluded from research. On the other hand, it was included studies addressing responsibility through an accountability lens. In S11, responsibility is a moral or legal obligation for which accountability can emerge, a personal requirement for IS. In S02, responsibility appears as an object's ascription to an entity (usually a person), which is answerable to an entity. In contrast, S23 describes a difference between terms: responsibility involves what we must do and our duties. It reflects only up to the point of decision, and accountability focuses on ramifications after some decision.

4.3.3.3 Dependence of People Regarding the Success of Information Systems

Studies are reporting roles in IS and their responsibilities. These results are associated with the need to improve ethical conduct, accountable behaviors, and how bad decisions may negatively affect purpose. Findings are based on understanding the sense of responsibility for tasks, relationships, communication, and participation. A significant aspect is highlighted by S09 and S11 when the authors consider improving skills and knowledge from IS developers and managers considering ethical and organizational objectives. Other results involving people are related to positive involvement in project performance by promoting development processes, including organizational technology learning, project control, and user-IS interaction.

4.3.3.4 Frameworks and Models for Thinking About Accountability

Studies are establishing frameworks and models for accountability. For example, S28 describes a service contract that supports management and business specifications for monitoring activities. S05 involves integrating to process unclear relationships, leading to monitoring and transparency. S12 presents the need to explore the concept of accountability associated with technology, mainly considering different modeling perspectives that may contribute to design development. Moreover, studies relating investments for improving management (S07), transparency (S08), and implementation of services (S10).

4.3.3.5 Information and Communication Technologies

Studies are addressing different types of IS and issues related to technology for supporting business. These discussions are based on security strategies, transparency, data access privileges, and strategies to prevent confidentiality in communications. S04 discusses digital signatures and the potentiality of comprehensive solutions to secure communication systems considering digital services (such as cloud computing). S03 focuses on cloud computing services and how they manage personal, sensitive, and confidential information for service delivery for reducing risk, detecting access (risk monitoring and violation policy), incident management, and remediation. S29 investigates policy violations and punishment (malicious insiders or abuse of trust).

4.3.3.6 Governance and Competitive Advantage

Studies are reporting initiatives of public or private services. These results focus on governance and competitive advantage, e.g., tracking activities, participating in system decisions, and evaluating provider services' quality. S16 presented a neural network-based application and algorithms to access public information as an e-democracy and participation involvement strategy. S29 detailed management as a relevant factor in Africa's public sector where databases were evaluated together to strengthen freedom of access to information, democracy, and integrity in government service to society. These studies are associated with best practices for governance, aiming to improve transparency and follow-up of consumption and expenditure resources.

4.3.3.7 Data Management

Studies are considering storing and retrieving data. S20 and S23 stem that e-health technologies raise medical professionals' issues regarding patient privacy and sharing data. For example, Health Insurance Portability and Accountability Act (HIPPA) establish standards to protect patients' medical records from security breaches. Finally, S24 studied IS for monitoring students' performance in state assessments and their progress in elementary and high schools, college, and beyond. It explored how data is measured, monitored, and regulated for an educational environment and school performance.

Regardless of focusing on people-process-technology and RQ1 findings, accountability plays an essential role in all three IS areas. For example, IS professionals must be involved throughout IS evaluation, considering accountable strategies for IS success. In this context, accountability may contribute to IS, i.e., whereas people should be involved in deciding who/what/how/when to an activity to be accomplished. Moreover, accountability is relevant in how IS should operate and how changes should be implemented to provide better results. However, in some previous topics, technical processes are much more detailed by defining guidelines for identifying access control and effects of accountability in business processes, IS tasks, services etc. Other findings emphasize the need to reach an agreement on personnel participation and commitment, especially considering organizational goals. In addition, these results suggest the creation of protocols for documenting and exploring responsibility information.

4.3.4 What are the research challenges related to accountability in IS?

Q02 summarizes future IS research challenges, addressing insights from studies' conclusions on what solutions merit further investigations. SMS challenges are organized considering the evaluation approach. Table 15 summarizes research challenges, organized with four life cycle processes, evaluation criteria, research topic, and source. This approach was inspired by Axelsson and Skoglund (2016), who developed a research agenda for quality assurance in software ecosystems - we adapted it for this thesis. For example, there are challenges around strategies to address actor, IS, and business processes concerning decision-making, and trade-off analyses.

Table 15 - Overview of research challenges agenda for accountability in IS.

Life-Cycle Process	Criteria	Research Topic	Source
Business process	Management	Develop design for business dynamics	S07, S25
	Regulation	Build automatic design case generation	S26
Establish and maintain accountability process	Engagement	Understand actors to meet results	S02, S24
	Management	Encourage involvement	S21
	Regulation	Balance between different specifications	S05, S12, S13, S18
Implementation	Engagement	Support for feedback collaboration	S06
	Regulation	Develop accountable strategies for responsibility	S11, S15, S16, S19, S20, S29
	Regulation	Support for identification for punishment	S27, S29
System requirement definition	Engagement	Support responsibility-sharing	S14, S17
	Management	Create structures for communication	S03, S09
	Regulation	Support to IS architecture and quality attributes	S01, S04, S08, S10, S22, S23, S28

4.3.4.1 Business Process

Business process aims to integrate a systemic view of IS environment to produce a complete picture of IS scenario that may influence decision-making and contribute to IS management. It considers several approaches for comprehending scenarios (interview, a document investigation, survey for process understanding).

- **Develop design for business dynamics:** organizations depend on IS people and different commitment levels to achieve objectives. In S25, the research identifies IS dynamics, IS customers, organizational problems, and accountability suggestions. Such research is built on design models for leading to better reporting and decision-making. S19 details accountability associated with designs to raise financial systems control, i.e., producing exception reports, process complies, reconciling subsystems with general ledger, obtaining audit trails and transaction details, and auditing to enable trace documents. Many challenges in accountability relate to information flow: who is responsible for what, who has the power to apply sanctions, which sanctions can be used to support interfaces, IS relationships, and manage data research;
- **Build automatic design case generation:** nature of understanding accountability strategies can be a lonely road. It includes understanding inputs, outputs, and processing around some organizational problems and business processes. Depending on available information about an issue, data gathering tends to be directly affected. S26 argues that strengthening an accountability approach and making it more workable by developing intelligent solutions is a growing challenge

beyond traditional methods to protect data, and must include complying with and upholding values obligations and enhancing trust. There are several potential types of research such as legal verdict, health diagnosis, artificial intelligence. It is worth noting that design could also evolve how evaluating emphasizes how IS is operated and maintained.

4.3.4.2 Establish and Maintain Accountability Process

This topic defines accountability as a relevant requirement that involves understanding IS environment for supporting an organization. It encompasses identifying backgrounds and impacts considering project plans, schedules, cost, capability, quality, or collaboration.

- **Understand actors to meet results:** understanding actors' demands and their relationships with an organizational objective is useful because it describes skills, knowledge, and efforts when accepting and using technology. It can help developers and managers analyze situations and investigate better products and solutions, mainly considering respond actors' involvement that affects decisions, actions, performance, ethical procedures in work, and communication (S19, S12, S18, and S24). Thus, addressing actors' understanding is essential because they can clearly define the scope of the dialogue, governance, and design opportunities. There is a need for more research to understand individuals for improving their accountabilities;
- **Encourage involvement:** creating an environment that focuses on engaging individuals or groups of them. It encompasses a continuous analysis of results, data analysis, and how they depend on people's involvement, affecting organizational performance (S02, S09, and S16). An accountable organization must focus on better managing opportunities, risk, reputation and enable polling resources to solve problems and reach organizational objectives. A research direction is to identify all intended actors, clarify their responsibilities, participation, involvement, adapt organizational strategies to organization's types and sizes to sustain changes, business processes, and competitive advantage;
- **Balance between different specifications:** designing for accountability demands choosing a focus. However, SMS highlighted different needs, such as architectures, control, democracy, technology, ethics, methods, and data. Behind each solution

has a step-by-step process for making things go right. S19 argues the need to control structure for internal and external factors and potential effects on the management cycle for several activities. However, it is more than a punishment for missteps and failure. It involves creating a win-win situation for organizations, promoting efforts, and implementing culture change. A challenge in this decision-making must establish necessary specifications to support IS dynamics and interoperability between systems (Maier, 1998; Azeroual *et al.*, 2018);

4.3.4.3 Implementation

The implementation process contains activities addressing people-process-technology, with close interactions between these activities. It encompasses solutions or element descriptions, including interfaces, boundaries, evaluation, measurement evaluation for enabling services, and traceability analysis for designers.

- **Support for feedback collaboration*:*** sharing information is a relevant objective for identifying opportunities and problem-solving. However, creating applications to evaluate products and services is not trivial when considering boundaries in different IS that must work together to achieve some goal (Maier, 1998; Azeroual *et al.*, 2018). S06 focuses on development collaboration, which may reduce development time, lower time-to-market, and reduce cost. Behind these processes, we face challenges supporting humans' issues and ethical dilemmas that often involve conflicts between positive impacts in some domains and adverse effects on others. This background demonstrates dependencies between IS areas by improving accountability to adapt to organizational objectives;
- **Develop accountable strategies for responsibility:** generating open and distributed IS, makes responsibility for services increasingly complex, mainly when considering access policy. S07 discusses how a description of activities has links with responsibility, the need for deployment policies in IT infrastructure's components, and relationships to IS components. In this context, challenges around transparency address issues such as defining a purpose, outcomes, and work product. Such contexts suggest that assessment models, protocols, frameworks, individuals' access (their background and where they live) are open challenges. In particular, dealing with transparency, security, and service is important to IS research, especially for systems around people with limited ITC knowledge. A

research direction is implementing related services, suppliers, or even unknown partners, formal protocols, and tools for representing other relationships considering obligations, sanctions, and conditions demands for strategies;

- **Support for identification for punishment:** extend understanding of service quality and customer profile within online settings, mainly considering scenarios that held anonymous users. S27 describes accountability strategies for ensuring security in IS, using as an example anonymous user and the need to access confidential data, connecting to a private network (such as public Wi-Fi, initially maintained by some entity). Authors argue that accountability strategies are vital to mitigate anonymous access and prevent a security problem through punishment. There is a need for more research around models of accountability based on events traces and access violations to define protocols for platforms and infrastructure evolving in time and are combined with new ones aligned with tools for punishment (automatic or not).

4.3.4.4 System Requirement Definition

This life-cycle process addresses actors' and organizations' transformation into accountability. It encompasses characteristics, such as functional performance requirements, that plans must possess to support accountability in tasks or behaviors in different organizations' stages.

- **Support responsibility-sharing*:*** sharing information demonstrates good governance roles (S04, S08, S13, S17, and S21). It depends on a large and free flow of organizations' information to be used by citizens and civil society groups to monitor governmental processes, including efficiency and effectiveness in achieving stated service, objectives, and targets. For example, (i) evaluation of competition and incentives for better organizational results; (ii) ensuring strategy for effective functioning of public service; (ii) definition of criteria's for preventing failures and formulate follow up of regulations; and (iv) public or private expenditure strategies including budget preparation, financial accounting, procurement, and audit. Interfaces for this information-sharing are areas where more research is motivated;
- **Create structures for communication*:*** from the developers' perspective, accountability is determined to consider follow-up on teams' performance and

effects on leadership and how a project is conducted. Another aspect focuses on a user-IS relationships and registering formal reviews, evaluation, and IS staff's work and design changes (S09). A challenge is how to clear communication as a strategy for pursuing better collaboration to avoid delays, rework, and mitigate project execution problems. S06 argues that the diversity of online services and the increase of these services, within its objectives and types of IS, demand exploring networks, integration, and how to pursue one's actions (or inactions) and respond for consequences. In this context, we find it meaningful to create a culture of accountability to produce faster results for improving management competency, which occurs by stretching commutation;

- **Support to IS architecture and quality attributes:** accountability can be related to several quality requirements, such as transparency, responsibility, irremediably, and sustainability (S03). This agenda addresses architectures and other essentials to support best practices, services, and models (S28). The top challenge is to achieve accountabilities for all phases in an investigated situation, i.e., more accountability investments can improve sustainability. There is a need for more empirical research to better understand the sense of stimulating accountability and those requirements that may be positively or negatively affected and to define appropriate technical support to attend to people, process, and technology practices and how to build and maintain ICT systems requirements;

4.4 Implications

In addition to the SMS findings, some results focused on a strategy of accountability in terms of evaluation, which we considered vital to accountability research for IS/SoIS. Such an approach aims to contribute to IS/SoIS research by focusing on accountability and considering who/what/how/when, i.e., "who is accountable for", "what to accomplish", "how to accomplish", and "when to accomplish".

As an analogy to IS area, we noticed that accountability might be achieved through an evaluation dimension as a set of strategies for evaluating it. Thus, we assert that accountability can be detailed through evaluation dimensions based on three criteria: (i) efforts of engagement level to accomplish some work; (ii) efforts of management level for organizing some work; and (iii) efforts of regulation level for supporting IS demand and solution. Thus, the following topics describe the accountability evaluation dimension considering engagement, management, and regulation.

4.4.1 Accountability Criterion: Engagement

The first dimension focuses on people from IS area, and it refers to the participation and involvement of IS users, considering engagement as one major goal for supporting accountability evaluation. The correlation between engagement and accountability may facilitate participation and involvement and influence IS quality, notably SoIS demand and solutions resulting from user feedback.

Several studies focus on engagement and potential effects on creating, problem-solving, reasoning, decision-making, and evaluation. Concerning Kearsley and Sheiderman (1998), engagement research is "*based upon the idea of creating successful collaborative teams that work on ambitious projects that are meaningful to someone*". Kearsley and Sheiderman (1998) argue that engagement emerges from three principles: (i) team efforts that involve communication, planning, management, and social skill; (ii) team effort for making learning a creative, purposeful activity; and (iii) evaluate the stress value of making a valuable contribution while learning. For example, these principles showed in findings on people's relationships with SI, demonstrating the SMS results.

O'Brien and Toms (2008) discuss user engagement with technology, focusing on key components that make up engagement. Authors considered engagement as "*a desirable—even essential— human response to computer-mediated activities*". Thus, discussions about engagement suggest that engaging interactions are sought after by both users and developers of computer systems and applications. To do so, identifying users' perceptions, actions, and behaviors about making a system functional and intuitive to use must concentrate on understanding how to make systems more engaging (H. L. Brien & Toms, 2008). When considering the dynamics of complex systems, user experience goes beyond usability and must incorporate new demands, new technologies, and new rules. Furthermore, engagement definition is associated with user-computer interactions that aim to integrate user's experience: "*engagement is a quality of user experiences with technology that is characterized by challenge, aesthetic and sensory appeal, feedback, novelty, interactivity, perceived control and time, awareness, motivation, interest, and affect*".

This thesis asserts that these characteristics are related to accountability. Therefore, we assert that engagement influencing accountability stems from the sense that investment in team engagement leads to improvements in products, services, and performance, making the organization operate better (AccountAbility, 2015). To illustrate the engagement dimension, the table presents the SMS results considering such dimensions. In addition, Table 16 presents engagement challenges, because of studies challenges presented in the SMS findings. Thus, this thesis proposes that engagement is a dimension for assessing accountability, as follows: **Engagement** involves maintaining and sustaining people's participation in identifying strategies that may help IS achieve its purpose.

Table 16 - SMS findings associated with engagement.

ID	Description
S01	Encourage practitioners to build solutions with more accountability by including modeling for specification.
S02	Consider that people are responsible, and there are crucial in the decision and must be encouraged to accountability.
S03	Clarify and acceptance of responsibility.
S04	Understand person role.
S05	Provide information about services.
S06	Understand needs to account for agency actions or inactions.
S07	Understand and acts regarding the right to stakeholder's status (worker, employee, manager).
S08	Sustain open government data portals and people participation.
S09	Encourage ethical practices.
S10	Support managers for developing articulation.
S11	Identify personal accountability for implementation.
S12	Integrate feedbacks for design.
S13	Include social analysis in designing.
S14	Encourage user participation.
S15	Encourage citizen participation.
S16	Encourage citizen participation.
S17	Encourage social welfare-orientation in health programs.
S18	Mitigate ethical problems, such as negligence and culpability.
S19	Develop a basic understanding of the government's macroeconomic and reform objectives and how these are being translated into policies, programs, and projects at the operational level.
S20	Develop strategies for patient security.
S21	Encourage citizen participation.
S22	Encourage citizen participation.
S23	Develop strategies for patient security.
S24	Engage to design, install, and operate educational systems.
S25	Sustain engagement strategies in IS management.
S26	Encourage consumer trust.
S27	Identify types of violations and punishment strategies to trace behaviors.
S28	Understand roles and responsibilities regarding mashup service solutions.
S29	Mitigate malicious behaviors.

4.4.2 Accountability Criterion: Management

The second dimension focuses on processes from IS area and refers to managerial strategies, considering management as one major goal for supporting accountability evaluation. The correlation between management and accountability may facilitate operation to optimize IS performance, notably SoIS demand and solutions.

Concerning Kearns (1994), accountability involves how public agencies and their workers manage the diverse expectations generated within and outside the organization. This assumption introduces the element strategy, where managers are, thereby, transformed from a role of passive compliance into one of active participation in framing and articulating the standards by which they are a judge. This statement appeared recurrently in the SMS findings, where the manager's role must proactively advance in product and service evaluations. In this context, Rasche and Esser (2006) assert that accountability entails effective control by customers, citizens, and beneficiaries, allowing an evaluation of the private or public good provided. The premise between management and accountability is to encourage management mechanisms to meet demands between the parties involved. In line with people accepting responsibility for errors and misjudgments, makes organizations of any kind accountable actors within the global economic system (Rasche & Esser, 2006)

On the other hand, today's complex systems require different forms of management. For example, supply chain management entails coordinating strategic and long-term cooperation among partners in a supply chain network to develop and deliver products (Zhang, 2011). Or even, SoS challenges for managing alliances of independent systems that work together to achieve complex tasks considering dynamics architectures (Maier, 1998; Fernandes *et al.*, 2020).

Meanwhile, for organizations supported by IS, SoS, SoIS, risk management plays a crucial role in protecting their information. Risk management is the process of identifying and accessing risk and applying methods to reduce it to an acceptable extent (Tohidi, 2011). Tohidi (2011) asserts that the main goal of risk management is to help organizations better manage risks associated with their missions.

In this context, accountability plays a relevant role in these initiatives, promoting an understanding of responsibilities. Administrators of an organizational unit must be assured that the organization has the conditions to support its business objective. They can provide the best conditions for encountering mission, i.e., SoIS goals. Tohidi (2011) argues that an effective risk management process helps managers identify the controls needed to maintain IT factors, and for this reason, most organizations allocate enormous budgets for IT security. In this line, IS area must allocate resources for managerial strategies regarding people-process-technology. Moreover, Table 17 presents management challenges, as results from studies challenges presented in the SMS findings.

Furthermore, accountability focusing on management must encompass good practices. Hence, there is a need to define structures for supporting accountability to assess the performance and impact of IS dynamics, mainly SoIS. Finally, the thesis proposes that management is a dimension for evaluating accountability, as follows:

Management seeks to support managerial workforce activities aligned with a process in public or private organizations.

Table 17 - SMS findings associated with management.

ID	Description
S01	Manage activities for supporting accountability.
S02	Provide structures and measurements.
S03	Evaluate data structure.
S04	Manage communication of services and levels.
S05	Manage structure for the service-delivery process.
S06	Evaluate adaptability and existing components.
S07	Attend to a management life cycle.
S08	Comprehend context for decision-making.
S09	Provide follow-up of responsibility.
S10	Manage performance of cross-boundary e-government systems and between governments.
S11	Identify managerial activities associated with responsibility.
S12	Understand complex concepts and relationships.
S13	Manage independent objects of enterprise systems.
S14	Evaluate performance regarding user performance.
S15	Manage data from the government.
S16	Manage data for e-Democracy.
S17	Manage decentralization of healthcare delivery.
S18	Understand man and machine relationship.
S19	Record keeping and management are fundamental building blocks of a functioning public institution.
S20	Provide mechanisms to safeguard patient's information.
S21	Manage data from the government.
S22	Manage data from the government.
S23	Provide mechanisms to safeguard patient's information.
S24	Evaluate student performance data to individual schools and teachers.
S25	Sustain management strategies in IS management.
S26	Manage responsibility to better decision-making.
S27	Manage mechanism for punishment.
S28	Manage services responsibility.
S29	Manage user-interface design artifacts with policy predictions.

4.4.3 Accountability Criterion: Regulation

In this section, the association of regulation with technology is explained. Considering the analogy with IS area, it is up to regulation to structure the bridge between engagement and management; as a result, it forms a tripartite relationship for accountability evaluation. Thus, the third dimension focuses on technology and refers to establishing structures (polices, las, technology, protocol) for assuming responsibility for and being transparent about the impacts of policies, decisions, actions, products, and associated performance. The correlation between regulation and accountability may facilitate technology use and management, and influencing IS quality, notably SoIS demand and solutions, resulting from adequate responses about resources.

Regulation is a vehicle for establishing it, and sometimes its target goals, norms, laws, structure, platforms, technology etc. Espeland and Vannebo (2007) consider the relevance of rules, while a great deal of law is intended to hold people and institutions responsible for their actions and accessible to their constituents. In this context, the regulation provides the infrastructure for political accountability and representation in government. In this line, we extend the need for infrastructure beyond public or private regulation, explore the infrastructure for supporting accountability. Additionally, regulation is central to accountability, as it determines conditions under which people are held responsible for the crimes they commit.

Creating accountable people and organizations is a goal; the difficulty is developing the means to achieve the goal. For this reason, regulation is so important, as its definition must consider the conditions (existing rules, organizational culture) and define the criteria. Furthermore, the regulation addresses the tools and techniques used to communicate and make work efficient, including architectures, hardware, and software. In complex systems in which disruptive technologies such as cloud, mobile application, big data, and ecosystems transform the way organizations do business, regulation is becoming more critical. In this context, regulation encompasses specifications that must provide facilities or capabilities to users, enabling them to achieve the specified. Thus, inappropriate specification of requirements is still considered one reason for the failure of software development projects (Belfo, 2012). In addition, Table 18 presents regulation challenges, as results from studies challenges presented in the SMS findings. Therefore, the thesis proposes that regulation is a dimension for evaluating accountability describing SMS findings considering the regulation dimension (see Table 18), as follows: **Regulation** refers to meeting an organization's requirements to comply with (and enforce) legal and regulatory standards aligned with technology.

Therefore, for this thesis, the accountability requirement is evaluated by the combination of three criteria: engagement, management, and regulation. These evaluation criteria must work together to support accountable behaviors and actions for mitigating problems and instigating new solutions. Finally, it is worth reiterating that although the results focus on IS, it is possible to infer that the analysis can be shared with SoIS. Since SoIS represents isolated IS, a SoIS arrangement potentially shares the same implications as IS (isolated IS interoperating with each other). On the other hand, given the SoIS characteristic focusing on technology, it is possible to imagine that some of the topics and research challenges may be complemented in the future. In this way, studies that reflect interoperability between constituent IS may come to be related by an accountability evaluation approach, precisely by the representation of responsibilities, obligation, sanction, and conditions that a constituent IS must operate.

Table 18 - SMS findings associated with regulation.

ID	Description
S01	Provide a standard production rule representation for business rules modeling.
S02	Consider lack of fulfillment of the conditions of responsibility.
S03	Support external agreed data protection approach.
S04	Define categorizations for systems controlling.
S05	Provide a protocol for cross-agency.
S06	Provide adjustments for improving processes.
S07	Consider IS access rights according to the business needs and deploy these rights to their heterogeneous IS components.
S08	Define stages of maturity.
S09	Define evaluation mechanisms regarding professional conduct.
S10	Define methods for investigation.
S11	Elaborate responsibility measurements.
S12	Map service teamwork practices, cooperation, and communication, as a basis for more design discussions.
S13	Define roles and detail responsibility.
S14	Define evaluation mechanisms regarding user performance.
S15	Evaluate laws and regulations for mining disaster reports.
S16	Evaluate laws and regulations.
S17	Develop solutions for sustainable healthcare.
S18	Sustain ethics on systems use.
S19	Look at a policy level, technical records, and management issues.
S20	Define strategies to safeguard patient's information.
S21	Evaluate laws and regulations.
S22	Enhance laws and regulations as mechanisms for democracy, transparency, and accountability.
S23	Define strategies to safeguard patient's information.
S24	Incorporate strategies for evaluating the design, implementation, and operation of educational systems.
S25	Sustain regulation strategies in IS management.
S26	Develop strategies regarding reporting, explaining, and answering for decisions made.
S27	Define punishment rules and laws.
S28	Define strategies for liability and obligation.
S29	Define roles for policy violation control.

4.5 Threats to Validity

As in every empirical study, several threats might affect the validity of this SMS. This section analyzes the threats to validity for this study, considering the descriptive validity, theoretical validity, generalizability validity, interpretative validity e repeatability, according to Petersen *et al.* (2015).

- **Descriptive validity**: it is related to how accurately and objectively the observations are described. The researcher designed a data collection form to support the execution of the protocol, the recording of decisions made, and the data extraction process to reduce threats related to this threat;
- **Theoretical validity**: Petersen *et al.* (2015) pointed out that two mapping studies of the same topic ended up with different sets of studies. We complemented the search with a snowballing technique of all studies after full-text reading to reduce this threat. A researcher performed the described classification. As such, it may contain personal bias. However, three researchers with 15 years of experience in SMS supervised the process and were consulted to generate the final report;

- **Generalizability validity**: it concerns the limitation of using the six search engines considered. However, previous experience (Kitchenham *et al.*, 2010) shows that the machines used have good coverage in software and information systems research. Furthermore, the researcher did not apply a filter concerning the publication years of the studies. In addition, the first author executed the classification addressing the accountability evaluation dimension (engagement, management, and regulation). As such, it may contain a personal bias. Other authors have been consulted in case of doubt and in randomized checks to mitigate this risk. Besides, the accountability criteria previously explored in real scenarios, as presented in Chapter 3;
- **Interpretative validity**: it is achieved when the conclusions obtained are derived from the data. This threat is related to researcher bias. To reduce the bias, we seek to elaborate a set of clear inclusion and exclusion criteria for study selection. Moreover, the researcher discussed the study protocol with two senior researchers to ensure a common understanding of study selection and mitigate the bias on study selection results. Furthermore, the researcher discussed all findings, results, and conclusions resulting from this SMS with another researcher. Additionally, the search keywords described in the planning step could have created a bias towards accountability and responsibility. However, mitigation of this bias is tricky: responsibility is a term that is clearly defined as addressing accountability concerns. Analogous keywords for accountability (such as answerability and liability) are harder to define or too vague, hence failing to filter publications reasonably; and
- **Repeatability**: it requires detailed reporting of the research process. The researcher applied a defined search string, used deterministic databases, used free tools to support the SMS process (Zotero, StArt, EvidenceSET) and followed a step-by-step procedure that can be easily replicated. Moreover, the entire protocol for conducting the mapping is documented in this thesis to address this threat.

4.6 Final Remarks

This chapter presented an SMS to complement the theoretical accountability background from Chapter 2 and the exploratory studies from Chapter 3, and also provided directions for further investigations in IS/SoIS based on identified research challenges. However, this SMS focused on understanding what additional issues arise or require attention when considering accountability challenges, e.g., evaluation.

Initially, this chapter is focused on addressing: (i) definition of accountability, (ii) accountability versus responsibility, (iii) dependence on people for IS success, (iv) frameworks and models for thinking about accountability, (v) information and communications technology, (vi) governance and competitive advantage, and (vii) data management. Although studies contain valuable information, mapping their findings made it apparent that more research is needed. Moreover, we noticed that accountability uses different demands to support its initiatives, such as accountability evaluation criteria. Regarding criteria, a focus in this research has been demonstrating three strategies concerning evaluation: engagement, management, and regulation.

In addition, a life-cycle process of research challenges was organized in research topics, namely: business process, establish and maintain accountability process, implementation, system requirement definition. It is worth mentioning that studies relating SoIS and accountability are scarce in the investigated literature, which suggests being an area that merits investigation. Thus, based on this investigation combined with the SMS findings, Chapter 5 presents a conceptual model of accountability evaluation concerning SoIS and its assessment with 21 IS specialists, as part of a contribution concerning frameworks and model, as explored in Section 4.3.3.4.

Chapter 5 - Accountability Evaluation Model

This chapter describes the studies carried out and the results obtained in the eleventh to twelfth methodology phase, notably the accountability evaluation model. In addition, it considers exploratory studies and SMS findings. Therefore, this chapter presents a conceptual evaluation model in the context of IS arrangements, notably SoIS. In addition, it focuses on an evaluation strategy for analyzing the proposed model based on an interview protocol conducted with 21 IS specialists.

This chapter is organized into sections as follows: introduction, model designing strategy, evaluation method, planning, execution, results and discussions, threats to validity, and the final remarks.

5.1 Introduction

The SMS results reported in Chapter 4 show that the term accountability is extensively explored in the IS domain, despite the scarcity of research in SoIS context. However, most of the results provide references of accountability as buzzwords or without promoting a discussion of how to achieve it. Instead, some studies address accountability associated with a business goal (transparency, governance, social participation) or technological view (security). In this line, some results indicate room for more research on the evaluation of accountability in IS arrangements, especially in SoIS, where the discussion of accountability is scarce. In addition, exploratory studies showed the relevance of understanding the nonlinear behavior of complex SoIS over time using causal loops, people feedback, and time delays.

Regarding this body of knowledge, the next step aims to represent an accountability evaluation approach. Furthermore, this model aims to investigate the first research question of this thesis: "***How can an accountability evaluation identify behaviors among SoIS elements to support an organizational objective?***" (RQ1).

Thus, this chapter focuses on conceptual modeling for representing IS arrangements elements affected by accountability evaluation. Fettke (2009) argues that conceptual models are usually a graphical representation of a modeling domain, which is crucial for IS professionals to denote both static and dynamic aspects of a particular domain. Additionally, Fettke (2009) states that "*they play an increasingly important role during* *all phases of the IS lifecycle, i.e., analysis, design, and implementation of software systems; business process engineering…*".

Thus, this chapter concerns answering the following question: **Q01. What concepts should be present in a modeling language for supporting accountability evaluation in SoIS?** This work follows a conceptual modeling approach as proposed by Dubois *et al.* (2010) in the IS domain: (i) identify the key concepts of the subject domain, and (ii) design (or adapt) a language to support it. To cope with this approach, a research method is defined as model designing (see Figure 36) and consists of four steps (Dubois *et al.*, 2010), as follows:

- **STEP 1 - Concept alignment** starts by managing the SMS findings, where its goal is to identify the core concepts of the domain and harmonize the terminology around accountability criteria (i.e., engagement, management, and regulation);
- **Step 2 - Construction of the Accountability Evaluation Model (AEM) domain model** defines a conceptual model of the AEM domain using a UML notation. It explores a holistic approach for determining model notation by extending the Third Working Draft of ISO/IEC 42030 Architecture Evaluation (ISO/IEC 42030, 2013). The draft is an international standard that provides an ontology for modeling. It encompasses different phases for developing architecture evaluations regarding a system of interest that prescribes structure, properties, and products. Moreover, in specific steps, it adopts the works of Feltus (2008b; 2010; 2012) and Gajanayake (2011a) for supporting some accountability model constructs, which provides the responsiveness branch (i.e., right, responsibility, obligation, and sanction classes on model);
- **Step 3 - Definition of AEM support** provides a set of definitions to each model construct. In addition, it proposes a list of preliminary terms. The primary outcome is a glossary of terms; and
- **Step 4 - Evaluation with IS researchers** focuses on presenting a preliminary AEM version to IS researchers with a significant experience in UML modeling, combined with a definition proposition and evidence, which is a strategy to explain model fragments. Each proposition is supported by evidence from literature based on three processes: (i) assumptions reflecting relationships between model constructs; (ii) citations extracted from primary studies; and (iii) fragments of AEM. The primary

outcome is a revised AEM, aiming that the model meets the highest standards in conceptualization.

Finally, steps 1-4 are meant to be conducted iteratively and incrementally. The remainder of the chapter is organized with an evaluation method formed by mode designing as an input for evaluation regarding planning, execution, results, and discussion.

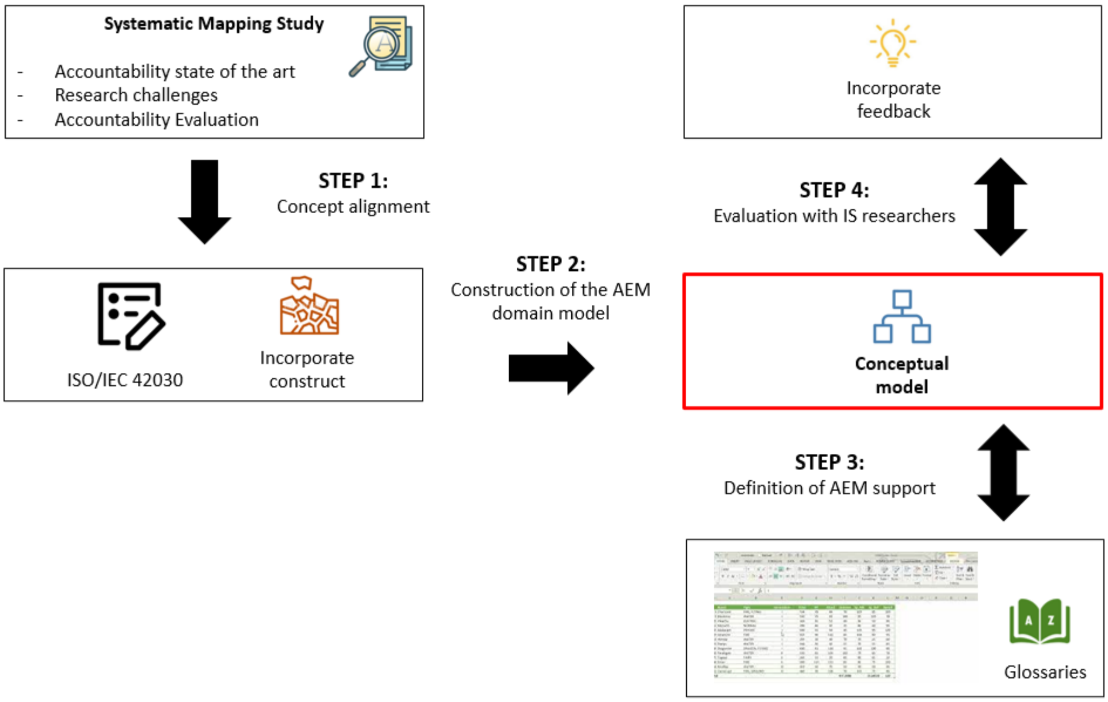

Figure 36 - Model designing.

5.2 Model Designing

AEM illustrates entities based on the body of knowledge formed by the initial literature review, SMS findings, exploratory study findings, mainly the evaluation approach (engagement, management, and regulation) concerning UML notation. In this context, a preliminary model encompasses a list of 15 terms (see Table 19) detailing key concepts that we consider relevant for mapping accountability evaluation in IS. Additionally, Figure 37 shows the preliminary AEM, which emerged from previous model designing steps. It presents a conceptual model for supporting accountability evaluation modeling.

The remainder of this section explains the graph considering propositions and evidence, which is a description from graph relationships. In this line, Figure 38 presents the UML notation supporting the chart, and Table 20 presents a glossary of relationships.

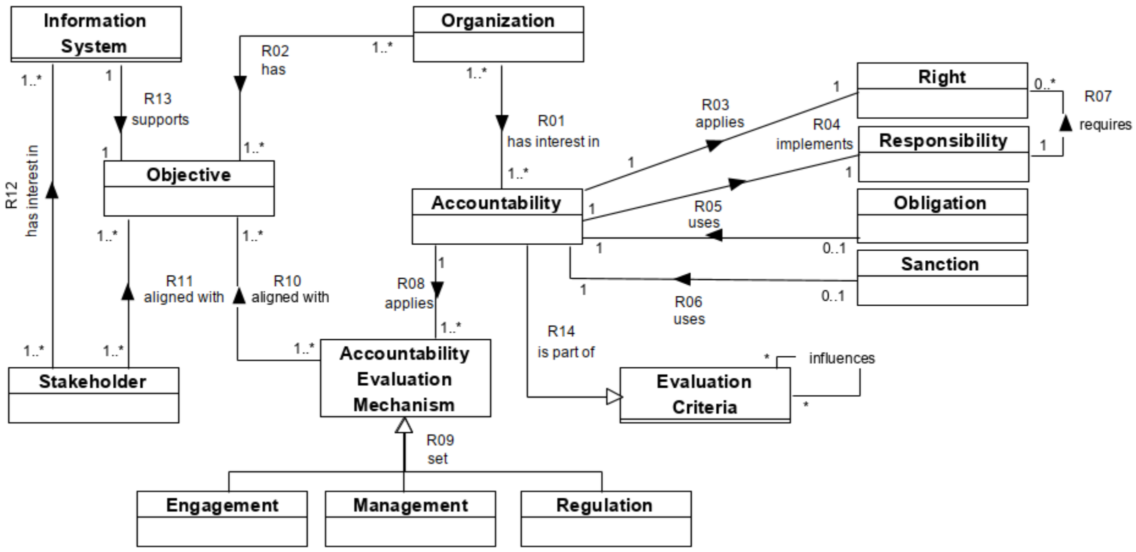

Figure 37 - Preliminary Accountability Evaluation Model.

Table 19 – Preliminary glossary of terms.

Entity	Definition	Source
Accountability	Accountability is a non-functional requirement for holding responsible actions in organizations and the results of those actions considering regulations and sanctions. It encompasses evaluation criteria aiming to support accountability evaluation.	(Feigenbaum *et al.*, 2011; Gajanayake *et al.*, 2011a; Pearson, 2011)
Accountability Evaluation Mechanism	It is a strategy to identify activities towards accountability to evaluate behavior efforts in systems as a way to address the evaluation objective.	(Pearson, 2014; Cordeiro *et al.*, 2020)
Engagement	It involves taking part in an activity, event, or situation and contributing to activities to achieve shared objectives.	(Gajanayake *et al.*, 2011a; Anagnostopoulos *et al.*, 2013; ISO/IEC 9000, 2015)
Evaluation Criterion	It is a principle, standard, rule, or test on which a judgment or decision can be based. It encompasses other quality requirements such as sustainability, performance, and security that may influence and influence each other.	(Campagnolo & Jacucci, 2006; ISO/IEC 42030, 2013; Lourenço & Serra, 2014; Pearson, 2014)
Information System	It is a set of interrelated or interacting elements with a goal(s). It includes, but is not limited to, information systems (and their constituents) and systems-of-information systems.	(Eriksén, 2002; Campagnolo & Jacucci, 2006; ISO/IEC 42030, 2013)
Management	It involves the exercise of control and supervision within the authority and accountability established by governance. The term management is often used as a collective term for those responsible for controlling an organization or subunits.	(Madon *et al.*, 2010; ISO/IEC 38500, 2015)
Objective	Interest relevant to one or more stakeholders, organizations, or systems.	(Stahl, 2006; Zou *et al.*, 2009; ISO/IEC 42030, 2013)
Obligation	It is a role of "must-do", which is a concerning state of affairs (e.g., execute an activity), and includes that what a role must do in order to fulfill a responsibility such as directing, supervising, and monitoring, whenever an obligation or a right is delegated.	Feigenbaum *et al.*, 2011; Gajanayake *et al.*, 2011a; Pearson, 2011; Khadraoui & Feltus, 2012)
Organization	A person or group of people has responsibilities, authorities, and relationships to achieve its objectives. The concept of an organization includes, but is not limited to, company, corporation, firm, enterprise, association, whether incorporated or not, public or private.	(Gortmaker *et al.*, 2005; Chuan-hui & Bing, 2011; Pearson, 2014; ISO/IEC 9000, 2015)
Regulation	It involves meeting the organization's requirements to comply with (and enforce) legal and regulatory standards (e.g., policies, guidelines, laws, and rules). It aims to support regulation activities (either formal or informal) in systems' processes. It means addressing parameters for sanctions/obligations aiming to assist engagement and management.	(Madon *et al.*, 2010; ISO/IEC 9000, 2015)
Responsibility	Obligation for acting and making decisions to achieve required outcomes.	(ISO/IEC 38500, 2015)

Table 19 – Preliminary glossary of terms (Part 2).

Right	It encompasses facilities required by an organization to fulfill its accountabilities. These facilities could include, amongst others, capabilities, authorities, or the right to delegate.	(Feltus *et al.*, 2009; Khadraoui & Feltus, 2012)
Sanction	Central importance for accountability. It evaluates a positive or negative sanction.	(Feltus *et al.*, 2009; Feigenbaum *et al.*, 2011; Pearson, 2011; Khadraoui & Feltus, 2012)
Stakeholder	Individual, team, or classes thereof, having an interest in a system.	(Eriksén, 2002; Campagnolo & Jacucci, 2006; ISO/IEC 42030, 2013)

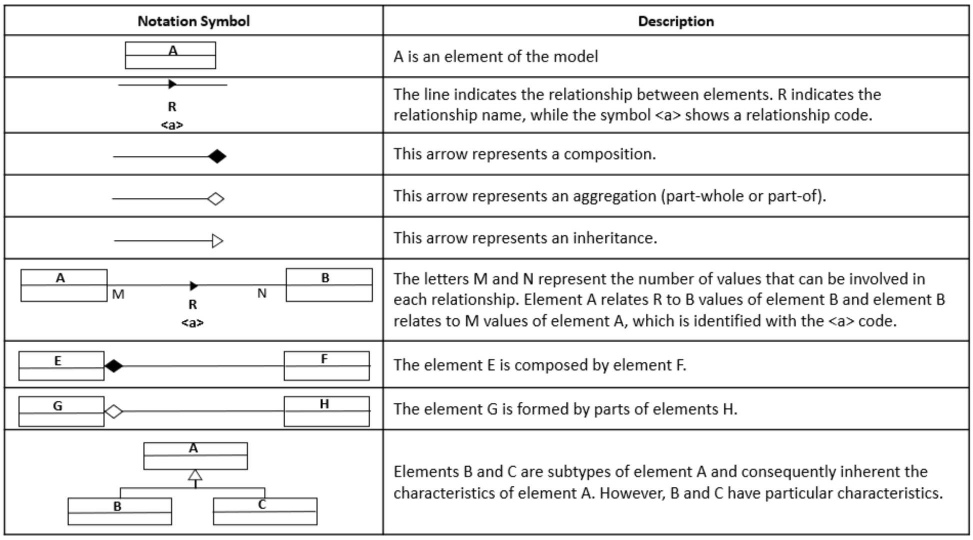

Figure 38 - UML notation.

Table 20 - Preliminary glossary of relationships.

ID	Definition	Source
R01	An organization has an interest in at least one accountability.	S03, S05, S15
R02	An organization has at least one concern (objective).	S12, S13
R03	Each accountability applies a right.	S18
R04	Each accountability implements responsibility.	S02, S29
R05	Each accountability uses at least one obligation.	S07
R06	Each accountability uses at least one sanction.	S07, S26, S27
R07	Responsibility requires the right action.	S07, S26, S27
R08	An accountability evaluation applies an accountability criterion.	S03, S25
R09	An accountability evaluation criterion is a set of accountability mechanisms.	S25
R10	An accountability evaluation criterion aligned with at least one concern.	S03, S09, S17
R11	A stakeholder has an interest in at least one concern (objective).	S14, S19, S24
R12	A stakeholder has an interest in at least one IS that supports an organizational concern.	S07, S21
R13	At least one IS supports an organizational concern (objective).	S03, S04, S05
R14	An accountability requirement is part of an evaluation criterion that may influence other quality requirements.	S03, S08, S13

An **organization** is an entity - a company, an institution, or an association - with a particular objective referenced by link <has>$_{(R02)}$. An objective is a purpose for some organizations, such as software development, consulting, or accounting. Moreover, an organization <has interest in>$_{(R01)}$ in at least one **accountability**. **Accountability** is an entity that aims to encourage responsibility analysis.

Accountability by link generalization<R14> is a part of the **evaluation criterion**. Such criteria encompass other quality requirements such as sustainability, performance, and security that may influence each other. For example, improving accountable strategies for a managerial task can impact performance and safety. Additionally, accountability is related to **obligation, sanction**, **right,** and **responsibility** parts. An **obligation** is an entity that <uses>(R05) at least one instance of accountability, and it represents what a role must do to fulfill a responsibility. **Sanction** describes by link <require>(R06) existence (or not) actions taken to make people obey a law or rule, or punishment given when they do not attend. Another entity associated with link <applies>(R03) to accountability is a right. **Right** describes available (or not) requirements an organization requires to fulfill their accountabilities, e.g., available infrastructure, trained business professionals. **Responsibility** by link <implements> (04) describes actions for making decisions and considering effects on outcomes.

Information System represents a constituent IS, and its arrangements to build an IS, aiming to capture, transmit, store, retrieve, manipulate, or display information, thereby supporting others IS thus by link <supports>(R13) an **objective**. As an example of IS arrangement is a SoIS. In turn, a **stakeholder** is an entity that defines who is <aligned with>(R12) at least one activity associated with an **objective** and <has interest in>(R12) at least one **information system**.

Accountability Evaluation Mechanism is a <set>(R09) of accountability criteria. The entity demonstrates potential approaches to diagnosing accountability (business process model and notation, and systems thinking). Furthermore, the generalization link describes three accountability criteria: **engagement**, **management**, and **regulation**.

Engagement aims to maintain and sustain stakeholders' involvement, commitment to organizational objectives and IS relationships. It involves participating in an activity, event, or situation and contributing to achieving shared objectives. For example, clarifying obligations and helping users meet these in cloud services ecosystems (S03), encompassing trust (S17, S24, and S28), and responsibility for implementation.

Management seeks to support activities and actions regarding the managerial workforce. It involves exercising control and supervision within the authority and managerial levels. Management is often used as a collective term for controlling an organization—for example, creating structures and procedures to support responsibility (S01, S02, S05, and S19).

Regulation refers to meeting an organization's objectives to comply with (and enforce) legal and regulatory standards (S08 and S29). It aims to support regulation activities (either formal or informal) in systems' processes. It means addressing parameters for supporting engagement and management.

In this context, the instruments for supporting AEM is formed by a proposition, evidence, and a partial description of the AEM as a fragment, which helps explain relationships between model constructs based on a definition for the term. Each proposition combines evidence with an AEM fragment, as follows:

- Assumptions reflect relationships between model constructs: it represents types of associations among elements and their interdependence; and
- Fragments of AEM diagram: initially, for evaluating proposes, the strategy focuses on describing fragments of the model, then with the knowledge from fragment understanding, the complete model is complete.

In this way, the complete AEM is divided into seven propositions that help to explain the proposed conceptual model.

Proposition 1 - The achievement of one or more organizational objectives depends on their stakeholders and how IS supports objectives (see Figure 39).

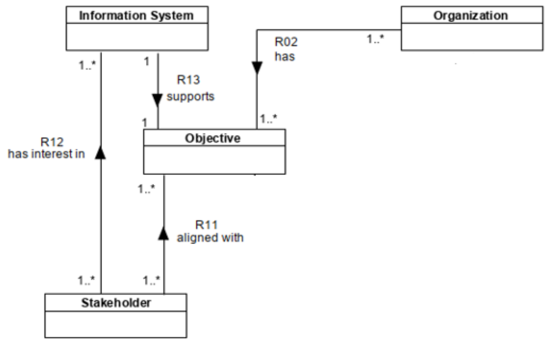

Figure 39 - Proposition 1.

- Evidence: An organization's concept includes, but is not limited to, company, corporation, firm, association, whether incorporated or not, public or private. An objective describes one or more interests relevant to at least one organization. IS area joins interrelated dimensions (people-process-technology), which support an organizational objective. An IS might include different arrangements, such as constituent IS, and -SoIS. A stakeholder is an individual, team, or class associated with one or more organization processes and might influence some IS's functioning (for example, by proposing improvements, characterizing responsibilities, and stimulating initiatives beyond those required by their function) (Eriksén, 2002; Campagnolo & Jacucci, 2006; ISO/IEC 42030, 2013; ISO/IEC 9000, 2015).

Proposition 2 - Accountability is a non-functional quality requirement in the IS domain (see Figure 40).

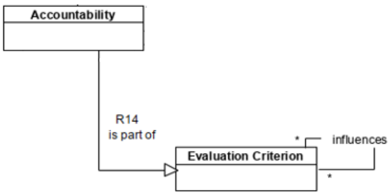

Figure 40 - Proposition 2.

- Evidence: Quality requirement covers functional condition (calculate, manipulate, process) and non-functional (sustainability, performance, safety, and interoperability) (Feigenbaum *et al.,* 2011; Pearson, 2014), which might influence each other (i.e., improving a business process can contribute to improving the performance of a service) (ISO/IEC 42030, 2013). Accountability is a non-functional requirement, a quality that defines what a system should be, as opposed to functional requirements, which define what a system should do. As a non-functional requirement, Accountability aims to carry out responsible actions in organizations supported by information systems (Feigenbaum *et al.,* 2011; Pearson, 2014).

Proposition 3 - Accountability implements responsiveness actions in an organizational environment, considering obligation, sanction, right, and responsibility necessary for supporting an organizational objective (see Figure 41).

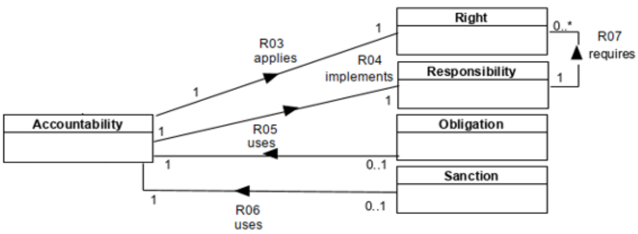

Figure 41 - Proposition 3.

- Evidence: Accountability is closely related to the implementation of responsibility, often used as a synonym in the literature. The effectiveness of the accountability also considers relations with obligations, sanctions, rights, and responsibilities. Obligation represents the state of concern (how an actor or system performs a task). The obligation reflects duties: a commitment to action (i.e., how to direct, supervise and monitor, whenever rights are granted). Sanction describes corrective actions, which can be positive or negative). Positive sanctions are those that bring benefits to something/someone, while negative sanctions are those that bring penalties to something/someone. Right includes demand for duty of some achievement, considering authorities and power of control. Responsibility for acting and making decisions to achieve required outcomes (Stahl, 2002; Feltus *et al.,* 2009; Madon *et al.,* 2010; Khadraoui & Feltus, 2012).

Proposition 4 - Organizations should seek to improve their accountability to achieve their objectives (see Figure 42).

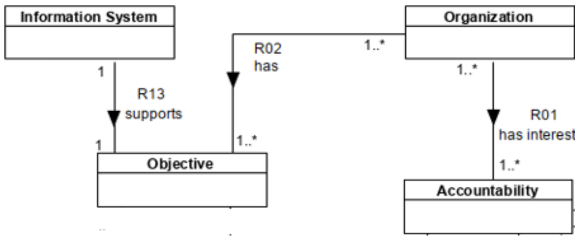

Figure 42 - Proposition 4.

- Evidence: The organization concept includes, but is not limited to, corporation, firm, company, association, public or private. Accountability is present in organizational environment through IS aiming to support some organizational objective, for example: (i) people's accountability and the way they use IS (initiatives, efficiencies, and responsibilities); (ii) accountability associated with access and requesting resources to support products, processes and services (maintainability, optimization, costs); and (iii) improvement of accountability strategy aiming at better control and management (transparency, effectiveness, governance). Thus, stimulating Accountability can provide better organizational results (Rogerson *et al.,* 2001; Mutula & Wamukoya, 2009; Chen *et al.,* 2011; ISO/IEC 42030, 2013).

Proposition 5 - One or more accountability evaluation mechanisms must analyze one or more organizational objectives (see Figure 43).

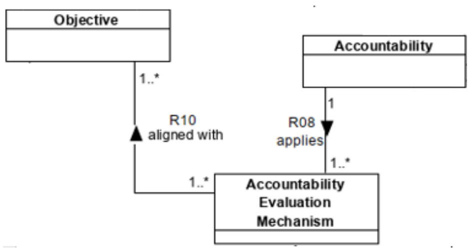

Figure 43 - Proposition 5.

- Evidence: Accountability evaluation mechanisms are needed to encourage accountability in organizations (Chen *et al.,* 2019). Strategies must encompass how organizational objectives are achieved (or not) and investigated (Vance *et al.*, 2013).

Proposition 6 - Accountability evaluation mechanism is formed by engagement, management, and regulation analysis, and it aims to hold stakeholders accountable, impact IS using/managing, and contribute to some organizational objectives (see Figure 44).

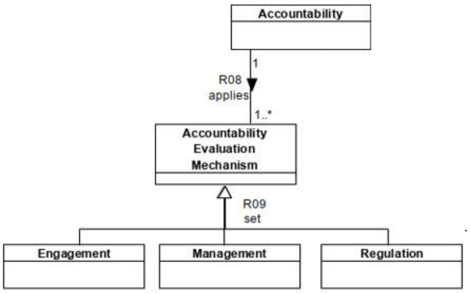

Figure 44 - Proposition 6.

- Evidence: Engagement strategies aim to maintain and sustain actor participation. Engagement encompasses those involved in favor of an activity, event, or situation to achieve common goals. Management strategies aim to support activities and actions with the organizational workforce. It requires an exercise of control and supervision within the organization's management's authority and responsibility. Regulatory strategies refer to compliance with an organization's requirements to comply with (and enforce) legal and regulatory standards (ISO/IEC 9000, 2015; ISO/IEC 38500, 2015).

Proposition 7 - Considering IS dimensions (people-process-technology), accountability assessment strategies are an approach to diagnose accountability influences in organizational objectives considering demands of different IS and actors, where they relate to (i) people with engagement, (ii) process with management, and (iii) technology with regulation (see Figure 45).

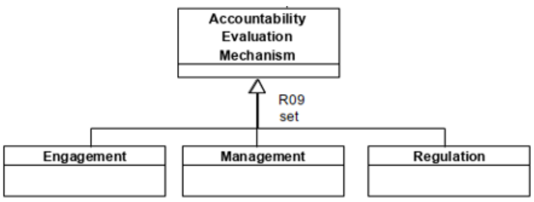

Figure 45 - Proposition 7.

- Evidence #1: In Proposition 7, Accountability is related to the behavior of people. Thus, engagement strategies include participating in favor of an activity, event, or situation to achieve common goals. Examples of engagement strategies are: (i) understanding about skills of actors that influence results (Stahl, 2002; Anagnostopoulos *et al.*, 2013); (ii) need to strengthen a sense of shared responsibility (Madon *et al.,* 2010); and (iii) encouraging collaboration between people for better results (Janssen, 2007).
- Evidence #2: In Proposition 7, Accountability is related to process demands. Thus, management strategies involve the exercise of control and supervision within authority and responsibility established by managers and demands of business processes. Examples of management strategies are (i) instruments to encourage participation (Chen *et al.,* 2010b); (ii) managing communication structures that integrate feedback loops (Rogerson *et al.,* 2001); and (iii) managing changes and their influences on business dynamics (Vance *et al.,* 2013).
- Evidence #3: In Proposition 7, Accountability is related to technology. Thus, regulation focuses on supporting an organization's purpose, mainly addressing standards, just as technologies support organizations' business processes. It is up to regulation to describe and standardize actions aimed at engagement and management. Examples of regulatory strategies are: (i) seeking to balance different standards and technologies with social factors (Zou & Pavlovski, 2007); (ii) characterization and dissemination of information systems architecture (Bhattacharya & Paul, 1999; Zou *et al.,* 2009; Vance *et al.,* 2013b;); and (iii) relationship between quality attributes and their effects (Gottschalk, 2001; Shires & Craig, 2003; Chuan-hui & Bing, 2011).

5.3 Evaluation Method

Considering the Model Designing form Section 5.2 as an input for the evaluation method, the remainder of the chapter presents the evaluation approach (see Figure 46). This method describes evaluating AEM with IS specialists regarding model designing, planning, execution, results, and discussion. In addition, it details the construction process, entailing input/output artifacts to support an interview for collecting specialists' feedback. Finally, as steps are accomplished, a final version of AEM was defined. The evaluating phase is formalized with GQM, as presented in Table 21.

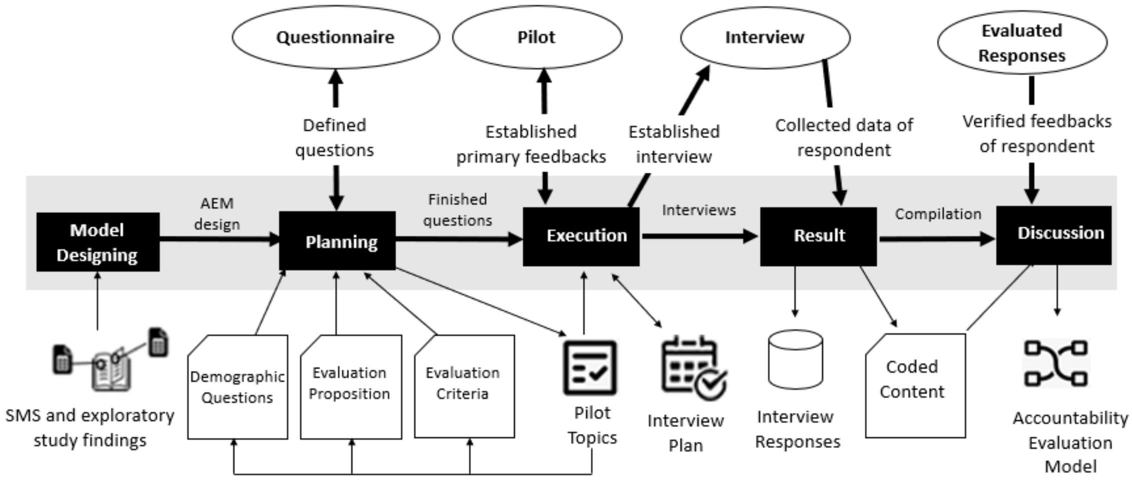

Figure 46 - Summary overview of AEM with evaluation study.

Table 21 - AEM GQM investigation.

Analyze	AEM propositions and conceptual model design based on SMS and exploratory study
With the objective of	evaluating
With respect to	AEM correctness
From the point of view of	IS researchers and practitioners
In the context of	information systems management and research

The following topics describe the evaluation phases:

- **PHASE 1** - **Model Designing** considers the AEM presented in Section 5.2, as an input to be analyzed;
- **PHASE 2** - **Planning** focuses on a survey approach to obtain knowledge from IS specialists, considering closed questions (CQ) and open questions (OC). IS specialists formed by IS managers and IS researchers were invited to collaborate on model evaluation to determine what kinds of assessment they suggest and what evidence they rely on to know how about IS' accountability;
- **PHASE 3** - **Execution** develops an executing an interview agenda, encompassing online interviews regarding two main activities—at first, a pilot, and then, interviews with IS specialists;
- **PHASE 4** - **Result** organizes findings for previous steps. The result considers the specialist's feedbacks, which addresses their comments for improving the preliminary AEM; and
- **PHASE 5** - **Discussion** evaluates results and promotes changes in preliminary AEM by redefining (i) new model constructs, (ii) redefining elements' link, (iii) rewriting propositions and evidence, and (iv) building a final AEM graphic.

5.4 Planning

The planning considered specialists in IS working in real and different organizations for collecting feedback from the AEM. Each of them has complete experience with various types of IS. The evaluation process comprises three steps, each step composed of CQ and OQ. Each CQ is detailed in the following paragraphs, while OC is defined as "Comment on your answer and, if you wish, record suggestions and/or examples". Open questions allow participants to describe their responses more completely.

PART I - Demographic Questions encompass nine CQ. CQ supports participants' characterization and their context (Table 22). This information allows us to explore differences in responses according to profiles.

Table 22 - Demographic questions.

CQ	Closed Question
CQ1	What is your name?
CQ2	What is your e-mail?
CQ3	What is the name of the organization that you work (worked) for?
CQ4	What is your highest academic degree?
CQ5	In which sector do you work (worked) for?
CQ6	How do you work (worked) in information technology management to support information systems in an organization?
CQ7	How long do you work (worked) with information technology management to support information systems in an organization?
CQ8	Do you know or have heard of the term accountability?
CQ9	Do you know or have heard of the term accountability associated with information systems?

PART 2 - Evaluation Proposition comprises seven questions to evaluate AEM propositions, as mentioned in Section 5. Specialists should analyze its proposition, its evidence, and the AEM graph. Each proposition is considered through one CQ and one OQ. CQ had four potential answers: (i) "I agree"; (ii) "I partially agree"; (iii) "I disagree"; and (iv) "I don't know". This questionnaire assesses participants' approval concerning a proposition for addressing "**What do the IS specialists say about accountability propositions?**".

PART 3 - Evaluation Criteria presents twelve questions (6 CQ and 6 OQ), where questions aim to assess the complete model according to Sjøberg *et al.* (2008). The basis of requirements is to list six relevant criteria in empirical studies, notably those related to theorization (see Table 23). Each proposition was evaluated through one CQ and one OQ. OQ had four potential answers: (i) "Useful for theory and practice"; (ii) "Useful for theory"; (iii) "Useful for practice"; and (iv) "I don't know". This questionnaire assesses participants' approval concerning a proposition for addressing "**What do the IS specialists say about the complete conceptual model?**".

Table 23 - Evaluation criteria.

Closed Question
Testability: Are the elements and relationships of the model unambiguous?
Empirical support: Are there studies (that you know of) that confirm the model's elements and relationships?
Explanatory power: Are the elements of the model understandable by the social innovation community?
Parsimony: In your opinion, was the minimum set of elements and relationships used to build the model?
Generality: In your opinion, does the model include different scenarios of IS arrangements?
Utility: Do you consider the model useful for theory and practice, or just for one perspective?

These steps are the basis for planning the model assessment. After creating the questionnaire, it was designed to run a **pilot**. Kitchenham and Pfleeger (2008) argue that such studies are intended to identify problems with the questionnaire itself, response rate, and follow-up procedures. A pilot was organized for evaluating and calibrating the survey with preliminary feedback. After adjustments, the **interview** is planned and executed. Finally, the last step focuses on discussion and feedback analysis for building the final AEM.

5.5 Execution

Before sending interview invitations to participants, we conducted a pilot with three specialists with modeling experience, who analyzed the structure of the model. The pilot execution promoted some improvements, such as text adjustments, resizing figures, and model entities ("accountability evaluation mechanism" was renamed to "evaluation strategy"). P02 mentioned that "*since accountability criteria are open, they should be defined a strategy; moreover, mechanisms are intrinsic to some strategy. For example, a strategy of improving management use some mechanisms*". APPENDIX III details the complete model feedbacks. After pilot adjustments, interviews were carried out from November 30 to December 12, 2020, involving 21 specialists. During the interview execution, a descriptive specification about the research was presented to each participant. The average interview time was 50 minutes. Interviews were recorded, and data was organized.

5.6 Results and Discussion

This section presents results and summarizes the discussion from a demographic analysis and research questions.

5.6.1 Demographics

According to demographic questions and participant's answers on questionnaires and profiles (LinkedIn network and Facebook accounts), they had job positions as an internal team (14), educators (4), external consultant (1), evaluator (1), internal consultant (1), and technician (1). Regarding participants' academic background (CQ4), it was observed that 2 have a bachelor's degree; 3 have a specialization degree; 12 have a Masters' degree, and 4 hold a Ph.D. Furthermore, to gain a better understating of participants' work background with the following perspectives:

- participant's sector of activity (CQ5), it was identified that majority (17) works at the public sector, private sector with three, and one participant in the third sector, i.e., associations, foundations, among other several civil societies organizations;
- participant's activity (CQ6), it was observed that the majority (14) works as an internal team (manager, developer), educators (4), external consultant (1), evaluator (1), internal consultant (1), and technician (1);
- length of experience (CQ7), it was perceived that the majority (12) works at least ten years, between three and five years (4), between six and ten years (3), between one and two years (1), and less than one year (1);
- knowledge about accountability (CQ8), it was observed that the majority (20) have experience about the investigated term, while one participant demonstrated no ability; and
- knowledge about IS's accountability, it was observed that the majority (14) knew investigated research, while seven participants showed no knowledge.

During the interview, participants explained their daily routines and accountability impacts. Significant findings point out the relevance of supporting accountability strategies in organizations and the challenges faced by them. Figure 47 encompasses summarizations of answers. It is possible to notice that at least 14 specialists accepted all propositions. In addition, each proposition had one evidence, while CQ7 has three pieces of evidence for supporting the proposition (CQ7 is a combination of CQ7a, CQ7b, and CQ7c).

The third part evaluation contains the criteria presented by Sjøberg *et al.* (2008). Figure 48 demonstrates that at least seven participants accepted all propositions. For example, the testability criterion had "*I agree*" (14), "*I partially agree*" (04), and "*I don't* *know*” (03). Finally, 20 participants answered that the model is “*useful for theory and practice*”, and one participant answered “*useful to theory*”, as part of the utility criterion.

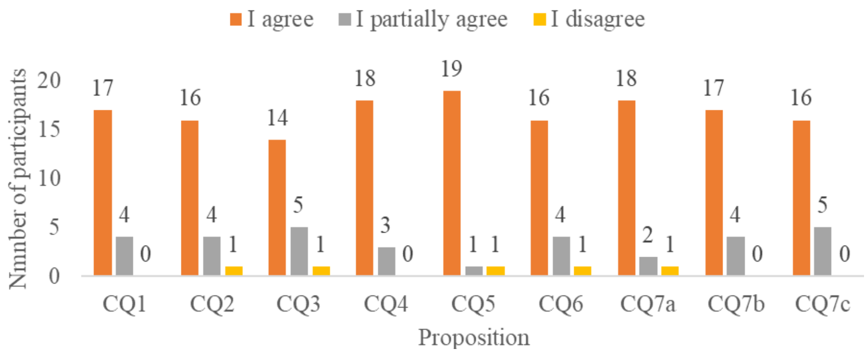

Figure 47 - Evaluation of propositions by specialists.

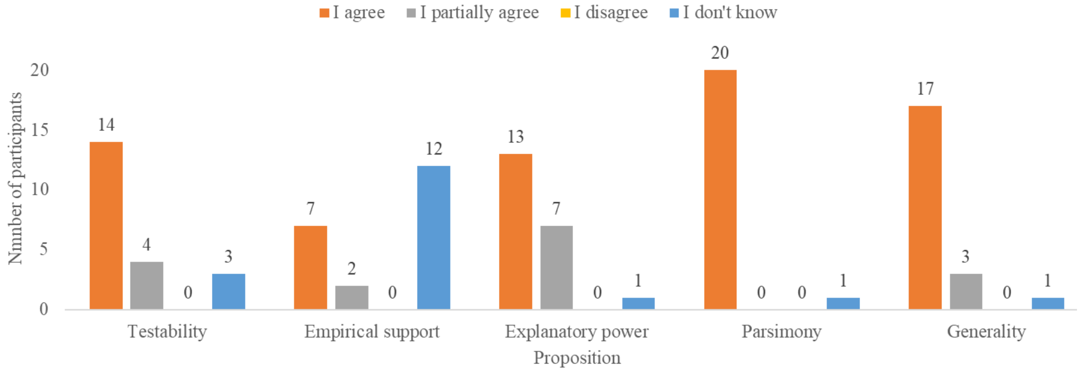

Figure 48 - Evaluation of the propositions based on Sjøberg *et al.*’s (2008).

5.6.1 What do the IS specialists say about accountability propositions?

This section describes the final propositions to incorporate specialist feedback (i.e., P01 defines Participant 01). Some feedbacks indicated that organizational objectives should be detailed with a new entity, “business process”. These responses aligned with SMS findings, such as: *businesses are demanding more accountability measures built-in at business process modeling level*” (P01).

Some specialists mentioned that “stakeholder” should be detailed (internal or external). For mitigating misunderstandings, the entity was renamed “actor” as a generalization of people. Additionally, some specialists mentioned that they missed some associations, mainly addressing a link between accountability and other entities. Thus, three new associations were defined, linking entity “accountability” with “business process”, “information system”, and “actor”. For example, P06 mentioned that the “*model does not represent who has ‘ownership’ of accountability. Is it IS? Is it a stakeholder? Is stakeholder using IS?*”.

This response is in line with several SMS findings since accountability is associated with people-process-technology solutions. In contrast, the original entity "responsibility" was excluded. This feedback considered responsibility as an attribute of accountability, which aligns with SMS findings. P20 mentioned that "*responsibility involves what we are required to do, our duties, and it reflects only up to the point of decision, and accountability focuses on ramifications after a decision is made*".

Thus, the distinction between accountability and responsibility was solved by defining the term accountability in the glossary of terms, where the description considers responsibility effects. Two compositions are created (between entities accountability and obligation/sanction), and a generalization link of evaluation strategy with accountability.

Another adjustment considered the branch responsiveness. Since the entity responsibility was incorporated, new links were made to represent associations with "sanction" and "obligation". Moreover, the entity "right" was renamed as "condition". P02 mentioned that "*I think it would be interesting to adjust the text to reflect the participation of the right class since it is close to task requirements*". Moreover, the association <has interested in> between organization and accountability has changed to "*1..* to 1*".

Analysis revealed that strategies around engagement, management, and regulation might contribute to IS assessment strategy. For example, P14 mentioned that "*activities and each actor's role when well-defined help understand how a problem occurs. Investigating how things happen and effects on the organizational environment are essential key for the success*". Such responses are in line with SMS research challenges.

5.6.2 What do the IS specialists say about the complete conceptual model?

The following topics describe the criteria proposed by Sjøberg *et al.* (2008). Results suggest a relevant contribution of a model since most of answered was indicated as "I agree", "I partially agree", and "Useful for theory and practice". Furthermore, Figure 49 shows the final model from evaluating phase.

- Testability involves analyzing ambiguity between model entities; thus, all relationships, multiplicity, and labels were adjusted. For example, P05 states that "*I believe that the relationship between accountability and system should be demonstrated*". The model's entities and glossaries were modified for incorporating feedbacks;

- Empirical support suggests that more than half of specialists do not know accountability evaluation studies. We observed that this lack of empirical support is not apparent or understood, such as mentioned by P10: "*this is my first time seen an evaluation about accountability associated do information systems*", or by P07 in "*I know the theme, but I don't know any model representing evaluation*". We believe that such feedbacks demonstrate a contribution to the research topic;
- Explanatory power reflects how understandable AEM is. It is interesting to note that specialists have UML knowledge. In this context, P07 states that "*despite using techniques already known to the community, the understanding model depends on an intermediate capacity for abstraction*", and P14 mentioned that "*IS managers may be more familiar with these elements (UML)*". We believe that more reporting is needed to explain notation and description;
- Parsimony focuses on the degree to which a theory is economically constructed with a minimum of concepts. We observed that parsimony had a high level of responses (20/21). P15 states that "*It is difficult to assess parsimony has been achieved without knowing diagram purpose. How can it be used and solve what problem?*". It is important to remember that the model does not focus on a specific problem. However, it predicted that a "business process", "information system", and "actor" should consider accountability within an evaluation strategy around engagement, management, and regulation;
- Generality indicates the potential of the model to be applied in different scenarios. Some specialists explored such standards: "*I can't think of anything that refutes the idea presented in the proposed model*" (P03), and "*engagement, management, and regulation strategies can provide great mechanisms for stimulating accountability and supporting IS use*" (P07); and
- Utility describes the influences of the model, considering theoretical and practical methods. Almost all specialists mentioned the practicality of "*useful for theory and practice*" (20/21). In contrast, P16 mentioned that the model is a utility for theorization: "*if the intention is to define procedures, it seems that examples and details are missing from diagram to supporting accountability*". It is important to note that the model does not focus on creating a protocol with procedures, but it entails some guidelines to orient an evaluation level for IS accountability.

Despite the above criteria findings, it is essential to remember that Sjoberg *et al.*'s (2008) standards are expected in Software Engineering, and most specialists answered that they have no experience in such a criteria approach. Perhaps, this is a reason for the strangeness of this criterion for the part of participants. During model analysis, all feedbacks were considered, and a new AEM representation emerged. Two researchers with 15 years of experience in conceptual modeling analyzed this new representation who studied the final version. Green indicates adjustments made, such as new entities, new entity labels, and relationships. APPENDIX III shows the evaluated glossary of terms, relationships, and the glossary of relationships from AEM; both products describe the AEM diagram, which incorporates the model changes (green).

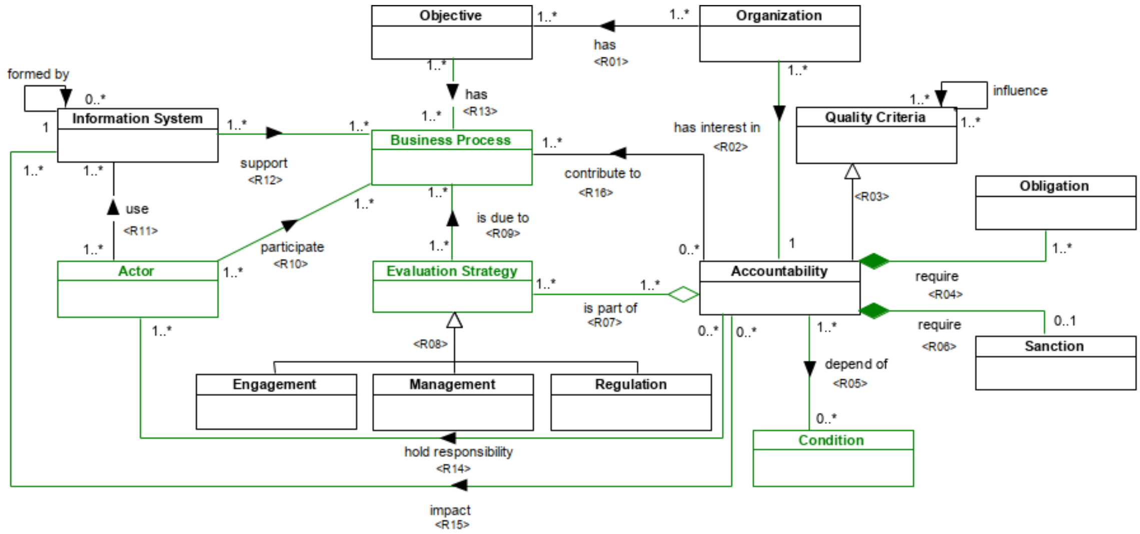

Figure 49 - Revised Accountability Evaluation Model version.

5.7 Threats to Validity

We identified some possible limitations of the work, as proposed by Wöhlin *et al.* (2012), i.e., construct validity, external validity, internal validity, conclusion validity, reliability, combined with the limitation of the developed model constructs strategy.

- **Construct validity**: refers to the connection between a theory behind an investigation and its observations. It is also concerning the capacity of measuring correctly the concepts studied. The main concept investigated in this research is the accountability evaluation, as this is a concept proposed in this study, we conducted a SMS to provide a wide understanding of the theme and ensure that the conceptual model was built based on definitions established by literature. In the evaluation of our conceptual model, we guaranteed confidentiality and offered anonymity of the responses to mitigate potential problems of evaluation inhibition. The threat of giving incomplete responses was mitigated by providing in the questionnaire an additional question to mention additional comments, suggestions, and examples when appropriate. Moreover, as the survey was conducted synchronously, the researcher could suggest that the specialist included comments on the reasons behind his/her disagreement with a proposition or model design. Obtaining feedback regarding the accountability evaluation model from specialists with different levels of knowledge and experiences also helped to address the construct validity;

- **External validity**: refers to the capacity of generalization for another context. According to 95.23% of the specialists, the conceptual model presented includes useful for theory and practice, which indicates a high level of generalization. It is also important to point out that all specialists work at different organizations (public or private);
- **Internal validity:** To attenuate a low number of participants, the specialists selected from a professional network according to the following criteria: (i) their profile must indicate their experience in IS management and IS research, and (ii) the specialists did not work for the same organization. Moreover, the selected participants act in these environments performing different functions. Therefore, the data collected through the perceptions of specialists was mitigated by experience achieved by specialists from various organizations. The use of a scale of responses in the interview minimized threats regarding the ambiguity of the specialists' responses;
- **Conclusion validity**: refers to the connection between a treatment and its outcome. To ensure the specialist's familiarity with the context of our research and its goal, we provided a site containing the glossary and references about accountability and detailed instructions on how to answer the questionnaire. Additionally, we mitigate misinterpretation threats by providing the specialist with a glossary of terms present in the conceptual model. The glossary adopted terminologies from literature studies in accountability and SoIS literature. Furthermore, the conceptual model does not aim to exhaust the issue of accountability evaluation, but rather to advance an agenda of relevant concepts that could be the target of new analyses;
- **Reliability**: The reliability of conclusions drawn concerning propositions due to a possible bias of researchers, and other model constructs could be represented. This

bias was mitigated by executing several cycles of the propositions process with two IS researchers, a plan, and a survey execution with IS specialists; and

- **Limitation of model constructs:** The data dump on which extraction was performed and restricted to 14 entities. This weakness has been balanced by including general propositions and evidence, which is a strategy for details, incorporates other entities, and expands it. Additionally, there are other accountability assessment and diagnosis strategies. However, one limitation is that they are restricted to standards, conceptual models, exploratory study findings, and standards. In a future work, other strategies could be analyzed.

5.8 Final Remarks

This chapter analyzed the implications of accountability in IS research, addressing SoIS and considering the thesis' body of knowledge for answering "*What concepts should be present in a modeling language for supporting accountability evaluation in SoIS?*" (Q01). It defines an accountability evaluation model that reflects the research experience. Furthermore, it evaluates the proposed AEM. Naturally, there are several accountability challenges in IS domain. However, regarding the eleventh and twelfth phase methodology, this study focuses on understanding what additional issues arise or require attention when considering accountability evaluation.

Thus, we developed a UML representation for key concepts and their relationships. At this point, the preliminary model was constructed with propositions and evidence. Finally, an evaluation plan is presented. Initially, a pilot was conducted and led interviews by IS specialists, who collaborated with feedback about the model. As a result, the final AEM is defined as an answer related to "***How can an accountability evaluation identify behaviors among SoIS elements to support an organizational objective?***" (RQ1).

Therefore, the next chapter proposes the use of AEM within a framework approach, mainly addressing business process problems, considering several constituents IS that must operate together in a real case. The focus is on collecting information and understanding SoIS scenarios, considering conditions faced by actors, business processes, constituent IS, and accountability evaluation.

Chapter 6 - AESoIS Framework and Tool

This chapter presents the conceptual framework proposed in this thesis to support SoIS scenario modeling in an organizational environment, obtained in the thirteenth methodology phase. It focuses on specifying and developing an approach for accountability evaluation, considering data gathering from SoIS users, BPMN files, and systems thinking. In addition, the AESoIS tool is presented.

This chapter is organized into sections as follows: conceptual framework, AESoIS framework guidelines, instruments and preparation strategy for conducting the study, AESoIS tool, and final chapter remarks.

6.1 Conceptual Framework Approach

Grobeshtein and Dori (2009) assert that constructing and using a comprehensive conceptual system model throughout a system life cycle is a key factor for the development of modern systems. Camacho *et al.* (2018) assert that in order to construct any structure, it is usual to have a plan for building a model, such as frameworks. In a relevant article addressing framework in IS domain, Zachman (1987) asserts that a framework contributes to

> "*rationalizing various architectural concepts and specifications in order to provide for clarity of professional communication, to allow for improving and integrating development methodologies and tools, and to establish credibility and confidence in the investment of systems resources*".

Thus, planning is essential to framework construction to ensure successful architecture, such as SoIS architecture (Maier, 1998; Fernandes *et al.*, 2019; Neves *et al.*, 2020). Unfortunately, SoIS lacks frameworks and tools for structuring information and helping to understand SoIS scenarios (Graciano Neto *et al.*, 2017; Neves *et al.*, 2020; Li, 2021). In this context, a framework for SoIS modeling may contribute to SoIS research, as it provides more accuracy and can reduce the number of errors when considering computational solutions based on a formal design of structures.

Concerning SoIS structure, this thesis proposes a framework for modeling solutions by including automation of systemic tasks regarding SoIS scenario understanding. For example, identify an organizational problem, identify a problems' cause, and identify consequences. In this context, this research proposal is to develop a conceptual framework consisting of concepts and relationships based on accountability evaluation strategies. Furthermore, the framework aims to investigate the second research question of this thesis: "***How to generate the representation of SoIS arrangement based on accountability evaluation?***" (RQ 2).

Therefore, this thesis proposes the Accountability Evaluation in SoIS (AESoIS) framework for SoIS scenario understanding and managing a set of visual elements based on ST. Overall, the AESoIS aims to evaluate SoIS elements and proposes improvements considering the accountability criteria presented in Chapter 3 and Chapter 4. The integration between the framework steps takes place through the thesis artifacts generated. Figure 50 illustrates the conceptual framework overview. It incorporates the AEM constructs, the proposed ASM layout, and notation combined with ST tools for modeling data, data gathering, and accountability indicators database.

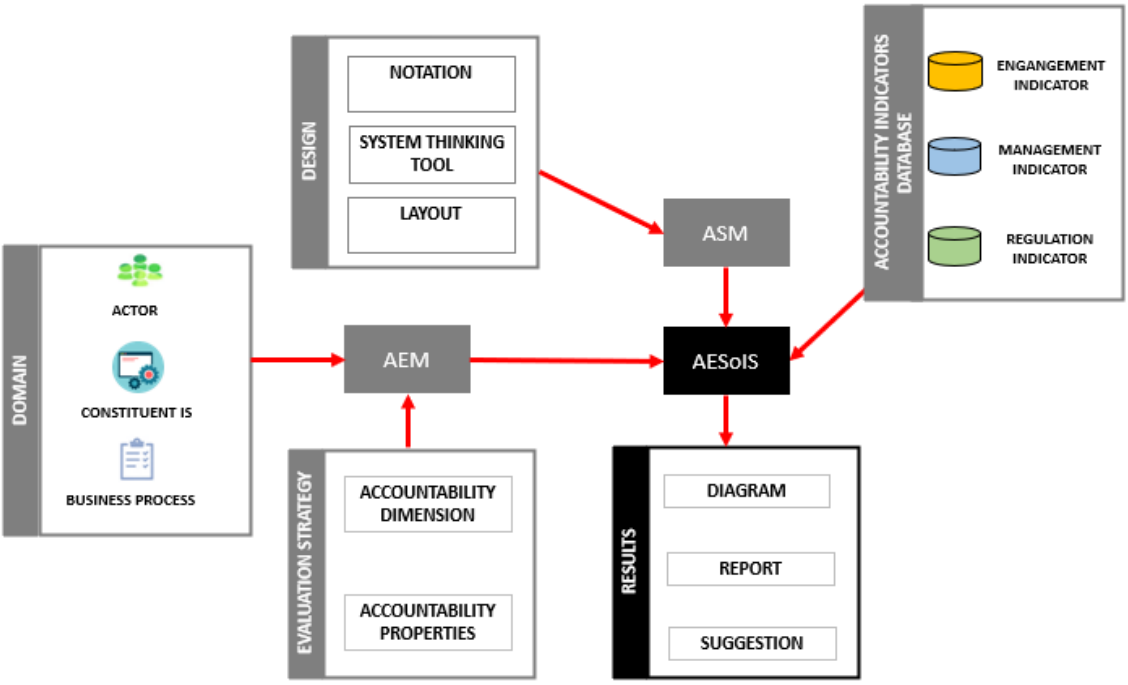

Figure 50 - AESoIS framework overview.

In addition, the framework application scenario concerns to organizations that aim to get an ST understanding in order to contribute to managers and practitioners (i.e., IS users, SoIS users) who should apply an SD approach to solve a problem-. In this way, an organization can diagnose its dynamics, know employees' attitudes and behavior, and understand how it works. Thus, the framework describes the relationships between the SoIS elements that make up a scenario and proposes an accountability evaluation to support organizational objectives. The proposed framework layout is an adaptation of the

Nadler-Tushman Congruence Model available online[11]. It analyzes information flow, i.e., inputs and outputs of both internal/external resources influencing a transformation process. Figure 51 shows a collection of flat shapes and arrows lines to provide a summarized layout.

Input defines the actions of or processing data into, AESoIS framework. It collects information about SoIS scenarios, i.e., circumstances, objects, interfaces from which several tasks can be performed. It contains history about the environment, which depends on a survey with SoIS users that helps to explain a situation. It describes sources that support the environment, e.g., a technology or a platform. In addition, the input phase is a start point of the framework that provides data to be analyzed. It encompasses information about IS arrangement, as it can be independent IS, manual IS, SoIS etc. It includes a plan of interest to be analyzed, e.g., defines research questions, defines a problem, or explore a scenario. Finally, it considers the elements from input and incorporates SoIS elements into processing.

Process is a compact version of soft systems' methodology (SSM) in Section 2.3.2, which describes stages to process transformation to incorporate SoIS elements. According to Shaked and Schechter (2017), SSM encompasses the learning from different perceptions that exist in the minds of various people involved in a situation, which is a relevant way of understanding complex systems. Thus, process is organized in four stages: (i) identify scenario; (ii) understand scenario; (iii) manage information; and (iv) evaluate scenario.

The first stage is **Identify Scenario** (Stage 1), which describes an investigation carrying out with SoIS users to identify SoIS scenario. It involves an investigation for collecting data, considering SoIS users' feedback, which may contribute to supporting an approach based on systems thinking. Stage 1 explores entering the problem situation for gaining an initial understanding of the scenario. At this point, data must be analyzed and organized into a formalization language, e.g., algorithm, graph, tables, and BPMN files.

Once Stage 1 is completed, then **Understand Scenario** (Stage 2) incorporates data from SoIS elements (if valuable). If there is no database, this phase should investigate SoIS elements and define a survey for collecting data regarding actors, constituent IS,

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[11] NTC Model - https://www.mindtools.com/pages/article/newSTR_95.htm

business process (and tasks), and interoperability links among elements. Stage 2 expresses a problem situation for starting the organization of ideas and understanding of a situation to enable and ease the analyses that will follow. It focuses on understanding relationships among SoIS elements (e.g., actor, constituent IS, business task).

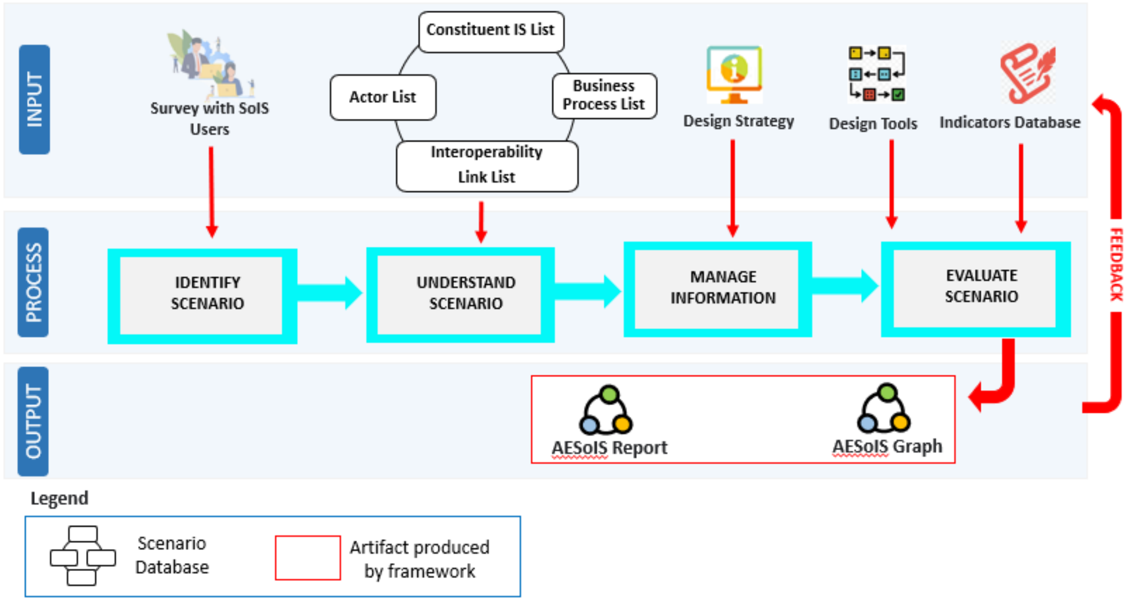

Figure 51 - Preliminary AESoIS framework.

In **Manage Information** (Stage 3), an analysis must be done to define a presentation strategy, considering SoIS understanding. Stage 3 describes the managing stages for assessing the scenario, such as (i) formulating root definitions describe the system in a structured way that enables modeling of the system; and (ii) building a conceptual model shows each operational activity that would be necessary to carry out the process described in the root definition. It encompasses, for example, ST tools as causal loops. Once Stage 3 is completed, the **Evaluate Scenario** (Stage 4) covers the diagnosis approach regarding interconnections, temporal effects, and accountability indicators. At this moment, the framework considers a list of accountability criteria (engagement, management, and regulation) as part of the indicator's database. The indicator's database purpose is to support the accountability analysis, as each indicator has a description of improvements to be evaluated by managers. For example, one investigated SoIS element from a scenario presents some difficulties, and then a manager can evaluate such element considering a set of indicators as potential suggestions to mitigate the identified difficulty. Therefore, Stage 4 encompasses the framework designing and the accountability strategy for evaluation. It expresses the three activities:

- comparing the conceptual models of activity with the real world, which contrast the thinking that has been done up to the systems designer;
- defining changes that are desirable and feasible considers the results from modeling to find out those that seem likely, if implemented, to have an accountability outcome in the situation; and
- recommends suggestions to amend the real details of the scenario situation to those interested in making changes. This phase is the framework's core since it describes the relationships between model elements, considering their influences and relationships, in time and space. It is formed by an accountability evaluation strategy considering three dimensions: engagement, management, and regulation. It is up to the development to define which strategies can be incorporated to analyze the dimensions.

Output defines the result of data processing from the AESoIS framework. Considering that the framework emerges from ST, two reports are created to explore the systemic aspects of the SoIS scenario. Finally, the framework must present a visual presentation in a diagram, where causal relationships overthrow the effects of time. In addition, the framework must submit a report describing modeled SoIS elements and the respective selected evaluation indicators.

6.2 AESoIS Framework Guidelines

To verify the AESoIS framework execution, this thesis proposes combining AESoIS with to BPSoIS tool (Oliveira, 2021). As mentioned in Section 2.2.3, BPSoIS is a method to analyze business process models to generate an architectural model for SoIS. In this context, BPSoIS data gathering is used as an input for the proposed thesis framework by extracting elements from BPM files. Furthermore, it encompasses managing data from SoIS scenarios, which considers mapping actors, business processes, constituent IS, and interrelationships. Thus, Figure 52 shows the AESoIS framework, including BPSoIS into **Identify Scenario** and **Understand Scenario**. Therefore, AESoIS framework data gathering is semi-automatized and realized by a SoIS user (e.g., employee) interested in understanding systemic effects on scenarios.

Integration between AESoIS and BPSoIS tool (Oliveira, 2021) started with some scheduled meetings with the author to gather information about the BPSoIS method and tool. At this moment, a partnership was signed between researchers aiming to integrate the solutions. During the integration research, Oliveira (2021) demonstrated the BPSoIS method. It is worth mentioning that integrating solutions is possible because both focus on SoIS elements, as proposed in the conceptual model for SoIS in a previous study (Fernandes *et al.*, 2019). Therefore, the AESoIS framework considers a Master's work of Oliveira (2021), which is part of the context of the solution proposed in this thesis. AESoIS framework follows the BPMN (OMG, 2011) to describe the process flow, namely AESoIS Generation Macro-process. Furthermore, the AESoIS purpose is formalized in GQM, as presented in Table 24.

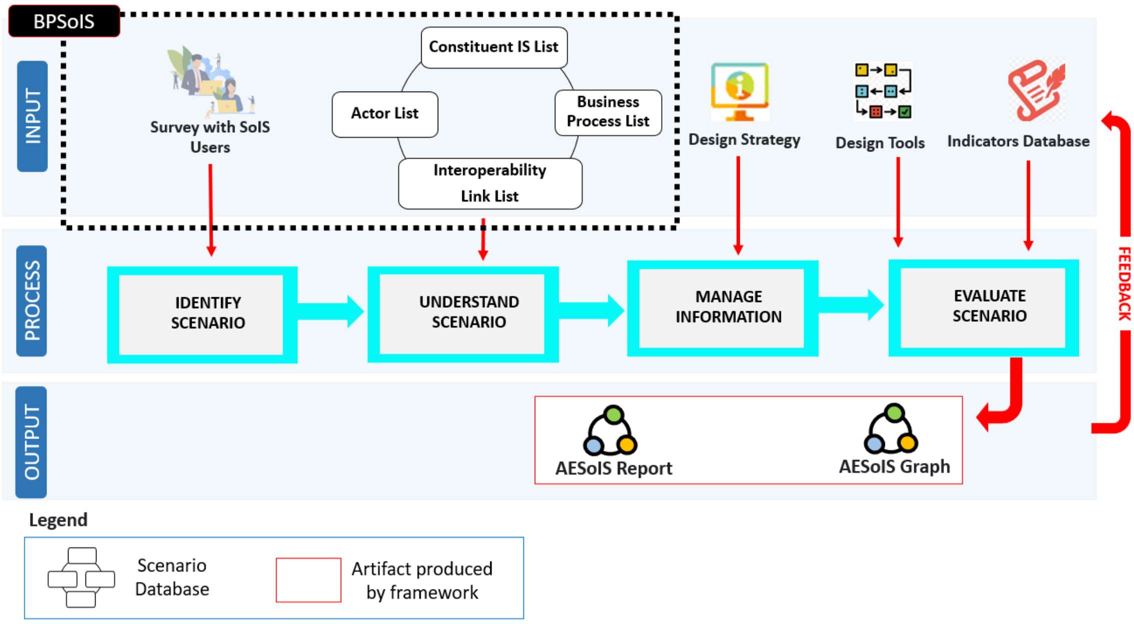

Figure 52 - AESoIS framework.

Table 24 - AESoIS framework GQM method.

Analyze	SoIS arrangement and modeling its elements
With the objective of	evaluating
With respect to	problem-solving in SoIS scenario
From the point of view of	SoIS actors (such as employees, managers, practitioners)
In the context of	organizations supported by SoIS

In addition, Figure 53 presents the Macro-process guidelines of the framework, from the point of view of employees in an organization supported with SoIS considering three BPMN sub-process: (i) prepare AESoIS data gathering; (ii) define accountability indicators; and (iii) generate AESoIS presentation.

Prepare AESoIS data gathering includes a survey for investigating an organizational problem. It is a start point for collecting data from a scenario. During this stage, the employee must define a problem to be better understood through the lens of ST, as explored with the ASM notation in Chapter 3.

Define accountability indicators is another sub-process. It focuses on defining a strategy for accountability evaluation. It is worth mentioning that an evaluation approach must map the interconnections between SoIS elements focusing on how the elements can be modeled considering ASM notation, such as relationships, causal relations, designing techniques. Furthermore, the framework must incorporate how engagement, management, and regulation analysis will be analyzed, focusing on scenario improvements based on an indicator repository.

The final stage at the macro-process is the **Generate AESoIS presentation.** It encompasses a set of activities for supporting AESoIS modeling, considering the previous meta-process, as inputs. In order to detail the macro-process, APPENDIX IV describes three sub-processes that integrate the AESoIS framework in detail.

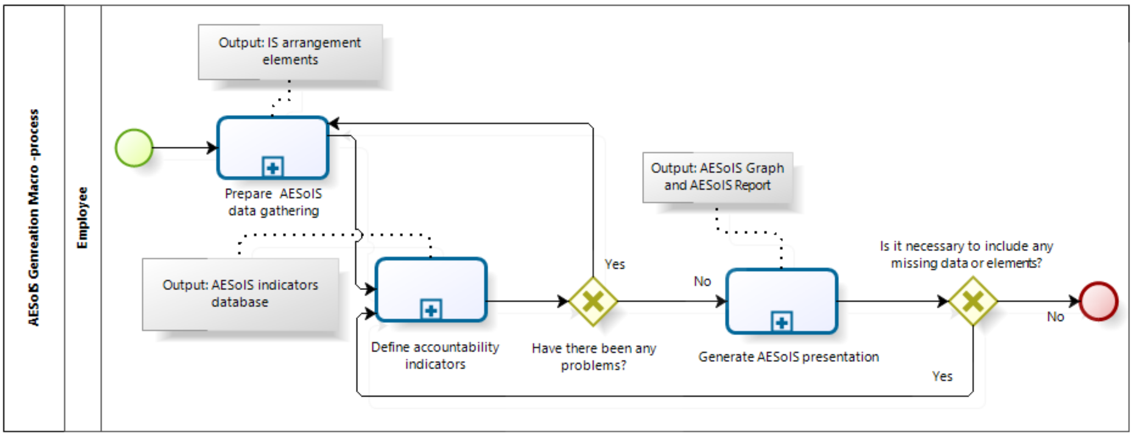

Figure 53 - AESoIS Generation Macro-process.

6.3 Instruments and Preparation

After developing the AESoIS framework, we performed, from March to July 2021, weekly meetings to integrate the AESoIS framework into BPSoIS. Thus, the process of identifying a scenario started by investigating the academic department of a public education institution, as detailed in Oliveira (2021).

At this point, BPSoIS data and BPMN files were analyzed. The extracted files describe the business processes and organizational goals, which details relevant information about the academic department of a public education institution supported by SoIS. In this context, **understand scenario process** focused on understanding the academic department scenario through SoIS elements lens and feedbacks for improving the academic SoIS. Table 25 describes this feedbacks.

To cope with AESoIS integration, we assume it must incorporate improvements identified by Oliveira (2021). In fact, Oliveira (2021) detailed that the improvements resulted from 12 participants who analyzed a set of assumptions about SoIS interoperability in the academic department scenario. Among the improvements, ***automate manual systems*** is one open problem: **students' requirements are manual**, as mentioned by a participant. Additionally, during the meetings, the technologies for tooling support were defined regarding standards and programming language.

Table 25 - Identified problems in BPSoIS analysis. Source: (Oliveira, 2021).

Category	Improvements
Systems	Automate/Computerize processes. Computerize/Digitize documents filed in folders. Implement a single management system to centralize all processes. Improve current computer systems. Perform integration between automated systems. Automate manual systems. Centralize sector data in the academic system. Use digital/electronic signatures, or QR Code, in processes.
Process	Continuous improvements in processes. Reduce bureaucracy and streamline processes. Stimulate the use of process management tools to improve organizational processes.
Organizational Culture	Conduct an effective follow-up of graduates.
Employee Training	Conduct a libras training for academic department attendants.
Infrastructure	Improve accessibility for wheelchair users.

Standards (e.g., ISO) is one strategy in this thesis used for defining accountability criteria. Standard strategy lies in being produced from a global consensus, contributing to the evaluation analysis (Abreu *et al.*, 2013; Georges, 2013). Furthermore, it highlights environment dynamics, problem-solving aiming to ensure quality products and services (Ursini & Sekiguchi, 2005). Thus, concerning accountability criteria, it focuses on indicators selected by the thesis ‘author and analyzed by researchers with knowledge of evaluation metrics in IS and Software Engineering. In addition, beyond the standard strategy, the indicators databases incorporate user experience as an approach to integrates organizational decisions to stimulate engagement, management, and regulation. Allam *et al.* (2013) provide an overview of several definitions for user experience in industry and academy, for example:

> “*a person’s perceptions and responses that result from the use and/or anticipated use of a product, system or service*”;
>
> “*all the aspects of how people use an interactive product: the way it feels in their hands, how well they understand how it works, how they feel about it while they are using it, how well it serves their purposes, and how well it fits into a context in which they are using it*”’; and
>
> “*a term that describes users’ feelings towards a specific product, system, or object during and after interacting with it. Various aspects influence the*

feelings, such as user's expectations, the conditions in which the interaction takes place and the system's ability to serve user's current needs".

In common, these definitions share the sense of providing feedback for supporting evolution. Thus, we argue that is relevant to SoIS modeling incorporates feedbacks from those involved. In this context, the AESoIS database manages the accountability criteria concerning standards and user experience. In this way, AESoIS manages two strategies related to the accountability criteria to support SoIS managers. To organize both strategies, a set of indicators based on standards is presented, while user experience indicators are created separately for the user's convenience.

As an example of standards indicators, Table 26 organizes engagement indicators from AA1000 (AccountAbility, 2015). AA1000 (2015) establishes a benchmark for good-quality engagement. AA1000 focuses on people engagement that affects and/or could be affected by an organization's activities, products, or services and associated performance regarding the issues addressed within the engagement. The standard asserts engagement is:

> "*a fundamental accountability mechanism, since it obliges an organization to involve stakeholders in identifying, understanding and addressing sustainability issues and concerns, and to report, explain and respond to stakeholders for decisions, actions, and performance*" (AccountAbility, 2015).

It is worth mentioning that the proposed standard indicators are selected as a preliminary approach to be evaluated during the tool's execution. It is not the thesis focus to detail all evaluation indicators for SoIS context, but rather to indicate the relevance of the indicators to improve accountability. Therefore, the following indicators tables detail ten indicators for evaluating processes and improving products and services assessment. Tables are organized with identification and description.

Regarding management, considering that there is no accountability-oriented management standard, ISO 21001 (2018) is used, although there are undoubtedly other standards related to management. It is worth mentioning that the standard focuses on management in the educational context, which is a thesis target of interest.

Table 26 - Engagement indicators. Source: (AccountAbility, 2015).

Identification	Description
Integrating governance	The organization shall integrate stakeholder engagement into governance and relevant decision-making processes. Governance and decision-making processes are relevant when they are associated with an issue or action that will have a material impact on a stakeholder or affect how a stakeholder impacts the organization.
Developing an engagement plan	Managers shall develop an engagement plan. The engagement plan shall be made available to stakeholders. Stakeholders shall have the opportunity to provide input into the plan.
Inviting stakeholders to engage	Managers shall ensure that stakeholders are invited to participate reasonably well in advance and that communications are appropriate for each stakeholder.
Establishing indicators	Stakeholders shall have the opportunity to provide input when establishing the indicators. The indicators shall be meaningful to the organization and its stakeholders. Indicators allow an organization to measure and evaluate the progress towards achieving quality stakeholder engagement output and outcome, identify areas for improvement, and demonstrate the value-added through engaging with stakeholders.
Identifying and preparing for engagement risks	Managers and stakeholders shall identify and address engagement risks: (i) conflict between participating stakeholders; (ii) unwillingness to engage; (iii) participation fatigue; (iv) creating expectations of change what the organization is unwilling or unable to fulfill; (v) lack of balance between weak and strong stakeholders; disruptive stakeholders; (vi) uninformed stakeholders; and (vii) disempowered stakeholders. Managers should make contingency plans to deal with the most likely or damaging risks.
Reporting on engagement	Organizations shall publicly report on their stakeholder engagement. Communicating to stakeholders on the value and impact of engagement should go beyond providing feedback to stakeholders who participated in specific engagements. The organization should publicly report on the aggregate of its engagement activities to demonstrate how they contribute value to the strategy and operations of the organization. Organizations should integrate public reporting on stakeholder engagement with other forms of public organizational reporting. Organizations should have the public reports independently assured. Independent external assurance of public reporting will increase the learning from engagement and increase the report's credibility.
Mobilizing resources	Managers shall identify and gain approval for the resources required for successful engagement. Resources are required for the engagement process itself and to make the necessary changes responding to the outputs of engagement. Engagement outputs may have significant consequences for an organization’s strategy and operations. Therefore, it is important to consider the resource requirements of them. Resource requirements should have been developed and documented in the engagement plan. The resources required for the engagement process will include the financial, human (including capacity building), and technological resources required for those carrying out the engagement and the stakeholders invited to participate.
Determining engagement level(s) and method(s)	Managers shall determine the level(s) and method(s) for engaging with stakeholders that are best suited to the purpose and scope of engagement and to the relevant stakeholders. In determining engagement level(s), the owners of the engagement define the nature of the relationship they have or aim to develop with their stakeholders. Engagement may take place at more than one level. Managers may choose to engage with stakeholders in one segment of its stakeholder map at one level and with stakeholders in another segment of the stakeholder map at another. The level of engagement may also change over time as relationships deepen and mature: (i) consult methods: Surveys, Focus groups, Individual dialogue, Meetings with selected actors, Public meetings, Online feedback mechanisms, Advisory committees; (ii) involve methods: Multi-stakeholder forums, Advisory panels, Consensus building processes, Participatory decision-making processes, Online feedback schemes, Workshops; (iii) Negotiate methods: Collective bargaining with workers through their trade unions, Contract negotiations; (iv) collaborate methods: Joint projects, Joint ventures, Partnerships, Multi-stakeholder initiatives; and (v) empower methods: Integration of stakeholders with governance, strategy, and operations.
Building capacity to engage	Managers and the stakeholders shall identify where the capacity to engage needs to be built. The engagement owners shall work with the stakeholders to respond appropriately to these needs to enable effective engagement. Engagement processes are likely to involve various people with different levels of specialistise, confidence, and experience. It is important to appreciate that some groups and individuals may find it difficult to take up an invitation to engage or that circumstances may hinder them in fully contributing to the engagement.

ISO 21001 (2018) defends certain premises that are related to the discussion on accountability developed in this thesis, such as (i) better alignment of objectives and activities with policy (including mission and vision); (ii) enhanced social responsibility by providing inclusive and equitable quality education for all; and (iii) widened participation of interested parties. Table 27 ranks indicators from ISO 21001 (2018).

Table 27 - Management indicators. Source: (ISO 21000, 2018).

Identification	**Description**
Designing and developing controls	The organization shall apply controls to the design and development process to ensure that: (i) the results to be achieved are defined; (ii) reviews are conducted to evaluate the ability of the results of design and development to meet requirements; (iii) verification, and validation activities are conducted to ensure that the resulting educational products and services meet the requirements for the specified application or intended use; and (iv) any necessary actions are taken on problems determined during the reviews, or verification and validation activities.
Designing and development changes	The organization shall identify, review and control changes made during, or subsequent to, the design and development of products and services to the extent necessary to ensure that there is no adverse impact on conformity to requirements or results. It concerns to (i) design and development changes; (ii) the outcomes of reviews; (iii) the authorization of the changes; and (iv) the actions are taken to prevent adverse impacts.
Communication purposes	Internal and external communication shall have the purpose of (i) seeking the opinion or consent of relevant interested parties; (ii) conveying to interested parties relevant, accurate and timely information, consistent with the organization's mission, vision, strategy, and policy; and (iii) collaborating and coordinating activities and processes with relevant interested parties within the organization.
Developing the policy	Managers shall establish, review and maintain an organization policy that: (i) supports the organization mission and vision; (ii) is appropriate to the purpose and context of the organization; (iii) provides a framework for setting organization objectives; (iv) includes a commitment to satisfy applicable requirements; (v) includes a commitment to continual improvement; (vi) takes into account relevant educational, scientific and technical developments; (vii) includes a commitment to satisfy the organization's social responsibility; (viii) describes and includes a commitment towards managing intellectual property; and (ix) considers the needs and expectations of relevant interested parties.
Addressing risks and opportunities	The organization shall determine risks and opportunities that need to be addressed to (i) give assurance that the organization can achieve its intended outcome(s); (ii) enhance desirable effects; (iii) prevent, mitigate or reduce, undesired effects; and (iv) achieve continual improvement.
Identifying organizational roles, responsibilities, and authorities	Top management shall ensure that the responsibilities and authorities for relevant roles are assigned and communicated within the organization, considering: (i) ensuring conforms to document requirement; (ii) ensuring that the organization policy is understood and implemented; (iii) ensuring that the processes deliver their intended outputs; (iv) reporting on the performance and on opportunities for improvement to top management; (v) ensuring the promotion of a focus on learners and other beneficiaries throughout the organization; (vi) ensuring that the integrity of the system is maintained when changes are planned and implemented; (vii) managing the organization's communications; (viii) ensuring that all learning processes are integrated, regardless of method of delivery; (ix) control of documented information; and (x) managing the requirements of learners with special needs.

In the context of regulation, the ISO 38500 (2015) provides guidelines for IT use in an organization (Table 28). It should be noted that there is no standard addressing regulation for accountability. However, there are undoubtedly several standards providing guidelines for supporting regulation regarding protocols, laws, and norms. Moreover, considering the analogy of regulation with technology to ISO 38500 (2015) emphasizes aspects related to legal, regulatory, and ethical obligations with IT use.

Table 27 - Management indicators. Source: (ISO 21000, 2018) (Part 2).

Evaluating resource support	The organization shall determine and provide the resources needed for the establishment, implementation, maintenance, and continual improvement on an organization in such a way that they sustainably enhance: (i) learner engagement and satisfaction through activities that improve learning and promote the achievement of learning outcomes; (ii) staff engagement and satisfaction through activities to improve staff competencies to facilitate learning; and (iii) other beneficiary satisfaction, through activities that contribute to the social benefits of learning.
Supporting awareness identification	The organization shall ensure that relevant persons doing work under the organization's control shall be aware of: (i) organization policy and strategy and relevant organizational objectives; (ii) their contribution to the effectiveness of work, including the benefits of improved organizational performance; and (iii) the implications of not conforming with organizational requirements.
Facilitating workforce	The facilities shall include, as applicable, the following facilities that meet workforce requirements: (i) equipment including hardware and software; and (ii) utilities.
Encouraging competence	The organization shall: (i) determine the necessary competence of person(s) doing work under its control that affects its organization performance; (ii) ensure that these persons are competent based on appropriate education, training, or experience; (iii) establish and implement methods for evaluating the performance of staff; (iv) where applicable, take actions to acquire the necessary up to date competence, and evaluate the effectiveness of the actions taken; (v) take actions to support and ensure the continual development of relevant staff competence; and (vi) retain appropriate documented information as evidence of competence.

Table 28 - Regulation indicators. Source: (ISO/IEC 38500, 2015).

Identification	**Description**
Pursuing compliance to meet the organizational objective	Create possibilities for individuals and groups to learn about the mandatory legislation and regulations that support the activity, notably by detailing the policies and practices being defined, implemented, and enforced.
Creating contingency plan for changes	Define a strategic plan for change situations in the organization so that operations are planned and managed. The impacts of the change on the business and on operational practices, information systems, existing and expected infrastructure, and the interested parties that participate must be considered.
Creating a plan on expected stakeholder responsibilities	Create plans and policies that describe expected responsibilities, considering the conditions for their implementation, such as the need for infrastructure, various investments, and information technology operations.
Defining relevant indicators	Consider strategic indicators for the business. Indicators serve as a beacon for evaluating strategies, proposals, and arrangements for service provision (internal, external or both). Thus, indicators can reflect different types of pressures (internal or external) that influence the business, such as technological changes, economic trends, social and political influences.
Encouraging digitalization	Encourage a culture of good IT governance so that organizational information is made available on time and in the best format, complying with guidelines and compliance. Paying attention to good governance principles (accountability, strategy, acquisition, performance, compliance, and human behavior).
Checking the performance of activities.	Managers must assess the resources (human, financial, technological) that support the business processes with the necessary capacity and competence. In addition, proposals should address the treatment of risks associated with the use of IT.
Investigating resource	Managers should allocate sufficient resources to ensure that the support teams meet the organization's needs in line with planning priorities and budget constraints. The need to keep data updated and protected from loss or misuse is highlighted.
Investing in monitoring	Managers should monitor the extent to which the IT staff supports the business. In addition, managers should monitor the extent to which policies, such as those relating to data accuracy and the efficiency of IT use, are properly executed.
Monitoring compliance	Managers should monitor IT compliance and compliance through appropriate reporting and auditing practices. Critical analyzes must be ensured within the deadlines and carried out in a comprehensive and proper manner to assess the degree of satisfaction of the business.
Directing human behavior	Managers should demand that IT activities be compatible with differences in human behavior. Thus, the analysis of risks, opportunities, findings, and concerns should be identified and reported at any time. Risks should be analyzed in accordance with published policies and procedures that influence decision-making.

6.4 AESoIS Tool

In this section, features of the tool are presented, considering the sub-processes of AESoIS framework guidelines in Section 6.2. The listing of the development process, all features, and screens are described in APPENDIX V. Concerning to AESoIS solution, the integration starts when a user accesses the bottom side button (1), detailed as (2) AESoIS module and its AESoIS indicators database (see). At this point, the module considers the existence of BPSoIS data for modeling the accountability evaluation approach and the option for managing AESoIS indicators that supports evaluation by defining news or editing indicators. Figure 54 shows the initial AESoIS module by defining AESoIS project metadata (owner, title, organizational objective, problem definition, and problem description).

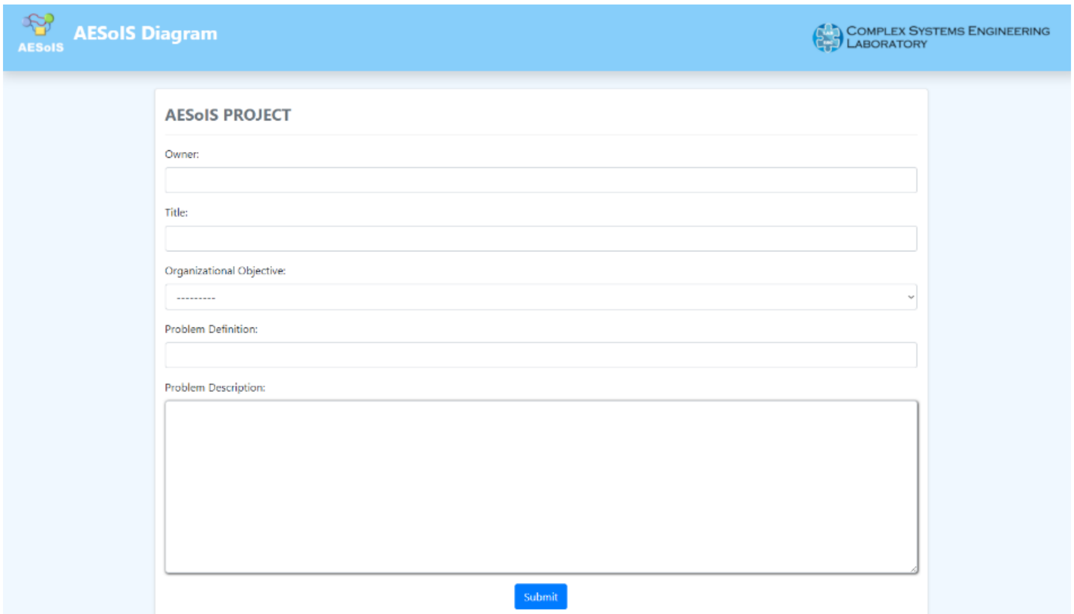

Figure 54 - AESoIS Project Description.

To illustrate the **Define Accountability Indicators sub-process**, Figure 55 presents a screen for managing AESoIS indicators. First, it shows an option for adding new indicators by selecting indicator type (i.e., standard or user experience - UX). At this point, the tool's user can define new indicators to be addressed, considering the accountability criteria type, a standard source, a title for the indicator, and a description about the indicator, e.g., indicator goal, indicator strategy, and indicator guidelines.

Next, it allows the definition of new indicators based on the standards approach. It considers a description for the indicator based on standard guidelines, standard definition, an accountability criteria type, an identification for the indicator, and its description. Manage AESoIS Indicators screen is important, as the design elements are integrated into the database. That is, by choosing a certain accountability criterion, the tool presents a list of previously registered indicators. Furthermore, the tool allows this record if the tool's user decides to define the new indicator at runtime. For example, let’s assume that the tool's user has an insight when modeling the problem, and the user decides on a new engagement indicator, then a new indicator can be defined.

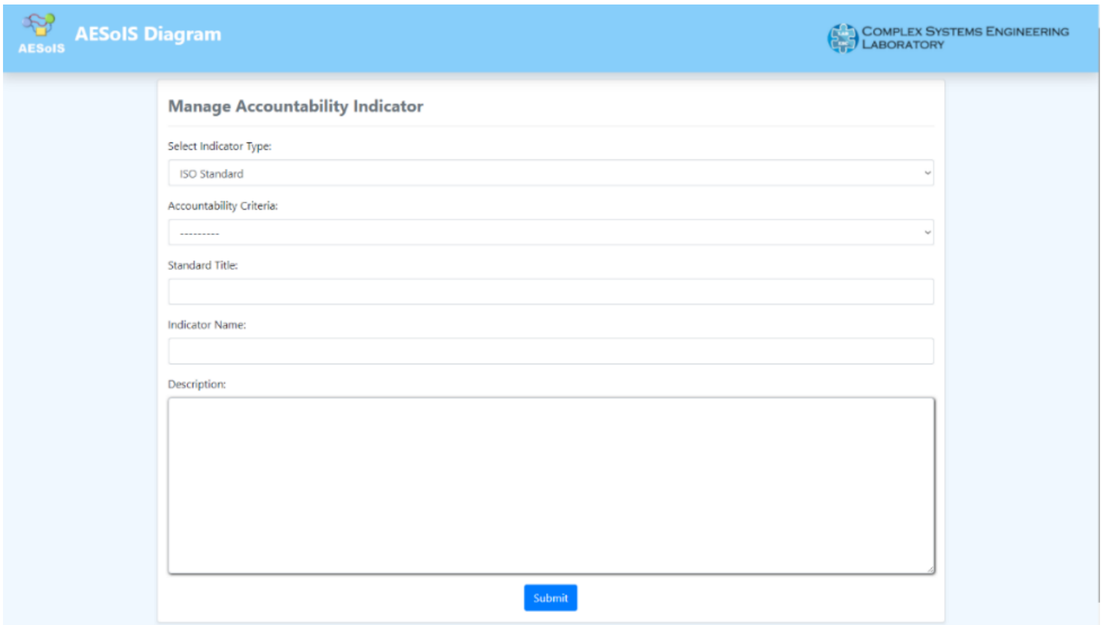

Figure 55 - AESoIS indicator management screen.

Regarding **Prepare AESoIS Data Gathering sub-process**, Figure 56 to Figure 59 present the initial AESoIS processing, which details basic guidelines concerning a problem definition. As previously described, the data collection process involves the BPSoIS data gathering. Therefore, all constituent IS, actors, business processes, and tasks are available for evaluation. In this way, the tool lists each element, and the user must select those related to the investigated problem, as a subset of elements. This strategy aims to automate the systems thinking process, as the elements presented are potential modeling elements to be incorporated into the diagram.

However, it is worth noting that the collection process strategy does not end at this stage. It is possible that during the problem modeling process, a user wants to represent other elements (i.e., user may have forgotten a relationship or has perceived an influence during modeling). Thus, at runtime, the tool provides the opportunity to define the elements’ constituent IS, actor, and responsibility vertices, further accountability criteria.

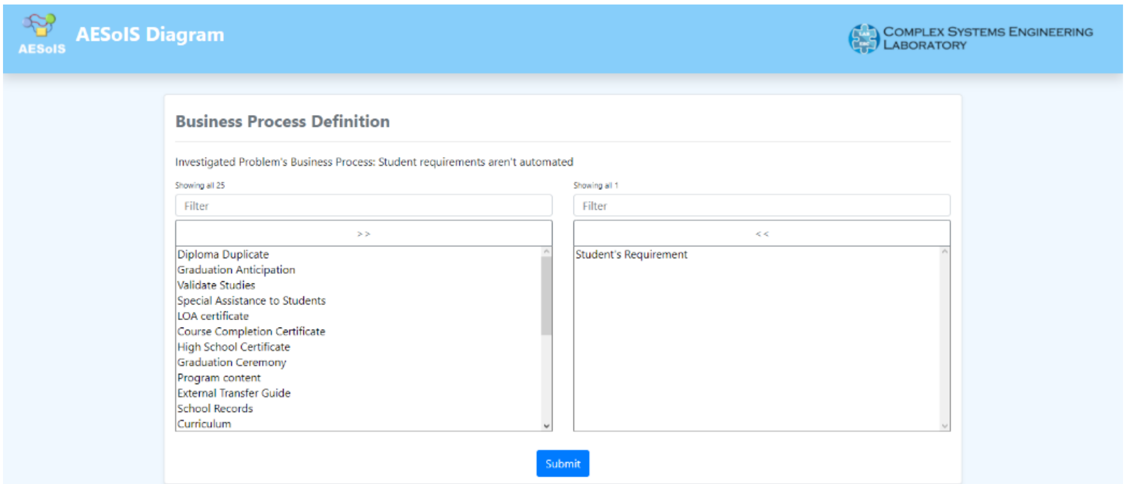

Figure 56 - Business Process Definition of AESoIS screen.

Figure 56 shows a list of BPSoIS business process that is organized considering an investigated problem into AESoIS. At this point, the AESoIS user defines the business process which is related to the investigated problem (*Student requirements aren't automated*). As a result, a business process is selected (*Student's Requirement*).

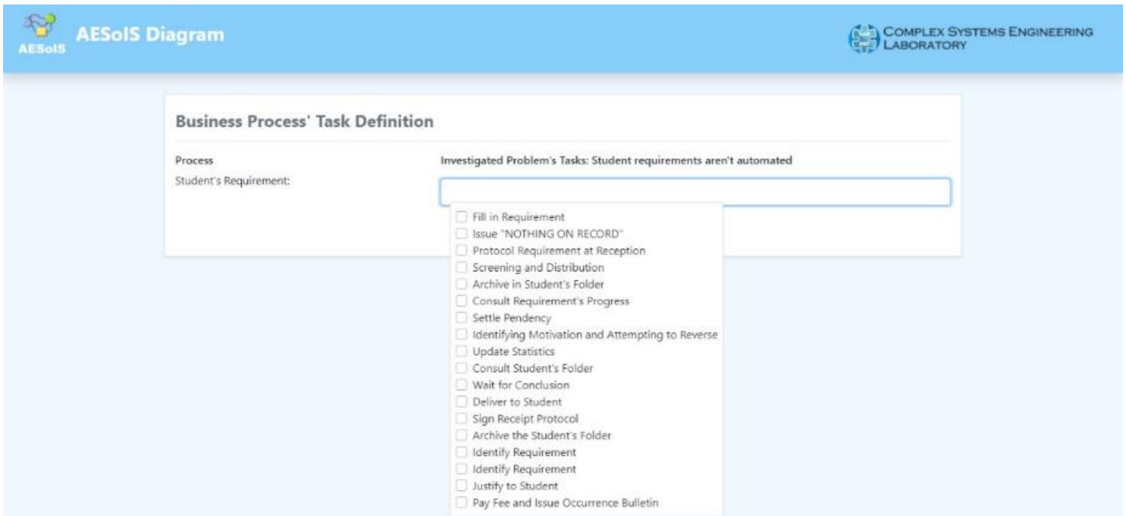

Figure 57 - Business Process Tasks Definition of AESoIS screen.

Once the related business process is defined, the AESoIS presents a filter with related business tasks, as shown in Figure 57. At this point, the AESoIS user defines the business task which is related to the investigated problem. Concerning to actors' definitions, Figure 58 demonstrates a filter with related actors that supports the business process. Additionally, Figure 59 shows a strategy for renaming business tasks. During the AESoIS development process, we identified that some tasks have extensive labels, which can generate AESoIS diagrams elements with extensive labels. To mitigate that, the AESoIS user can define responsibility vertex. Such approach defines the elements responsibility vertex into AESoIS modeling, as a result of renamed business tasks.

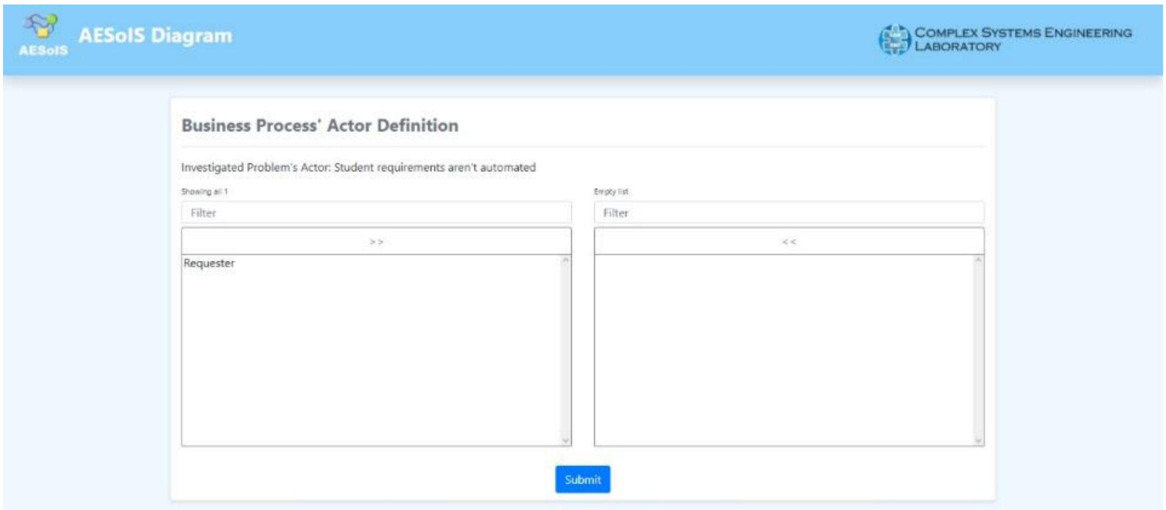

Figure 58 - Business Process's Actor Definition of AESoIS screen.

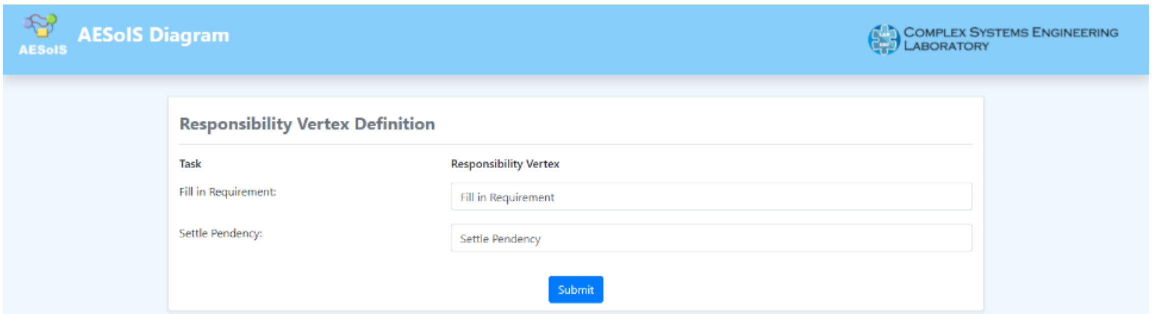

Figure 59 - Responsibility Vertex definition.

Figure 60 presents the initial screen for modeling from **Generate AESoIS Presentation sub-process** with the environment defined. The design area is divided into (i) the upper bar, which encompasses modeling elements, and (ii) a workspace, which encompasses a gray gradient form for describing time impacts, and a support area for modeling. The gradient design represents a region that incorporates temporal effects regarding immediate, gradual, and structural. The support area (light blue), on the other hand, is a region to support elements outside causal loops and accountability criteria. For example, assume a diagram formed by two causal cycles, where the first describes an immediate felt situation and the second a gradual-effect situation. In these cases, each cycle is in the respective gray gradient region. In contrast, the blue region must display supporting elements such as actors, textual elements, and accountability criteria that influence the cycles.

The tool is used by pressing the buttons (drag-and-drop) for drawing elements. IS node icon, Actor node icon, and Vertex node icon are designing resources that allows the selection of previously selected BPSoIS elements or even new elements at the tool's runtime. It is made possible by transposing data from the BPSoIS database to the AESoIS database. In contrast, the accountability criteria icon presents a list of accountability indicators based on the AESoIS indicators database, considering that it is possible to select registered indicators or create new indicators at the time of the tool's execution. Additionally, the Text node icon describes basic textual information for supporting systems thinking, the text variables. For example, Figure 61 demonstrates the Manage Information System Screen. It defines two options: (i) select from an indicator database or (ii) create a new indicator. It is worth mentioning that the tool uses an additional function to additional elements. Thus, the user must return the selection option and choose the registered element for each element registered in the tool's runtime.

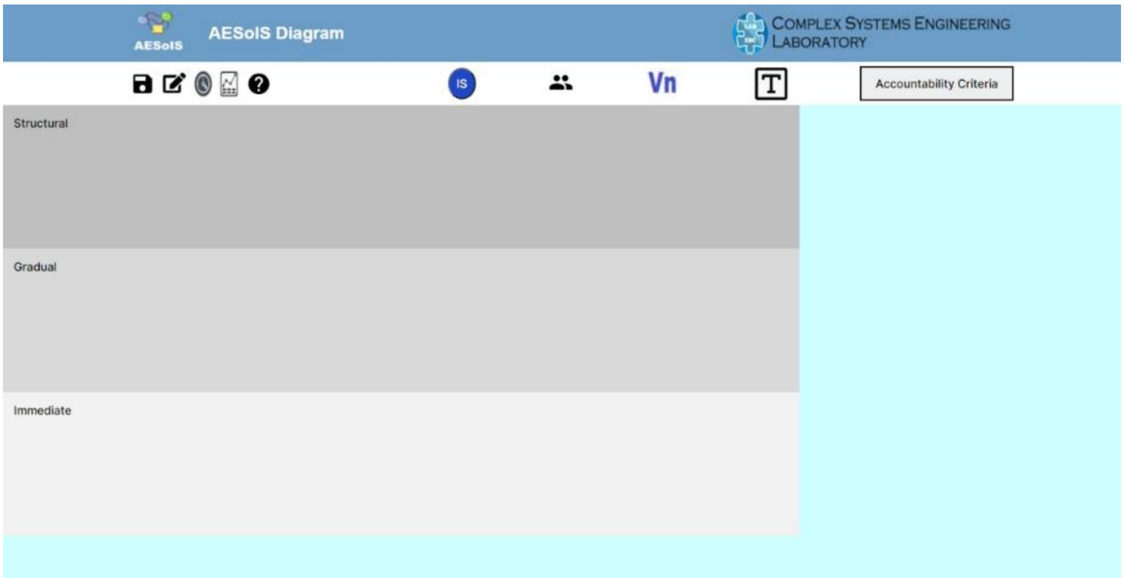

Figure 60 - AESoIS modeling screen.

For example, consider a new engagement indicator: "XPTO". To insert "XPTO" in the diagram, the user must define between "Select" and "Add". "Select" defines pre-classified indicators, while "Add" permits the creation of news indicators. Since the example is new, then the "Select" option must be chosen. It is worth mentioning, that AESoIS modeling elements such as the actor node, IS node, and vertex node has the option of customization, e.g., the accountability criteria property model (Figure 61). Property modal is accessed when selecting the right mouse button. Thus, it presents the element properties formed by rename element, combined with four accountabilities attributes: conditions, obligations, sanctions, responsibilities. In this context, Figure 62 shows the Manage Information Systems Properties. It encompasses the accountability attributes and permits that a set of data to be added by selecting a property focus. Regarding associations between elements, the tool automates links. Thus, the tool's strategy mitigates the need for the user to previously define a specific association by defined at ASM layout, e.g., the association between constituent IS must use a red link. In this context, the tool in runtime automatically allows: (i) causal cycles encompasses arrows with positive, negative, or default; (ii) interoperability between constituent IS occurs with a red link, and a blue arrow connects; and (iii) accountability criteria to some diagram element. Finally, with the decision to create a digital tool, the ASM layout was explored, and the following features were added to AESoIS: Project saving; Runtime saving; Configuration of Time Impacts; Report Generation in PDF format; Tool Help; and Management of Accountability Indicators.

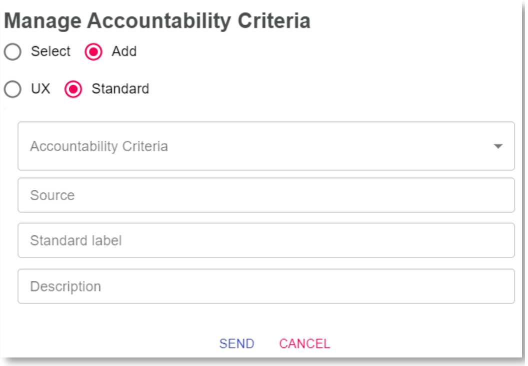

Figure 61 - Example of adding standard.

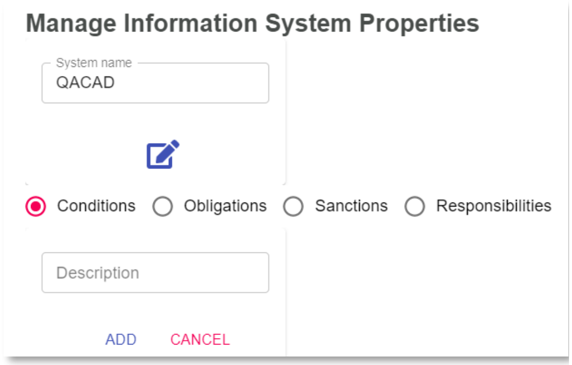

Figure 62 - Manage IS properties screen.

6.5 Final Remarks

Considering the lack of research that combines accountability evaluation with SoIS, the AESoIS framework is built upon sustain accountability analysis and SoIS scenario modeling. One contribution of this thesis is the proposal of the AESoIS framework for integrating AEM, ASM to support the creation of domain problem-solving based on ST. Additionally, the AESoIS framework addresses challenges presented at the SMS. It explores accountability criteria combined with the need to demonstrate relationships between elements that make up a SoIS to support modeling SoIS context.

As described, the AESoIS framework establishes ST analysis, carried out with the support of techniques and guidelines. As noted throughout the chapter, the approach proposed, this thesis's most significant contributions and work effort are concentrated in modeling SoIS scenario, performed through the evaluation strategy.

In this context, the framework aims to help an employee to understand causal relationships and map their relationships, manage accountability properties (condition, obligation, sanction, and responsibility), and visualize the SoIS dynamics concerning a scenario. The diagram proposal provides interactive drawing tools for modeling relationships and SoIS elements. Regarding the modeling tool for SoIS, the AESoIS framework focuses on representing actors, business tasks, and constituent IS interconnections, considering accountability criteria as suggestion indicators. Additionally, the AESoIS tool allows a problem investigation in drawing screen, through ST lens concern to existing or new data, considering the proposed framework steps.

Regarding the above conclusion, the next chapter reports on the evaluation of the AESoIS solution, mainly addressing business process problems, considering several constituents IS that must operate together in a real case. The focus is on identifying associations among constituent IS, considering conditions faced by actors, business process, and accountability criteria for supporting SoIS modeling.

Chapter 7 - AESoIS Tool Evaluation

This chapter presents a feasibility study, as part of the fourteenth methodology phase. It aims to evaluate the AESoIS tool in two educational organizations. Initially, AESoIS is evaluated by three participants, who received some tasks to be accomplished in one organization (Educational Organization #A). Second, two participants evaluated the AESoIS in a second organization (Educational Organization #B), considering free modeling in SoIS scenario. Such participants have large experience in modeling. The evaluation aims to verify the ease of use and usefulness of AESoIS in modeling SoIS arrangement activities from the academic management practitioners' perspective. This type of evaluation is explored in educational organizations cooperating with AESoIS tool, concerning effectiveness.

This chapter is organized into sections as follows: introduction, planning, execution, results and discussions, threats to validity, and the final remarks.

7.1 Introduction

This chapter presents the experimental studies carried out in the context of this thesis. It explores the importance of investigating a new tool. In this context, Althuizen (2018) argues that understanding personal acceptance and use of information technology has vastly improved how people accept and use new technologies. Concerning Venkatesh *et al.* (2003), several theoretical models explain technology acceptance and use regarding acceptance technology research. Such theories focus on different techniques for evaluating attitudes, intentions, and actual behavior (Althuizen, 2018). Specifically, in the context of theoretical models in our study, we used part of the Technology Acceptance Model (TAM), as proposed by Davis (1989), to evaluate AESoIS.

TAM is one of the most influential strategies in academic studies to measure technology acceptance and has a robust theoretical foundation and extensive experimental support (Hu *et al.*, 2009; Hernandes *et al.*, 2010). TAM is designed to predict information technology/usage on software, and it has been widely applied to a diverse set of technologies and users (Venkatesh *et al.*, 2003).

Based on this, measuring technology acceptance/use is fundamental for the success of new technology introductions, helping users understand tasks and planning interventions (e.g., training, collaborating etc.). However, measuring SoIS is more complex, as it encompasses functions bringing even more complex feature sets. At the same time, they are becoming more interactive, demonstrating the evident shift from the command line interaction paradigm to the graphical interface.

We then proposed an approach for evaluating the AESoIS tool in two real educational organizations, as a scenario. First, it considers the study of Olivera (2021), who developed an exploratory study at an educational organization with SoIS to support organizational objectives. In such a study, some organizational problems are identified in the context of the academic department. Therefore, the first phase encompasses a tool evaluation in Educational Organization #A, considering a controlled scenario. In such an approach, study practitioners are invited to use the AESoIS tool following a set of tasks associated with the problem-solving understanding. During the execution of the evaluation study, each participant can create diagrams related to an investigated problem. For example, "*Select the System Node option in the button bar, and then choose the Qualidata IS placing it in the area of immediate effect*" is a type of guided task from the first evaluation study.

Secondly, the evaluation focuses on free modeling a scenario based on exploratory study findings proposed in Chapter 4 into AESoIS. It considers an evaluation in an Educational Organization #B regarding a not controlled scenario. At this point, IS practitioners are invited to model a problem into the AESoIS tool, considering their SoIS scenario for modeling the proposed problem. Thus, while the first phase focuses on a controlled scenario with tasks guidelines for supporting problem-solving, the second phase permits participants to create a runtime solution from AESoIS. For example, "*Identify and model the information systems that influence the investigated problem*" is a type of generic task of the second study.

Both studies aim to collect information about the ease of use and usefulness of AESoIS. From the above overview, we propose to use TAM (Davis, 1989) to evaluate the AESoIS tool. TAM's evaluation is bases on two concepts: (i) *perception of ease of use*; and (ii) *perception of usefulness*. According to Polancic (2010), TAM model strengths are: (i) focusing on specific information of technologies; (ii) solidifying several kinds of research and reliability influences; (iii) extensibility; and (iv) it can be used during and after the adoption of a particular technology (Santos, 2016). Therefore, to evaluate the AESoIS, a feasibility study is conducted with practitioners in a real scenario problem (i.e., SoIS practitioners with experience in educational organizations, supported by SoIS). Feasibility studies focus on characterizing a technology to ensure that it does what it asserts to do and is worth an extra effort to develop it, as potential effects of changes in emerging technologies (Shull *et al.*, 2001). To cope with the feasibility study, it was divided into two phases.

From the above introduction, the chapter details the feasibility study developed considering the following phases: (i) planning; (ii) execution; (iii) analysis; and (iv) results and discussion. Figure 63 details the evaluation method. Furthermore, the AESoIS evaluation aims to investigate the third research question of this thesis: "***Is the proposed AESoIS tool feasible to aid practitioners in performing accountability analysis with effectiveness***" (RQ3).

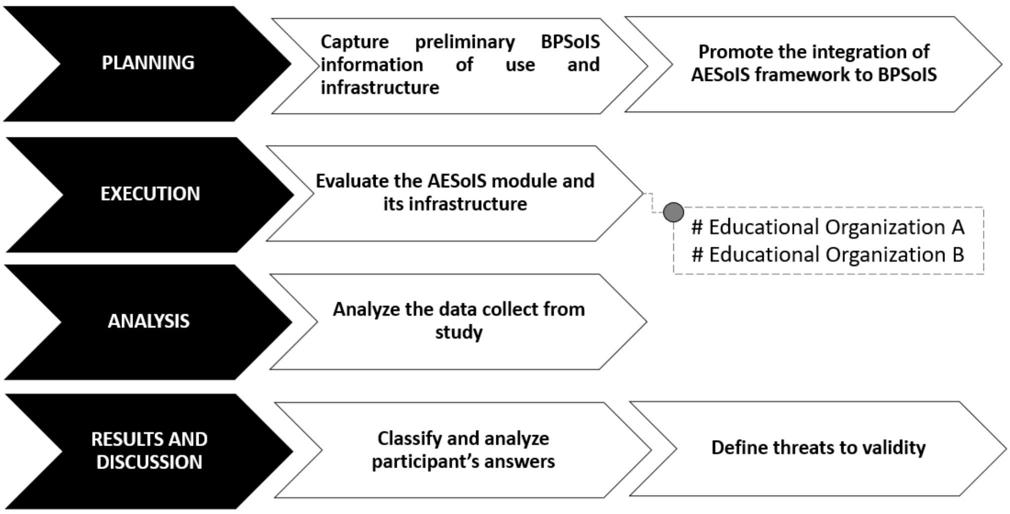

Figure 63 - Evaluation method.

7.2 Planning

This section plans the evaluation process through a feasibility study for supporting AESoIS. Initially, we are particularly interested in the BPSoIS method since it helps the identification of interconnections between actors, tasks, and constituent IS. Furthermore, we are also interested in automating part of the representation of the AESoIS by combining it with a database and a repository of accountability criteria, as proposed in ASM. Thus, the planning phase faces two strategies: (i) capture preliminary BPSoIS information of use and infrastructure; and (ii) promote AESoIS modeling. Second, beyond the BPSoIS solution, this section presents an investigated problem in two educational organizations (A and B), organized as follows: (i) controlled scenario, which is formed by a set of tool tasks addressing a scenario in the organization A; and (ii) uncontrolled scenario, which encompasses a problem and participants are invited to model a solution for the organization B. It is worth mentioning that in both scenarios, participants received training to use the AESoIS notation and tool processing.

7.2.1 Objective

The primary purpose of this study is to evaluate our approach for AESoIS modeling as a module for BPSoIS, more specifically, AESoIS. Secondary goals took place over evaluating the infrastructure regarding ease of use and usefulness from this main goal. Study goals are defined accordingly to the GQM paradigm (Basili *et al.*, 1994). Figure 64 describes a set of questions related to characterizing the influence of AESoIS in modeling SoIS activities (Q01 to Q034 and Q13 to Q17). It shows the other questions (Q05 to Q08) related to G2 and G3 (Q09 to Q12). Three goals are described in Table 29 (evaluating strategy), Table 30 (ease of use), and Table 31 (usefulness).

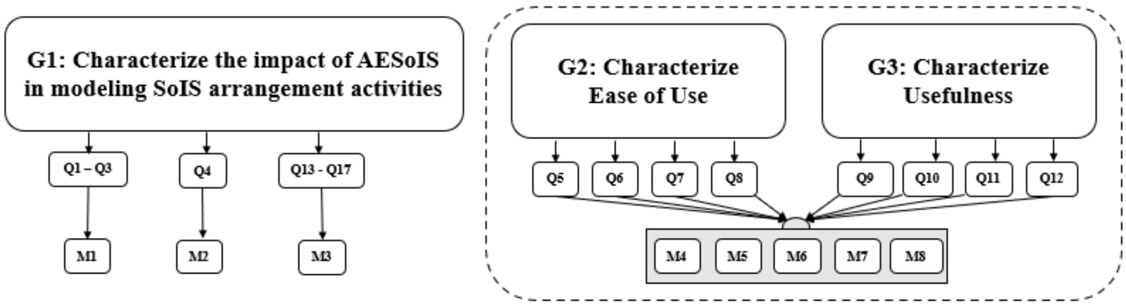

Figure 64 - GQM model for AESoIS module.

As detailed in Figure 64, the questions aim to capture the dimensions of ease of use and usefulness of our approach combined with user use perception, as proposed by Hernandes *et al.* (2010) and Santo (2012). Thus, some questions are related to use perception. Questions 1 to 3 can be answered with (M1), and question 4 can be answered with (M2). Such questions organize initial questions before the TAM. Questions 13 to 17 can be answered with (M3) and represents the final questions after the TAM (see Table 32). Metrics are organized as follows: (i) M1 - Number of participants who choose “Yes”; “Partially”; or “No”; (ii) M2 - Number of participants who choose “Executing the tasks is very difficult”, or “Executing the tasks is difficult”, or “Performing tasks is easy”, or “Executing the tasks is straightforward”; and (iii) M3 - Number of participants who choose “Comment your answer”, which represents open questions.

Table 29 - Goal G1.

Analyze	AESoIS framework and tool
With the purpose of	characterizing
With respect to	the influence of AESoIS in modeling SoIS arrangement activities
From the point of view from	academic management practitioners
In the context of	organizations that operate with SoIS and its infrastructure

Table 30 - Goal G2.

Analyze	AESoIS framework and tool
With the purpose of	evaluating
With respect to	ease of use
From the point of view from	academic management practitioners
In the context of	organizations that operate with SoIS and its infrastructure

Table 31 - Goal G3.

Analyze	AESoIS framework and tool
With the purpose of	evaluating
With respect to	usefulness
From the point of view from	academic management practitioners
In the context of	organizations that operate with SoIS and its infrastructure

Table 32 - Characterization questions.

Question	Description
Q01	Did you perform the entire set of proposed tasks?
Q02	Were you satisfied with the result?
Q03	Is it possible to see that the approach contributed to AESoIS evaluation, considering the systemic aspects, the interactions between elements, and influences of accountability, based on the information presented?
Q04	What is the degree of difficulty in carrying out the tasks?
Q13	Which features of the AESoIS tool were most useful in carrying out the tasks?
Q14	In your opinion, list the positive aspects of using the tool.
Q15	In your opinion, list the negative aspects of using the tool.
Q16	Do you have any suggestions for improving the AESoIS solution?
Q17	What conclusions or observations can you draw about the importance of accountability as a requirement to assess the SoIS scenario and its influence on the elements that describe the constructed diagram?

Furthermore, eight questions (Q05-Q12) are defined as derived from TAM: (i) four questions related to the evaluation of the use (see Table 33), and (ii) others related to usefulness (see Table 34). Participants answer each question with a value on an ordinal scale. For each question, we provided a text field for additional comments on a given answer. For each question has planned a set of related metrics, as follows: (i) M4 - Number of participants who choose "Totally Agree"; (ii) M5 - Number of participants who choose "Agree"; (iii) M6 - Number of participants who choose "Neither agree nor disagree"; (iv) M7 - Number of participants who choose "Disagree"; (v) M8 - Number of participants who choose "Strongly disagree".

Table 33 - Ease of use questions.

Question	Description
Q05	I easily learn how to use the approach.
Q06	I use the approach in the way I want to.
Q07	I understand what happened in the interaction with the tool.
Q08	I easily execute the proposed tasks with the tool.

Table 34 - Usefulness questions.

Question	Description
Q09	I think that the approach is useful for modeling SoIS demand and solutions.
Q10	AESoIS solution allows me to realize how SoIS context understanding depends on SoIS elements.
Q11	AESoIS solution improved my performance over the execution of the proposed tasks.
Q12	AESoIS solution support SoIS management activities.

7.2.2 Questions and Metrics

Once the preliminary questions are developed to understand the AESoIS tool and scenario details, this section presents the question and metrics defined for the feasibility study. The main question is detailed: **Q01: Are the participants able to realize the influence of AESoIS analysis regarding effectiveness?** This perception is measured by the participant's answers given a set of tool tasks concerning characterization questions (Q01-Q04 and Q13-Q17), ease of use, and usefulness questions (Q05-Q12). Measurement considers the following metric:

Metric - Effectiveness

Effectiveness calculation measurement describes the relation of some results with some objectives.

$$\text{Effectiveness} = \frac{number\ of\ correct\ answers}{total\ number\ of\ questions}$$

7.2.3 Context of Population

The population adopted for the study is formed by participants who work with academic management activities and an external consultant who works in a public educational organization as an academic management practitioner. Such population involves people who (i) are starting, or (ii) started analysis of academic processes for support managing activities in organizations, represented as follows:

a) External consultant: With the development of the systemic analysis research carried out in previous research (Cordeiro & Santos, 2019b; Cordeiro *et al.*, 2020), some research partnerships were created. Among them, the academic managers, when evaluating the ASM layout, expressed interest in collaborating with the thesis research. Therefore, the profile was selected because the professional works in similar scenarios and has experience supporting academic department demands.

b) Educational Organization: It describes data from two educational organizations (A and B), which use SoIS to attend to complex educational demands. It focuses on supporting the business process for high school, undergraduate, master's, and doctorate courses' needs. Therefore, the academic managers were contacted and asked if they would enjoy participating in the research.

7.2.4 Data

During the evaluation study, we captured the following data, as proposed by Albusays *et al.* (2021): (i) responses to closed-ended questions were recorded; (ii) additional written notes were taken for open-ended responses, with particular focus on capturing feedbacks; and (ii) timestamps were noted when an important issue was raised to facilitate the researcher reviewing key portions of recordings. As the tool implemented the ASM layout, participants from the Evaluation Study #2 could verify the ease of use and usefulness by comparing the manual modeling and modeling supported by a device. Finally, AESoIS generate two types of data: (i) AESoIS diagram and (ii) AESoIS report.

7.2.5 Task Strategy Evaluation and Variables

A set of eight tasks are defined for exploring if practitioners can realize the influence of AESoIS activities for demand and solution analysis around the accountability evaluation approach proposed in this thesis. The data gathering took into account the work of Oliveira (2011; apud Santos, 2016), who detailed the three major goals of classifying tasks according to the complexity of execution time, organized as follows:

- **Filtering tasks**: it comprises simple tasks that depend on reading some information using the approach's infrastructure for answering some questions. If a participant cannot execute such tasks, he/she should be removed from the analysis because this situation can affect the understanding of the tool or tasks. As an example, specific tasks executed in the context of this category in our study are:
  - Define your full name on Identification Screen in the Author field; and
  - Define a problem to be investigated and its descriptions.
- **Basic tasks**: it details basic tasks that depend on reading some information using the approach's infrastructure and interpreting the results to answer some questions. As an example of this category in our study were:
  - Define on Screen Actors Definition Process, e.g., Student; and
  - Define on Screen Definition of Information System, e.g., Qualidata IS.
- **Assimilation tasks**: this category comprises difficult, complex tasks that depend on the participant's background to understand and interpret information related to systems thinking to answer some questions. For example, some specific tasks executed in the context of this category in our study were:
  - Select the QADAD IS and choose the properties option. Then, in the opened pop-up, select the Condition and provide the following condition types: (i)

- Need internet connection for communication between information systems; (ii) Must receive an updated enrollment listing to issue new student cards; and (iii) Must receive an updated listing of anything from the academic department. In the end, the conditions will appear in the condition listing.

Participants should not be informed about such categories to avoid any influence in the proposed tasks. Therefore, an oracle (correct answers) is created as a repository for help (see APPENDIX VI). Furthermore, regarding variables, it is organized as follows: (i) independent variable - the use of AESoIS approach; and (ii) dependent variable - number of answers for each participant concerning to time spent to execute a proposed task.

Independent variables refer to inputs from the experimental process. Such variables demonstrate causes that affect the result of the experimental process. Their objective is to identify the forces that influence (or can influence) the execution results (Travassos *et al.*, 2002). In turn, dependent variables refer to the outputs of the experimental process relevant to an evaluation in the study execution. Therefore, variables are defined according to goals and questions established for the study:

- Independent variables: The approach used to support IT management activities for demand and solution analysis. This variable has two treatments: (a) the use of the AESoIS tool by SoIS practitioners; and (b) collecting information about the study evaluation; and
- Dependent variables: Number of correct answers for each participant; and Time spent to execute the proposed tasks.

7.2.6 Instruments and Preparation

As instrumentation of the feasibility study, an online questionnaire was developed in Portuguese, allowing the participants to access it through the Internet and fill out the questionnaire (APPENDIX VI). It is adapted in five instruments as inspired by Santos (2016).

- **Informed Consent Form**: it informs the study objective and participant's rights. It also reports that collected data should not be used to evaluate participants' performances and explains confidentiality terms. This form should be sent to participants before the study execution. Each participant should return the document;
- **Characterization Form**: it allows the researcher to analyze participants' profiles;

- **Execution Form**: it presents the context of the work and the eight proposed tasks. The participants are asked to play a specific scenario. This document is also used to collect answers for each task considering confidence level. A confidence level indicates the probability, with which the estimation in a sample survey is also true for the population. Each proposed task is ranged from 1 to 10 confidence level;
- **Evaluation Form**: it consists of a questionnaire in which each participant should evaluate his/her experience after the study execution. Qualitative information on the study execution is collected, as well as suggestions of improvement for the approach and considerations regarding the specialists in the study; and
- **Tool Guide**: before starting the study, participants should submit a short training on both accountability evaluation and systems thinking methods. Additionally, the tool presents a tool guide, as shown in APPENDIX V.

7.2.7 Planning Validity

As proposed by Mafra and Travassos (2006) and Santos (2016), we developed a planning validity phase before executing the study with two practitioners (chosen by convenience) who have experience in the academic department business process. In addition, we conducted a pilot test to ensure that our question plan, interview technique, and procedure were well-formed (Albusays *et al.*, 2017). The pilot also helped to improve preparation, instruments and to simulate the study runtime.

Additionally, since the sample size for the TAM study is small, participants were chosen for their experience in SoIS, SoIS modeling, and educational organization managerial capabilities. Thus, despite the quantitative, the comments had high quality and contributed to evaluating the AESoIS solution.

7.2.8 Interpretation and Analysis

Results were analyzed in both qualitative and quantitative ways. Quantitative analysis refers to effectiveness and efficacy. In turn, qualitative research relates to participants' satisfaction, perception of complexity, and accuracy in performing the proposed tasks. Results analysis focused on (i) participants' answers, (ii) timestamps, and (iii) participants' feedback.

7.2.9 Pilot

A pilot was conducted in August 2021 with two participants through individual sessions. The first participant is an IT specialist, and the second is an IS manager with a

Master's degree. The first participant was informed of high level and experience in IT, IS, IS Management, Software Engineering, and Computer Science (more than fifteen years of experience), and medium level in Requirements Engineering (less than three years of experience), with no knowledge on modeling tools for SoIS. The second participant has informed of a high level and experience in all areas (rank five and more than ten years of experience, with no knowledge on modeling tools for SoIS). Participants hit 60 min (P1) and 80 min (P2) for solving all evaluation forms.

After signing the informed consent form and filling the characterization form, they were given the AESoIS and BPSoIS background. Then, both executed the proposed tasks and filled in the evaluation form. Both performed all the tasks, despite the fact of the duration of the activities. The main problem reported was configuring the BPSoIS to AESoIS and the total of tasks to be executed. Participants used the approach efficiently and performed the filtering and basic tasks. However, they had difficulties with assimilation tasks since they had just been introduced to a new tool and the accountability evaluation approach; thus, more time is needed to answer the questions. Additionally, both participants had some difficulties understanding causal loops, as proposed in AESoIS native terminology and graphical user interface, and reported some bugs found during the execution. After some improvements in the study's instruments and infrastructure, the questionnaires were redesigned, and it incorporated a new strategy for addressing tasks (e.g., a fragment to support tasks understanding). It is worth mentioning that the pilot study was significant to refine the study's instruments and fix bugs found in the AESoIS tool and study forms.

7.3 Execution

From the pilot execution, the following adjustments are implemented: (i) the proposed tasks are supported with a partial fragment of a potential diagram, as a guideline for supporting modeling; (ii) 39 tasks were reorganized into 08 tasks, without loss of instructions to facilitate the reading and comprehension of proposed tasks; and (iii) small adjustments were implemented to improve the display of resources. After the adjustments, the study is conducted with three participants working in academic management in September 2021. The evaluation study was conducted separately.

In the first stage, three participants followed the planning protocol, where they signed (i) the informed consent form and (ii) answered the characterization form. In the second stage, participants received the AESoIS background form, a short training on

AESoIS module, and then used the tool to perform the tasks. Such planning allowed evaluating the ease of use and usefulness. Secondly, two participants were invited to free model a solution addressing two investigated problems related to an educational organization.

7.4 Results and Discussion

This section describes (i) participant's profile and (ii) dataset analysis.

7.4.1 Evaluation Study #1

The research was conducted considering data from an educational organization, specifically in the academic department. The proposed scenario and the characterization of employees for organizations are shown in APPENDIX VI. Considering the first evaluation study, and three participants answered the survey. Quotations are labeled with code numbers preceded by the letter P that represent individual participants (i.e., P1, P2, P3). Regarding academic education, two participants reported having a Ph.D. degree (P2 and P3) and one Master's degree (P1). The participants informed experience degree according to the following scale:

- 0 is "none" (no experience);
- 1 is "I studied in class or in a book" (very low experience degree);
- 2 is "I used it in some projects in the classroom" (low experience level);
- 3 is "I used it in my own projects" (average experience degree);
- 4 is "I used it in few projects in the industry" (high experience degree); and
- 5 is "I used it in several industrial projects" (very high experience level).

Table 35 presents the results obtained from the participant's experience level. As detailed, all participants were informed to have very high experience in IS, IS Management, and Software Engineering, Accountability. Concerning experience with similar tools, none of the participants reported familiarity with systems thinking modeling tools, as stated by 0 when it is "I have no familiarity", 1 when it is "I have some familiarity", and 2 when it is "I am very familiar". On the other hand, all participants mentioned familiarity in metal maps. Therefore, we understand that this sample could develop important findings regarding how AESoIS can promote SoIS scenario understanding.

Table 36 presents participants' experience level ranging with years on a 0-5 scale. These results detailed participants' average time is between 3 and 5 years. IT is worth mentioning that P2 and P3 have more than 15 years of experience in modeling. Concerning experience with similar tools, none of the participants reported familiarity with systems thinking modeling tools, as stated by 0 when it is “I have no familiarity”, 1 when it is “I have some familiarity”, and 2 when it is “I am very familiar”. On the other hand, all participants mentioned familiarity in metal maps.

Table 35 - Participants’ experience level (degree) of Study #1.

ID	Information Technology	Information System	Accountability	Requirement Engineering	Computer Science	Software Engineering
P1	5	5	5	5	4	4
P2	5	5	5	5	3	5
P3	5	5	5	5	5	5

Table 36 - Participants’ experience level (time) of Study #1.

ID	Information Technology	Information System	Accountability	Requirement Engineering	Computer Science	Software Engineering
P1	>5 years	>5 years	< 3 years	>5 years	< 3 years	>5 years
P2	>5 years	>5 years	>5 years	>5 years	>5 years	>5 years
P3	>5 years	>5 years	>5 years	>5 years	>5 years	>5 years

In this context, results are analyzed based on participants’ answers, duration of the activity. An analysis is organized and evaluated according to qualitative and quantitative data. In total, all participants executed the proposed eight tasks. Participants hit 90 min (P1), 110 min (P2), and 70 min (P3) for responding to all evaluation forms. In APPENDIX VII, these data are organized in detail. Regarding confidence level, Table 37 demonstrates some participants (P1 and P3) with high confidence levels when modeling an investigated problem into the AESoIS. It is worth mentioning that during the study, P3 states that “*initially, I needed time to understand the proposed task approach*”, as demonstrated in rank 5 (task #1). Such perception was also mentioned by P2, which suggests a learning curve increasing the confidence level.

We observed a difference in the number of times taken in favor of P1 and P3. Such results suggest that the proposed strategy of a guided task in Study #1 obtained satisfactory answers. In contrast, P2 had more difficulty in executing tasks, which is explained by the time taken to execute the study (110 minutes). As such, this participant demanded more attention during the study. Regarding effectiveness, Table 38 summarizes the data. The evaluation of the studies is presented in APPENDIX VII. The relation between the number of correct answers over the total number of questions, Study #1 had a very high average effectiveness (0.917).

Table 37 - Confidence level of Study #1.

	Confidence level							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
P1	10	10	10	10	10	10	10	10
P2	3	6	8	5	8	9	8	10
P3	5	10	10	10	10	10	10	10

Table 38 - Effectiveness results per participant of Study #1.

		Tasks									
ID	**Time**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Correct**	**Effectiveness**
P1	34	1	1	1	1	1	1	1	1	8	1.000
P2	60	1	1	1	0	1	1	1	1	7	0.875
P3	30	1	1	1	1	0	1	1	1	7	0.875
Average											0.917

7.4.1.1 Study #1 Analysis

Concerning the study execution evaluation, we analyzed the evaluation questionnaire that participants filled after the execution. All participants agree that the AESoIS perspective can benefit or support SoIS modeling. This result can motivate more research on this topic in SoIS research. Table 39 presents the evaluation of study execution findings. Participants declare that the proposed tasks are easy or very easy to perform, as demonstrated by the confidence level in Figure 64. For example, some participants state the following comments to Q01: "*Execution is easy as long as prior training takes place*" (P3); and "*I managed to carry out all the tasks, and I believe it was effective*" (P2).

Table 39 - Evaluation of study of characterization questions.

Question	ID	Yes	Partially	No
Q01: Did you perform the entire set of proposed tasks?	P1	1	-	-
	P2	1	-	-
	P3	1	-	-
Q02: Were you satisfied with the result?	P1	1	-	-
	P2	-	1	-
	P3	-	1	-
Q03: Is it possible to see that the approach contributed to AESoIS evaluation, considering the systemic aspects, the interactions between elements, and influences of accountability, based on the information presented?	P1	1	-	-
	P2	-	1	-
	P3	1	-	-

On the other hand, participants declare some lack of comprehension concerning BPSoIS and AESoIS layout (P2), time spent modeling the diagram (P2), and difficulties in remembering causal loops classification (P3). P2 states the following comment about Q02:

> "*I was pleased, although a little unsure about the diagram, because I noticed some different points in the model image. I believe that as the tool handles a*

lot of information, which requires from the user a very minute attention" (P2 in Q02).

Concerning Q04, all participants mentioned that "Performing tasks is easy". In addition, participants evaluate the approach ease of use (Q05-Q08) as "Totally Agree" or "Agree" in most cases (see Table 40). However, P2 disagreed on "*What is the degree of difficulty in carrying out the tasks?*" (Q04). This participant with high-level experience and was evaluating the tool as an academic department manager. Regarding Table 40, some comments are presented as follows:

"*The greatest difficulty was the lack of familiarity with the tool's components since it is new software. But this is normal in any first experience with a software*" (P1 in Q01);

"*There is a lack of semantic explanation of the problem addressed and the elements of the graphical interface*" (P2 in Q01); and

"*I believe that the perception of how the responsibilities of the SoIS elements are related and how these influences can be represented to better understand the whole of a problem can be better performed if the tool presents a legend indicating what represents the green, red dots, and the signs of x. While we operate the tool with the model table, it is easy to understand, but when we visualize the diagram, we have to force our memory to remember. Perhaps this is also because it is the first contact with the tool*" (P1 in Q03).

From the usefulness questions (Q09-Q12), most answers were set as "Totally Agree" or "Agree". Results reveal that all participants had accomplished all the tasks, and participants were satisfied (or partially satisfied) with the study's outcome. However, P2 manifested difficulties in understanding AESoIS functionalities, e.g., association links among SoIS elements. In contrast, with the task's execution, the process of comprehending association links was improved.

Additionally, P2 questioned the relevance of accountability for BPSoIS, concerning an investigated problem. P2 states that "*I can't see the contribution of the accountability module so far, since I'm using information that was filtered and selected in a previous module*".

We argue that all elements extracted from BPSoIS to AESoIS, were selected from a list of actors, business process tasks, and constituent IS, and they were incorporated as potential AESoIS elements for modeling an investigated problem. As the participants have experience in BPSoIS, two participants expressed difficulties compressing that automatization and challenges for supporting accountability evaluation demands and solutions.

In this context, it was explained that a scenario without a tool's support considers questions about the scenario dynamics. Such explanations helped the participants to understand the AESoIS framework with steps collecting data from BPSoIS investigating a problem. It is noteworthy that AESoIS tool can incorporate BPSoIS elements or create new ones at runtime. It is up to the AESoIS user to define the SoIS elements to be modeled.

Table 40 - Ease of use and usefulness answers of Study #1.

	Question	ID	Totally Agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
Ease of use	Q05. I easily learn how to use the approach.	P1	-	1	-	-	-
		P2	-	1	-	-	-
		P3	1	-	-	-	-
	Q06. I use the approach in the way I want to.	P1	1	-	-	-	-
		P2	-	-	-	1	-
		P3	1	-	-	-	-
	Q07. I understand what happened in the interaction with the tool.	P1	-	1	-	-	-
		P2	-	-	1	-	-
		P3	1	-	-	-	-
	Q08. I easily execute the proposed tasks with the tool.	P1	1	-	-	-	-
		P2	-	1	-	-	-
		P3	1	-	-	-	-
Usefulness	Q09. I think that the approach is useful for modeling SoIS demand and solutions.	P1	1	-	-	-	-
		P2	-	1	-	-	-
		P3	1	-	-	-	-
	Q10. AESoIS solution allow me to realize how SoIS context understanding depend on SoIS elements.	P1	1	-	-	-	-
		P2	-	1	-	-	-
		P3	1	-	-	-	-
	Q11. AESoIS solution improve my performance over the execution of the proposed tasks.	P1	1	-	-	-	-
		P2	1	-	-	-	-
		P3	1	-	-	-	-
	Q12. AESoIS solution support SoIS management activities.	P1	1	-	-	-	-
		P2	-	1	-	-	-
		P3	1	-	-	-	-

In addition, participants pointed out the strengths and weaknesses of the approach and considerations on the support for SoIS scenario understanding analysis (Q13-Q17). As for strengths, participants mentioned that the approach allows IT/IS practitioners to analyze different scenarios to prepare for an acquisition round and highlighted the support SoIS elements to AESoIS, such as:

> "*the functionality of extending actor, business process tasks and IS automatically from BPSoIS is interesting*" (P1 in Q12);

"*drag and drop menu is relevant, as the visual design is difficult to implement*" (P1 in Q12);

"*visually pleasing and quick in actions*" (P3 in Q13).

"*a user needs to obtain a better understanding of the elements of a BPMN in order to understand how relationships happen*" (P2 in Q14);

"*Improve association*" (P2 in Q15); and

"*The learning curve in drawing the diagram seems to need more time. I say this because the initial phases are very simple. The diagram part tends to be more pleasant after learning consolidation*" (P2 in Q15).

As for weaknesses, participants reported "*the high learning system thinking curve from beginners, although it decreases over time*" (P3 in Q14). When questioned on their conclusions related to accountability criteria. P2 and P3 state that:

"*the degree of importance is high, but the manager or user of the tool needs to have a theoretical background to understand the modeling*" (*P2 in Q16)*; and

"*the learning curve in drawing the diagram seems to need more time. I say this because the initial phases are very simple. The diagram part tends to be more pleasant after learning consolidation*" (P3 in Q14).

Finally, the last two questions (Q16 and Q17) address conclusions and open space for comments. All participants shared some opinions on the solution, for example:

"*High degree of importance regarding the influences of the elements described. I say this because the diagram helps in making decisions related to changes that are often taken to improve processes in an immediate, gradual or even structural way*" (P1); and

"*I conclude that the presentation of the scenario for improving responsibilities is well designed and developed for its purpose*" (P2).

7.4.1.2 Developed AESoIS Diagrams from Study #1

The following pictures show the participants' developed AESoIS diagrams. In this case, Figure 65 details P1 modeling, Figure 66 details P2 modeling, and Figure 67 details P3 modeling. It is possible to notice that even though each task has a modeling oracle, and participants made some adjustments. In the evaluation study, P2 and P3 identified and proposed new titles and new relationships for the modeled elements, reflecting the knowledge about the domain and the investigated problem. For example, QACAD IS (which is the label of an IS) becomes "Qualidata IS", representing the correct IS label.

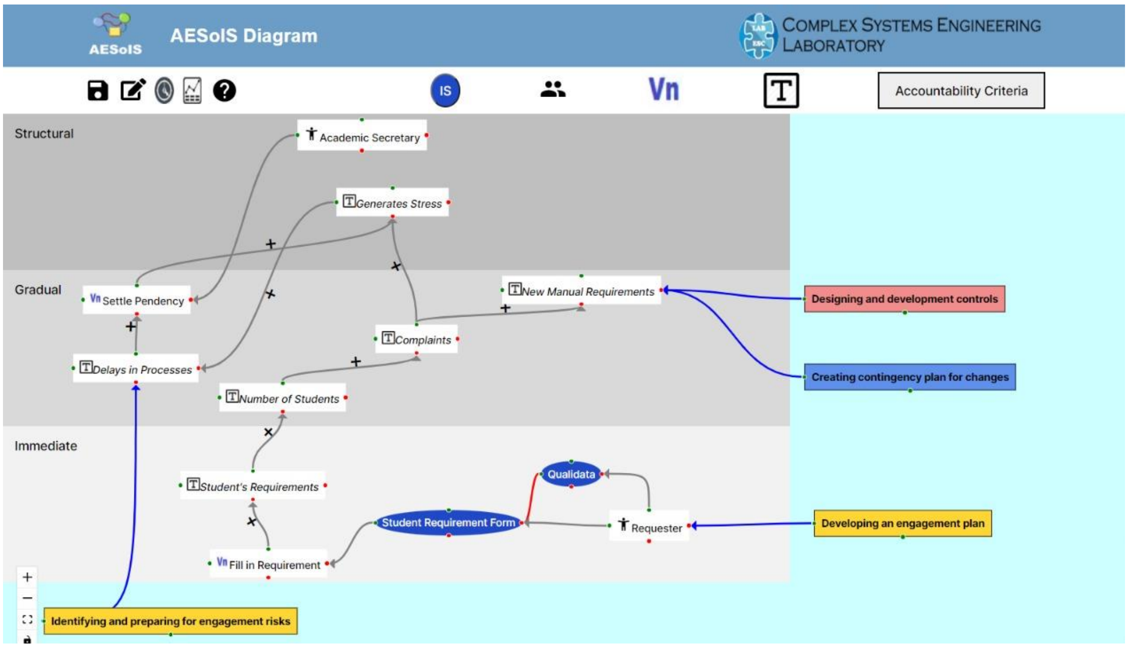

Figure 65 - AESoIS solution from Study #1 - Participant 1.

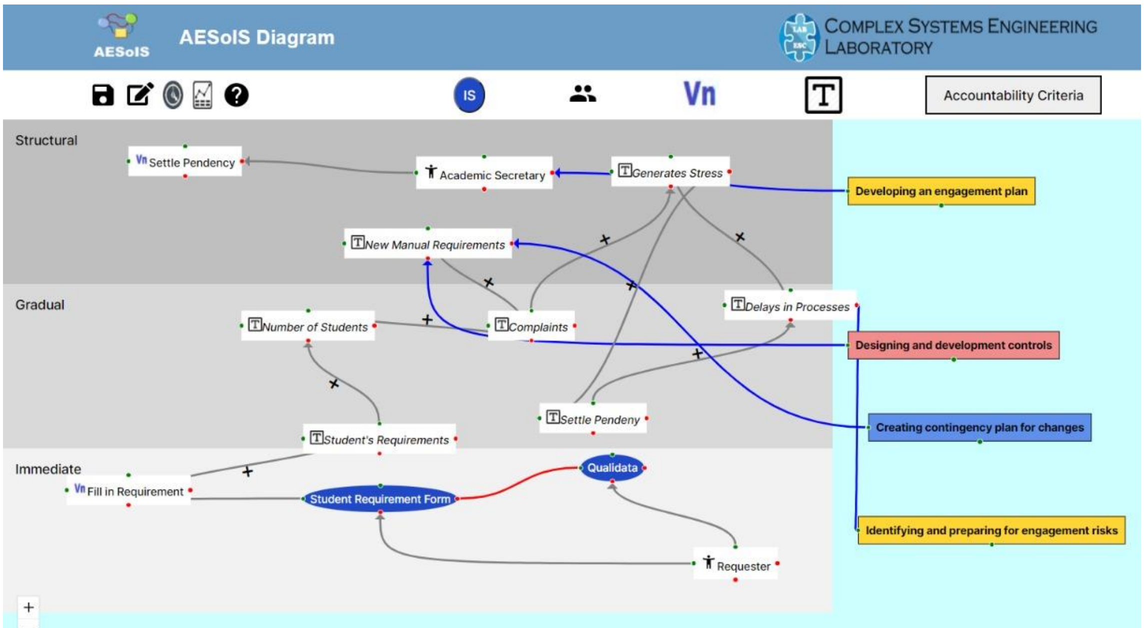

Figure 66 - AESoIS solution from Study #1 - Participant 2.

On the other hand, academic secretary IS was pointed out by P3 that it does not represent an IS, but a collection of manuals task, while others assert that this collection of tasks is an IS. A common error in all three AESoIS solutions from Study #1 is cross-association, with causal loops overlapping lines. During the execution, despite the task protocol, we allow the participants to act freely, without interference during their modeling.

It is noteworthy that one participant identified no association between "Qualidata IS" and "Requester". In this case, Figure 67 shows the diagram, excluding the red association between IS, as proposed by the participant. In addition, it is worth noting that precisely because of the flexibility of the tool, all diagrams were modeled differently. It is justified, as each participant could customize their solution. In this context, comments are presented as follows: "*an observational study would be very interesting for evaluating the tool*" (P3); and "*the execution of the AESoIS tasks are excellent, but I believe the tool could be used in an observational study*" (P2).

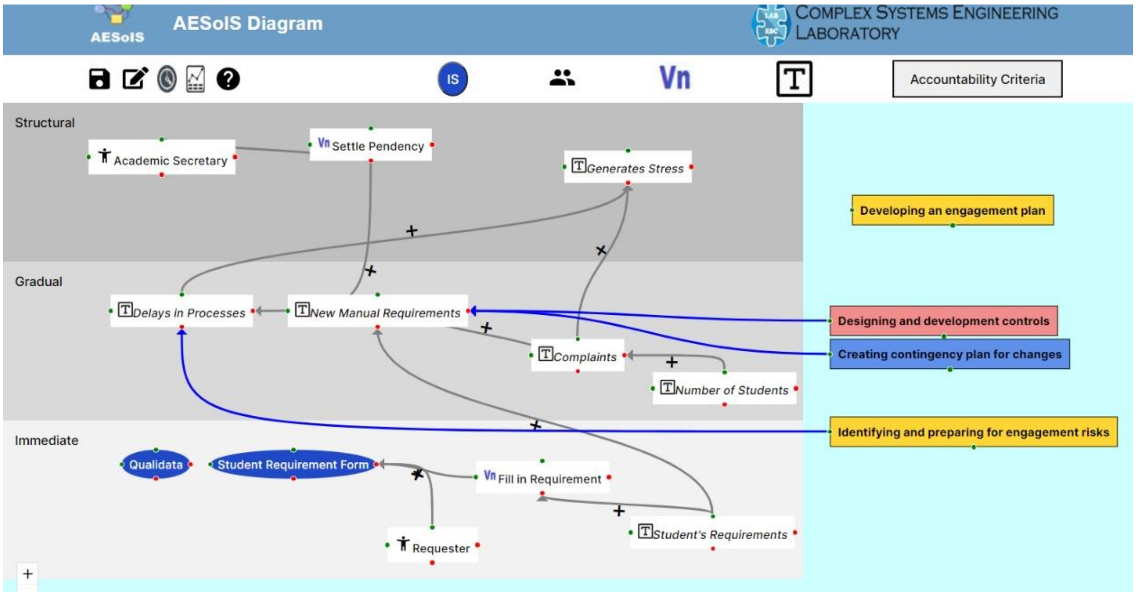

Figure 67 - AESoIS solution from Study #1 - Participant 3.

7.4.2 Evaluation Study #2

Considering the need to complement the BPSoIS solution evaluation, this section presents the Study #2. Such a study considers SoIS users' demand to model SoIS scenarios and solutions in an unguided way, as explored in Section 3.3. The research was conducted considering data from the exploratory study (Cordeiro & Santos, 2019b; Cordeiro *et al.*, 2020), as shown in Chapter 3.

In Study #2 approach, two IT/IS participants from the exploratory study were consulted to verify their availability for being part of AESoIS evaluation framework and tool. Both participants confirmed their availability, and in September 2021, an evaluation study was planned and conducted, focusing on an observational study. The study took 200 minutes to re-evaluate the created diagrams into AESoIS. APPENDIX VII details all participant feedback when evaluating the tool.

Regarding the Study #2 evaluation, it begins with the presentation of AESoIS (and its functionalities). Additionally, previously modeled diagrams were made available for the participant as a start point for modeling. As previously defined (Cordeiro *et al.*, 2020), it represents a real organization with two problems: (i) Problem #1 Absence of Educators; and (ii) Problem #2 Evasion Rates. In both scenarios, eight tasks were planned to support the use of the AESoIS, as shown in APPENDIX VI. It should be noted that unlike Study #1 (Section 7.4.1), the proposed tasks are related to the elements of the tool and do not propose a guide (oracle) for accomplishing a task (oracle).

Furthermore, some guidance was given, which included the fact that the AESoIS is intended to support modeling activities in SoIS focusing on an actor, IS, and vertex nodes, combined with different associations and accountability criteria. At this moment, the P4 and P5 mentioned that "*We don't have the business processes mapped*". Thus, it was explained that the integration of AESoIS with BPSoIS allows the creation of new SoIS elements without exclusively relying on BPMN files.

In this context, Table 41 presents the results obtained from the participant's experience level. As detailed, both participants were informed to have very high experience in IS, IS Management, and Software Engineering, Accountability. Table 42 presents participants' experience levels ranging from years on a 0-5 scale. These results detailed participants' average time is between 3 and 5 years. IT is worth mentioning that P4 and P5 have more than 20 years of experience in modeling and IS management.

Concerning experience with similar tools, none of the participants reported familiarity with systems thinking modeling tools. On the other hand, both participants mentioned familiarity in metal maps and UML. Therefore, we understand that this sample could bring important findings regarding how AESoIS can contribute to SoIS scenario understanding. In this context, results are analyzed based on participants' answers, duration of the activity. It is worth mentioning that even though Study #2 participants answered separately, they work together in AESoIS modeling. Regarding effectiveness, Table 43 summarizes the data. The evaluation of the studies is presented in APPENDIX VI. Concerning the relation between the number of correct answers over the total number of questions, and both participants had a very high average effectiveness (1.000).

Table 41 - Participants' experience level (degree).

ID	Information Technology	Information System	Accountability	Requirement Engineering	Computer Science	Software Engineering
P4	5	5	5	5	4	4
P5	5	5	5	5	3	5

Table 42 - Participants' experience level (time).

ID	Information Technology	Information System	Accountability	Requirement Engineering	Computer Science	Software Engineering
P4	>5 years	>5 years	< 3 years	>5 years	< 3 years	>5 years
P5	>5 years	>5 years	>5 years	>5 years	>5 years	>5 years

Table 43 - Effectiveness results per participant in Study #2.

		Tasks									
ID	**Time**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Correct**	**Effectiveness**
P4	59	1	1	1	1	1	1	1	1	8	1.000
P5	68	1	1	1	1	1	1	1	1	8	1.000
				Average							1.000

Table 44 demonstrates a high confidence level regarding confidence level when modeling an investigated problem into the AESoIS. It is worth mentioning that the participants work together in AESoIS modeling. Such a result explains the same results of confidence level shared by both participants. Participants from Study #2 spent on average 76 minutes to perform the proposed investigated exploratory studies, while P4 took 72 minutes and P5 took 80 minutes.

Table 44 - Confidence level of Study #2.

	Confidence level							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
P4	10	10	0	10	10	10	10	10
P5	10	10	0	10	10	10	10	10

7.4.2.1 Study #2 Analysis

Concerning the study execution evaluation, we analyzed the evaluation questionnaire that participants filled after the execution. All participants agree that the AESoIS perspective can benefit or support SoIS modeling. "*I was curious, then I opened the study invitation email in the expectation of being able to access it through the cell phone, but the features did not work*" (P5). At this point, it was explained that the tool does not include mobile use. In addition, concerning Q04, both participants mentioned that "*Executing the tasks is straightforward*". These types of answers are justified by the fact that the AESoIS evaluation took place in person and in pairs. Table 45 presents the initial question before TAM. In this context, participants mentioned how practical and fast the tool is and that the layout is stunning. Another high point was the fact that the indicators are cataloged. Some comments were mentioned:

"*the tool is very nice and practical to use*" (P4);

"*the possibility of creating the own indicators is interesting because, despite the ISO standards being ideal for organizations, unfortunately, we don't have people to evaluate ISO*" (P5); and

"*I was curious, then I opened the study invitation email in the expectation of being able to access it through the cell phone, but the features did not work*" (P5).

At this point, it was explained that the tool does not include mobile use. In addition, concerning Q04, both participants mentioned that "Executing the tasks is straightforward". These types of answers are justified by the fact that the AESoIS evaluation took place in person and in pairs.

Table 45 - Evaluation of Study #2 execution.

Question	ID	Yes	Partially	No
Q01: Did you perform the entire set of proposed tasks?	P4	1	-	-
	P5	1	-	-
Q02: Were you satisfied with the result?	P4	1	-	-
	P5	1	-	-
Q03: Is it possible to see that the approach contributed to AESoIS evaluation, considering the systemic aspects, the interactions between elements and influences of accountability, based on the information presented?	P4	1	-	-
	P5	1	-	-

Regarding Table 46, some comments are presented in APPENDIX VII. Some examples are presented as follows:

"*we don't have the business processes mapped*" (P4 in Q05);

"*the training was enough to understand the tool use*" (P5 in Q05);

"*the tool is very nice and practical to use*" (P4 in Q06);

"*Unfortunately we don't have business process tasks, but we do have tasks. In this case, I will use text presentation*" (P4 in Q07); and

"*The tool is fast, but it would be interesting to increase the connection point between elements. Sometimes it is difficult to position the cursor*" (P5 in Q08).

During the evaluation, the participants showed themselves to be confident and comfortable in modeling the proposed scenarios. The comments above serve as a guide to predict that the AESoIS solution is understandable and can explore beyond BPMN, given the limitation of business processes at organization B. Additionally, some negative points were mentioned, such as "I was in doubt whether the tool should be exclusive to BPSoIS, when in fact I didn't use business processes, it might be worth reviewing the tool's name" (P4 in Q05).

Table 46 - Ease of use and usefulness answers of Study #2.

	Question	ID	Totally Agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
Ease of use	Q05. I easily learn how to use the approach. Q06. I use the approach in the way I want to.	P4 P5	1 1	- -	- -	- -	- -
	Q07. I understand what happened in the interaction with the tool.	P4 P5	1 1	-	-	-	-
	Q05. I easily learn how to use the approach. Q06. I use the approach in the way I want to.	P4 P5	1 1	- -	- -	- -	- -
	Q07. I understand what happened in the interaction with the tool.	P4 P5	1 1	- -	- -	- -	- -
Usefulness	Q09. I think that the approach is useful for modeling SoIS demand and solutions.	P4 P5	1 1	- -	- -	- -	- -
	Q10. AESoIS solution allows me to realize how SoIS context understanding depends on SoIS elements.	P4 P5	1 1	- -	- -	- -	- -
	Q11. AESoIS solution improved my performance over the execution of the proposed tasks.	P4 P5	1 1	- -	- -	- -	- -
	Q12. AESoIS solution support SoIS management activities.	P4 P5	1 1	- -	- -	- -	- -

Despite such critics, participants evaluate the approach ease of use (Q05-Q08) and usefulness approach (Q09-Q12) as “Totally Agree”. Some examples of comments are presented as follows:

> “*it is easy to create associations. I imagine the automation of the association types was designed to reduce the effort of understanding the notation*” (P4 in Q10);
>
> “*the possibility of creating own indicators is interesting, because, despite the ISO standards being ideal for organizations, unfortunately, we don't have people to evaluate ISO*” (P5 in Q11);
>
> “*the tool is very practical and beautiful. I see there were new elements incorporated*” (P4 in Q12); and
>
> “*Although the tool requires systems thinking knowledge, the solutions found such as colors, labels and selections help to resolve doubtS*” (P5 in Q15).

Finally, the last two questions (Q16 and Q17) address conclusions and open space for comments. All participants shared the solution, for example:

"as we don't have the processes mapped with BPMN, I got the feeling that I didn't use the tool as much as possible, even though I managed to change and carry out the proposed scenarios effectively" (P4 in Q16); and

"*I was curious, then I opened the study invitation email in the expectation of being able to access it through the cell phone, but the features did not work*" (P5 in Q17).

7.4.2.2 Developed AESoIS Diagrams from Study #2

The following pictures show the participants' developed AESoIS diagrams. In this case, Figure 68 details P4 modeling, and Figure 69 details P3 modeling. It is possible to note that the generated ASM solution concerning *Problem #1: Absence of Educators* (Cordeiro *et al.*, 2020) has been changed in both AESoIS diagrams.

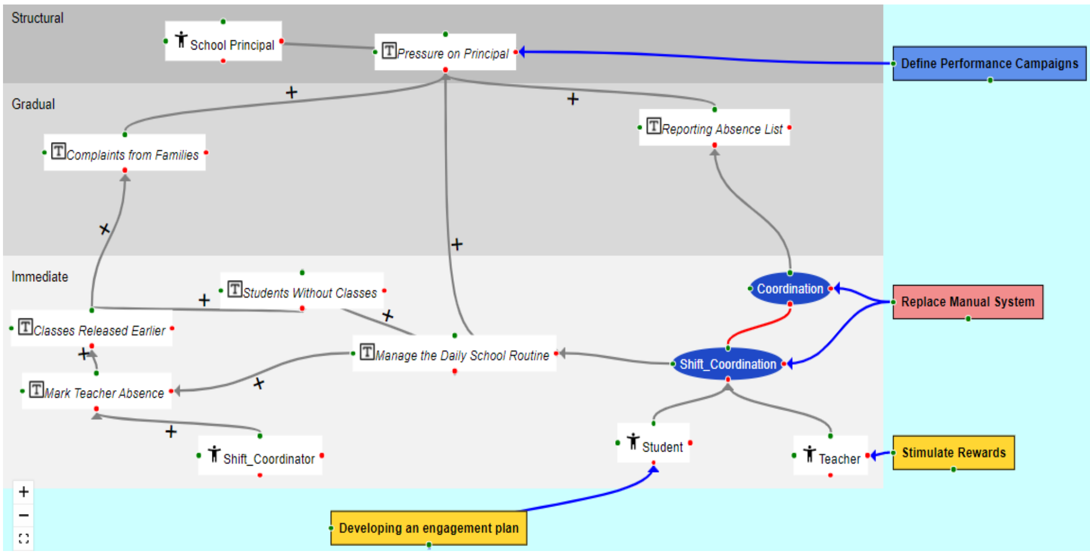

Figure 68 - Problem #1: Absence of educators.

It encompasses previous nodes, including new elements, such as actor student, actor teacher, actor shift coordinator, actor school principal, and an extra accountability engagement criterion (Developing an engagement plan, which is an ISO indicator). Beyond new elements, the participant reorganizes associations and changes some time impacts alignment, i.e., students without classes in immediate time impacts instead gradual, as previously defined in the exploratory study.

Another point that the participants signaled is related to the fact that they can include suggestions. At this point, participants were able to reflect and maintain the criteria for engagement, regulation, and anticipated management created in the exploratory study.

Figure 69 shows the generated AESoIS diagram concerning *Problem #2: Evasion Rates* (Cordeiro *et al.*, 2020). It encompasses previous nodes, but it includes new elements, such as actor student, actor guidance educator, text variable manual register, and a different accountability criterion (Developing the policy, which is an ISO indicator). Beyond new elements, the participant reorganizes associations and changes some time impacts, i.e., compile educational rates, and manage organizational subunit in immediate time impacts instead of gradual.

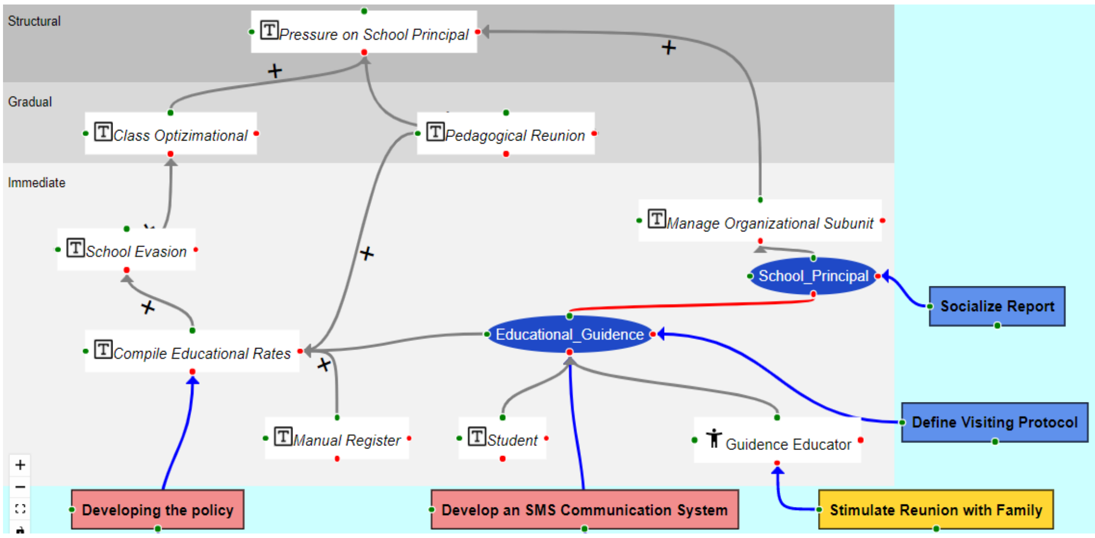

Figure 69 - Problem #2: Evasion rates.

7.5 Implications

The previous sections explore participants' developed AESoIS diagrams. In Study #1, it is possible to note that the participants made some adjustments even though each task has a modeling oracle. A common error in all three AESoIS solutions from Study #1 is cross-associations, with causal loops overlapping lines. During the execution, despite the task protocol, we permit the participants to act freely, without interference during their modeling. One contribution signaled by two participants of Study #1 is the relevance of evaluating the tool in uncontrolled scenarios, where managers are faced with a problem without data for modeling. In this case, it was explained that although the study elements are targeted, the participants have the autonomy to create the elements (or new ones) and evaluate all the associations. Thus, it is worth noting that precisely because of the flexibility of the tool, all diagrams were modeled differently. It is justified, as each participant could customize their solution.

On the other hand, the Study #2 investigation complemented the Study #1 since it was possible to verify the modeling in uncontrolled scenarios. For each problem, we present the preliminary studies that contributed to understanding their particularities in AESoIS. Then, we proposed the task and activities to support the participants in each problem and a set of causal associations among AESoIS elements.

The lack of strategic thinking about SoIS is discussed in this thesis, and the advantages of adopting systems thinking may be promising. The AESoIS framework strategy and tactics with regard to SoIS are investigated. The importance of continually realigning information resources with organizational and environmental requirements is highlighted with the AESoIS solution. The approach stresses the need to treat any SoIS as a whole complex system by interpreting from a holistic viewpoint.

The AESoIS approach suggests that the accountability evaluation may promote improvements in the SoIS understanding of problems and potential solutions. This premise arises from the potential benefits of combining ST with IS, as proposed by Checkland (1988), in which successful ST analysis involves the ability to grasp the essence of a scenario investigation. Whilst accepting the implied vagueness and limitations of weak definitions in SoIS research. Furthermore, by the very nature of a consensus demarcation of a boundary, any AESoIS element will have an identity, which must be maintained in dynamic yet recognizable accountability properties (condition, sanction, obligation, and responsibility).

Another factor evidenced by the evaluation studies is the indication that AESoIS diagrams must be able to adapt to the continuous, predictable, and unpredictable changes in the SoIS environment, survive, co-operate, and achieve intended missions in different ways. It can be seen from the results of Study #1 and Study #2 that despite the strategies being different, the results of using the tool remained very close. Moreover, concerning the relation between the number of correct answers over the total number of questions, both groups had a very high average effectiveness (Study #1 - 0.917 and Study #2 - 1.000).

Therefore, with the execution of the evaluation studies, it was possible to verify the advantages of modeling SoIS scenarios considering accountability. The results corroborate the relevance of diagnosing elements from SoIS scenarios, aiming to understand their implications in achieving organizational goals. Furthermore, it was possible to infer that despite the initial effort for ST comprehending, the generated AESoIS diagrams covered relevant elements, according to specialist users. In addition to the accountability evaluation, the associations and accountability properties play a relevant role in supporting engagement, management, and regulation. In this context, all participants mentioned that accountability criteria are relevant and may support accountability in organizations.

From the above implications, this thesis claims that the AESoIS solution helped answer the chapter question "*Are the participants able to realize the influence of AESoIS in BPSoIS activities for demand and solution analysis regarding effectiveness?*" (Q01). It provided steps and activities to support the SoIS users in modeling demands and solutions for the proposed scenarios, which is part of the thesis: "***Is the proposed AESoIS tool feasible to aid practitioners in performing accountability analysis with effectiveness?***" (RQ3).

7.6 Threats to Validity

This work has some limitations regarding the construct, internal and external validity of the evaluation (Wohlin *et al.*, 2012; Santos, 2016). **Internal validity** defines if the relation between the treatment and the result is casual and derived from influences of other uncontrolled (or even not measured) factors. For example, sampling, grouping, treatment application, and social aspects are concerns in this category. **External validity** defines conditions that make it difficult to generalize results to other contexts. Participants' interaction with the treatment, location, and occasion should be considered in this category. **Construct validity** considers the relations between theory and observation, i.e., potential cause and a result that reflects an effect. For example, undesirable behavior from the participants' or researcher's sides should be analyzed in this category. **Conclusion validity** refers to the conditions to make the right conclusions on the relations between the treatment and the results. Statistical methods and sample size choices, as well as measures' confidentiality, should be discussed in this category.

Internal Validity:

- There may be some bias since the participants handed their responses directly to the researchers undertaking and reporting in both evaluation studies (Study #1 and Study #2);
- since the AESoIS evaluation involved more than one participant, the greatest threat to internal validity is the relationship of the results with the selection of participants or a given scenario of interest. Regarding the results, relationships with the selection of participants or a given scenario of interest is a great threat - to reduce this risk, a

participants' characterization form was applied in order to balance the evaluation process;

- the infrastructure can influence the results of the participants face unexpected difficulties (e.g., slowness, server errors etc.), and the interactions with the tool can influence the way they perform the tasks - to reduce this risk, a short training session and a pilot was run to capture any confounding factor. Additionally, the evaluation protocol suggested some guidelines for better participant convenience, e.g., suggest the use of two monitors, and print the evaluations forms;
- learning effect can manifest itself in the order the study's tasks were executed - to reduce this risk, tasks were arranged in an increasing complexity sequence and without entanglement, to not affect the thinking and the execution. It is noteworthy that the task sequence was the same for participants;
- the understanding of the execution form is directly influenced by the way the questions were designed, i.e., if the question was poorly worded, the study may be adversely affected - to reduce this risk, a pilot study was previously run to capture any confounding factor. Additionally, the participants were free to demand some guidelines from the researchers when conducting the modeling with AESoIS; and
- For the data analysis, the participants' characterization information should be used - unfortunately, it is not possible to meticulously verify that such information is correct, although the research can recommend the participants to be precise in their answers.

External Validity:

- Participants were selected from an educational organizational scenario, and some problems were addressed. Thus, the sample represents a cross-section of experiences for SoIS problem-solving by the proposed accountability evaluation;
- It is impossible to represent all the accountability criteria, so studies in different engagement, management, and regulation indicators should be performed. However, a strength of our study is the fact that we used a preliminary dataset from ISO standards;

Construct Validity:

- Since participants were chosen for convenience, their behavior might reflect assumptions on the expected results for this study - to reduce this risk, and we executed the study with different participant profiles with two evaluation studies.

A random selection was not possible since the approach requires participants that work as SoIS practitioners and have experience in the academic department context;

- the tasks were grouped by type to aid data analysis, and the same weight is assigned to all tasks. However, some tasks might have higher difficulty degree compared to others, and this fact can influence the results - we decided to keep this setting because of the subjectivity in assessing difficulty degrees (which would introduce bias in the analysis); and
- the selected measures might not be good indicators for the feasibility of the proposed approach - to reduce this risk, measures were chosen based on the information needed to answer the tasks, and a pilot study was previously run to capture any confounding factor.

Conclusion Validity:

- The main threat is the sample size, with a small number of participants, not being ideal from the statistical perspective - to reduce this risk, our analysis included all data collected from the participants. Unfortunately, this is a recurrent difficulty for empirical studies in IS research, especially for SoIS approaches that require an IT infrastructure, as in our case. Thus, our study presents a limitation on the results, which are considered indications (and not evidence).

7.7 Final Remarks

The main objective of this chapter was to evaluate the question: "*Are the participants able to realize the influence of AESoIS analysis regarding effectiveness?* (see Section 7.2.2). Such a question integrates the RQ3 investigation for identifying if the thesis solution is feasible and aids practitioners in performing accountability analysis of AESoIS effectiveness.

Therefore, this chapter reported on a feasibility study conducted with practitioners in real two educational organizations concerning to organizational problems. It investigated SoIS scenarios to evaluate the proposed approach and contribute to SoIS analysis aligned with accountability evaluation research and practice. Details on the evaluation study are planned and executed in two phases: (i) controlled investigated scenario formed by task guidelines; and (ii) uncontrolled scenario formed by data from an exploratory study. The total evaluation was around 8 hours, which included: (i) explanation of AESoIS use; (ii) explanation of the accountability evaluation strategy resulting in SoIS modeling and accountability indicators; and (iii) user autonomy to create solutions based on systems thinking approach.

To cope with the Q01 investigation, a pilot was conducted with two participants. After the pilot refinement, the evaluation study was performed with five participants. As a result, the effectiveness of performing accountability evaluation activities for demand and solution analysis was improved, considering the SoIS scenarios in two organizations.

After analyzing the participants' comments, there are indications that the approach is applicable for SoIS modeling, especially demands and solutions. By creating a model that represents the question under investigation, the requirements are raised, aiming to improve the manager's compression of the question. The feasibility studies demonstrate the viability of the AESoIS modeling approach, which has been fundamental for its refinement throughout this research process. Throughout the performance of feasibility study, it is possible to see the importance of evaluating a technology, method, or process in IS/SoIS before it is transferred to an industrial or academic context. We can say, after this experience, that the evaluation process is "vital" for the maturation of an approach or confirmation of a theory in any area, technological or scientific.

As presented in Chapter 6, the process proposed in this thesis comprises three contributions: (i) the definition of an AEM; (ii) an assessment framework; and (iii) a computational tool. Thus, this chapter demonstrates experimental studies confirming that the feasibility of the solution proposed in this thesis. In this context, to verify whether the AESoIS contributes to the analysis of accountability evaluation, we planned and executed the evaluation study in two phases. The first phase is a controlled scenario where participants perform a set of tasks and evaluate the tool. The second uses the same evaluation forms, but instead of using targeted tasks, the participants receive a problem and can model it regarding their interest.

We carry out the studies we deem to be a priority for supporting the theory defended in this thesis about the combination of systems thinking and BPMN for mining data for extracting useful knowledge about SoIS and problems to be investigated. In this sense, it was possible to verify the feasibility of AESoIS and the feasibility of rebuilding elements from AESoIS that can be used to compose a reference architecture of SoIS by combining AESoIS with extended BPSoIS.

It is worth emphasizing the importance of studies involving, initially, business processes developed in the same research context as this thesis, i.e., systems for supporting educational organizations, and then with the approach more mature, studies with a system for use in an academic department and school routines demands and solutions. Thus, the use of accountability evaluation to organizational context can lead to an investment of mapping effort and resources, resulting in new solutions for mitigating problems. The evaluation study was carried out to verify that contributions can be given complex IS arrangements in this thesis.

Chapter 8 - Conclusion

This chapter concludes this thesis. It also presents some perspectives and future work. Finally, this chapter is organized into sections as follows: epilogue, contributions, limitations, future work, and publications.

8.1 Epilogue

This thesis presents an approach of accountability evaluation to support SoIS scenario modeling, which can be applied for SoIS scenario understanding, called AESoIS. AESoIS is a tool that emerges from the framework (Chapter 6) proposed in this thesis, composed of three phases: prepare AESoIS data gathering, define accountability indicators, and generate AESoIS presentation. *Prepare AESoIS data gathering* is an initial phase of AESoIS data gathering process that considers the database from the BPSoIS tool as an input that collects SoIS elements. *Define accountability indicators* encompasses an approach for managing the accountability criteria (i.e., engagement, management, regulation), as results it generates a database formed by standards and user experience. Finally, *generate AESoIS presentation* provide technological infrastructure for modeling SoIS scenarios concerning some problem definition.

As demonstrated in this thesis, SoIS is an example of SoIS formed by constituent IS. As a result of their architectures that consider technology platforms, SoIS missions, user profiles, business processes, etc. However, SoIS research lacks models and tools addressing SoIS contexts. Furthermore, SoIS research is scarce of accountability evaluation topics and their impacts on the SoIS scenario. Therefore, the proposed accountability evaluation aims to model SoIS scenarios, using the systems thinking approach as a reference. Such an approach is chosen due to the proximity between the accountability principles of identifying the SoIS element's responsibility and ST for representing elements, associations, and feedback. As demonstrated through this thesis, user feedback stimulates learning and change. It is an essential part of accountability resulting from condition, obligation, responsibility, and sanction. Feedback begins with defining relevant elements to be modeled. In this context, the accountability evaluation approach contributes to SoIS understanding, guided to a problem-solve definition and accountability criteria influences.

Since SoIS problems are often complex, poorly understood, and do not have up-to-date supporting documentation, this thesis's greatest research and development effort is concentrated on the SoIS scenario understanding. The focus derives from the interest in modeling SoIS architectures by developing a modeling approach for integrating retrieval of elements that form a SoIS, starting from the BPSoIS. Finally, the recovered characteristics are evaluated regarding their influence in investigated scenarios through the AESoIS tool and user decision about which aspect is relevant to problem-solving. Therefore, AESoIS represents the last phase of the thesis. It involves modeling investigated problems, which considers time effects (immediate, gradual, and structural).

Consequently, to generate a SoIS modeling through the accountability evaluation lens, this thesis addresses the following hypothesis: **H1 - Accountability evaluation affects SoIS context understanding, precisely SoIS arrangement.**

From this hypothesis, some research questions (RQ) are established throughout our work. Some effort was spent in research studies on accountability for IS arrangement, as follows:

RQ1 - How can an accountability evaluation identify behaviors among SoIS elements to support an organizational objective?

To solve **RQ1**, two specific goals are addressed, as follows:

Goal 1 (G1) - Describe an accountability evaluation model drawn from accountability models and theoretical studies on the subject.

Goal 2 (G2) - Develop a set of accountability suggestions for evaluating SoIS scenarios.

To solve G1, we conducted an SMS of accountability in IS domain. SMS characterizes the state of the art of accountability regarding key concepts and provides directions for further IS investigations based on identified research challenges. Initially, this research focused on addressing: (i) definition for accountability, (ii) accountability versus responsibility, (iii) dependence on people for IS success, (iv) frameworks and models for thinking about accountability, (v) information and communications technology, (vi) governance and competitive advantage, and (vii) data management. Moreover, we noticed that accountability uses different demands to support its initiatives, such as investigated exploratory studies. Regarding the accountability dimension, a focus in this research has been demonstrating three evaluation strategies: engagement (effects on people), management (acts on process), and regulation (effects on how processing). Each criterion includes relevant suggestions and their values (i.e., the definition of to do).

These suggestions permit us to clarify the characteristics of accountability and its evaluation, which is part of the second goal.

Furthermore, we propose the AEM. Initially, a preliminary model was constructed with propositions and evidence. The proposition and evidence strategy describes a partial description of the AEM combined with a model fragment, which helps to explain the construct. Each proposition combines evidence with an AEM fragment, as follows:

(i) assumptions are reflecting relationships between model constructs - it represents types of associations among elements and their interdependencies; and

(ii) fragments of AEM diagram - initially, for evaluating proposes, the strategy focuses on describing fragments of the model, then with the knowledge from fragment understanding, the complete model is complete.

Finally, an evaluation plan is presented with a pilot study and interviews with IS specialists, who collaborated with feedback about the model.

Next, to solve G2, we considered analyzing three standards (e.g., ISO) associated with accountability dimensions as a strategy. Standards lie because they are produced from a global consensus, contributing to the evaluation analysis (Abreu *et al.*, 2013; Georges, 2013). In addition, standards tend to highlight SoIS environment dynamics, problem-solving of production, distribution, aiming to ensure quality products and services (Ursini and Sekiguchi, 2005). Thus, a list of ten indicators is presented to sustain the engagement, management, and regulation in organizational scenarios focusing on SoIS elements. This strategy aims to deliver accountability criteria as indicators that can improve elements identified in SoIS. As a result, indicators describe actions in the organizational context. It enables better information in SoIS scenario and help users analyze their processes, permitting users to assess SoIS elements for improving critical thinking and supporting.

RQ 2 - How to generate the representation of SoIS arrangement based on accountability evaluation?

To solve **RQ2**, one specific goal is addressed, as follows:

Goal 3 (G3) - Develop an accountability evaluation framework.

To solve the G3, a framework retrieves SoIS elements that correspond to domain concepts, as verified in the AEM. In addition, it is necessary to explore how to deploy and implement the conceptual model in real scenarios. In this thesis, we explore the framework for supporting accountability evaluation. Such an approach aims to collect data from organizational scenarios, mainly potential problems to be investigated. The proposed framework encompasses. It analyzes information flow, i.e., inputs and outputs of both internal/external resources influencing a transformation process. It depends on the collection of flat shapes and arrows lines to provide a summarized layout regarding input, process, and output organized in four phases. The first input describes an investigation with IS users to identify environment dynamics, considering identifying a problem to be investigated. Phase 1 is processed in understand scenario (Phase 2), which incorporates data from SoIS elements (if evaluable). If there is no database, this phase should investigate the elements and define a survey for collecting data regarding the following data: actors, constituent IS, business process (and tasks), and interoperability links among elements. An analysis must be done to manage information (Phase 3) to define a presentation strategy, considering the SoIS understanding described in Chapter 4. The evaluated strategy (Phase 4) covers the diagnosis approach regarding interconnections, temporal effects, and accountability indicators. At this moment, the framework considers a list of engagement, management, and regulation indicators. The indicator database's purpose is to support the accountability analysis, as each indicator has a description of improvements to be evaluated by managers.

RQ3 - Is the proposed AESoIS tool feasible to aid practitioners in performing accountability analysis with effectiveness?

To solve **RQ3**, two specific goals are addressed, as follows:

Goal 4 (G4) - Develop a tool to support the proposed framework.

Goal 5 (G5) - Execute a feasibility study for the proposed computational tool.

To solve G4, it considers the AEM contribution and framework. Based on this approach, we built a web-based prototype to support the framework proposal, a continuation of Oliveira (2021). The framework BPSoIS extracts data from a BPSoIS database and accountability indicators. Furthermore, the framework is used as a guideline for the proposed thesis tool. Thus, the AESoIS tool focuses on modeling solutions by automatizing and mapping SoIS elements to better understand SoIS scenarios. The tools are opportune to create a visual presentation that describes the interconnections among elements that form a SoIS arrangement. Furthermore, the evaluation strategy focuses on mapping responsibilities among the framework elements, assessed by an accountability evaluation approach. As a contribution from G4, the AESoIS prototype is planned, executed, and then evaluated, as explored in the G5. It is worth mentioning that during the exploratory study, we perceived that it is common for the organization to develop its evaluation strategy. In this context, we developed a database that includes user experience when defining accountability criteria beyond that standard strategy for encompassing engagement, management, and regulation. Such a strategy aims to create an organizational repository addressing accountability evaluation demands and solutions.

In order to solve G5, the thesis solution considers data collected from an educational organization in two stages. In the first phase, the module is evaluated on a pilot basis with two IS practitioners with a large experience in IS and business processes. The feedback from the pilot is incorporated into tool improvements. Finally, the module is evaluated by three SoIS practitioners with extensive experience in educational organizations, more precisely, an academic department unit. This evaluation study takes into account the experience and specialists of participants as practitioners on SoIS. Additionally, in a second phase, the AESoIS is evaluated by two SoIS practitioners with significant experience in IT/IS, considering that participants were free to modeling the proposed scenario. Results provide indications of the effectiveness of the use of the approach for SoIS practitioners.

From the above discussions, it is expected that the Ph.D. thesis will help IS/SoIS managers to better understand SoIS arrangements as part of an accountability assessment strategy. In addition, with the SoIS scenario modeling, it is possible to evaluate potential interventions and improvements, considering accountability criteria.

8.2 Contribution

All contributions of this Ph.D. thesis were motivated in investigating accountability strategies for IS/SoIS managers focusing on understanding SoIS arrangements to support complex problem-solving modeling. Therefore, this thesis contributes with (i) the identification of an approach for supporting evaluation regarding engagement, management, and regulation, based on SMS, exploratory studies, and specialist's opinion; (ii) the definition of a strategy of evaluation considering standards and user experience; (iii) the development of a framework to help researchers to understand SoIS scenario, key concepts better and to analyze organizations' platforms based on an accountability evaluation; (iv) the definition of an approach for evaluating AESoIS framework and tool; (v) AESoIS evaluation with practitioners performing demand and solutions analysis in a real scenario, (vi) it advances in an agenda to implement accountability evaluation in the scientific community considering concrete cases, and (vii) accountability research challenges for advancing accountability research in IS/SoIS research. Furthermore, the Ph.D. research and work provided the IS community with the following detailed contributions:

- **SMS of accountability and research challenges** (Chapter 4): we organized accountability studies in IS and research challenges supporting analyses of SoIS. This contribution focuses on key concepts and evaluation strategies. The SMS has served as part of the body of knowledge for the thesis solution. The results of the SMS supported the creation of the AEM. Additionally, the research indicates the need to create accountability evaluation strategies to ensure accountability in organizations, notably those with complex arrangements. To illustrate this demand, a set of indicators is presented based on standards (e.g., ISO). Indicators reflect actions to be implemented and include descriptions. The indicator approach, as accountability suggestions, is used in the strategy in the developed tool;
- **Conceptual model evaluated with specialists**: Chapter 5 presents a UML representation, namely AEM. At this point, the AEM was constructed with propositions and evidence, considering a pilot and interviews with IS specialists, who collaborated with feedback about the AEM. As a result, the final AEM is defined;
- **AESoIS framework and tool**: Chapter 6 presents a framework tool supported. This phase considers an educational SoIS scenario. It encompasses the thesis contributions and provides an approach for accountability evaluation in SoIS based on ST. Such an approach collects data from investigated scenarios, considering SoIS users' feedback aiming to model investigated scenarios. In addition, its promotes analysis of accountability criteria among AESoIS elements and their relationships;
- **AESoIS evaluation** (Chapter 7): practitioners evaluated part of the proposed approach and infrastructure in a real scenario. A structured investigation protocol was developed and improved with pilot research. It is the basis for the SoIS community to conduct such studies since analytical models, real data case studies, and integrated tool support are lacking. The effectiveness of performing IS management activities for demand and solution analysis was improved with the approach support in the selected and applied context.

8.3 Limitation

Some boundaries were identified for this Ph.D. thesis. Limitations of this work are mainly related to six items: (1) factor that influences the implementation of accountability evaluation; (2) models for the analysis of SoIS; (3) improvement accountability suggestions for AESoIS; (4) assessments with an educational organization using the tool-supported framework; (5) survey with Brazilian researchers and practitioners; and (6) construct validity.

1. Factor that influences the implementation of accountability evaluation

As mentioned in Chapter 1, several factors can influence the implementation of accountability initiatives when focusing on people-process-technology demands and solutions. However, this work focuses only on SoIS, as causal relationships, without considering the other aspects relevant to a constituent IS' successful implementation or maintenance. Thus, factors such as technologies' specifications and technological platforms were not considered in the proposed approach, reinforcing the assertion that the objective of the approach is related to understanding the dynamics of systems.

2. Models for the analysis of SoIS

There are some accountability models in the literature. However, this work focuses on organizing the knowledge arising from the body of knowledge and considers the relevance of instrumentalizing assessment strategies for accountability. A limitation is the use of indicators with a cut in standards (e.g., ISO). It is possible that if other models were identified, in this case, new strategies could be incorporated and could be part of the set of strategies that compose the proposed framework. Thus, we would have more comprehensive accountability assessment strategies.

3. Improvement accountability suggestions for AESoIS

One limitation concerns the number of indicators used in the AESoIS. Although the tool allows the inclusion of new indicators, most of the suggestions were not evaluated in the real scenario, as the study based on TAM is directed to tasks to be performed. Thus, only a few indicators are selected. This limitation may result in unselected suggestions that may or may not help with the SoIS analysis. Other publications with new indicators may be part of the user experience investigation that make up the framework.

4. Assessments with an educational organization using the tool-supported framework

Although all stages of the framework are based on primary and secondary studies, it is necessary to carry out case studies with organizations with SoIS, putting the tool into practice to verify its effectiveness. In this research, the evaluations performed were non-intrusive, analyzing only the opinion of managers of educational organizations regarding usability from the application of the proposed framework.

5. Survey with Brazilian researchers and practitioners

The limitation of the survey with specialists is that they were conducted with Brazilian researchers and practitioners. Therefore, the approach developed by this Ph.D. thesis relies on opinions that may reflect the national accountability scenario for IS/SoIS demands and solutions. Another limitation is the number of participants, which can limit the generalization. Finally, considering the exploratory studies, some limitations can be pointed out: the number of cases analyzed (two); and the subjectivity of the researcher's impressions, opinions, and thoughts.

6. Construct validity

A limitation of the thesis solution is that the approach was developed based on limited resources (mapping study, two exploratory studies, and interviews with specialists). To minimize such risks, we decided to evaluate our approach with real data and practitioners in two different scenarios. Another limitation is the number of participants that evaluated the approach (seven) and the context where the study was performed.

It is worth mentioning that more treats to validity are presented through chapters in this thesis and complements these limitations (Section 3.4, Section 4.6., Section 5.7, and Section 7.6).

8.4 Future Work

Some opportunities were identified from this Ph.D. thesis:

- Investigation of strategies to support an accountability evaluation in SoIS context combined with other quality requirements;
- Investigation of indicators for supporting engagement, management, and regulation associated with SoIS elements;
- Evaluation of AESoIS to improve ease of use and usefulness considering participant's feedbacks in scenarios;
- Preparation and execution of other studies with a BPMN file in different domains for supporting SoIS modeling combined with the thesis solution;

- Investigation of SoIS properties to be included in AESoIS analysis for diagnosing SoIS characteristics, by incorporating other elements of SoIS conceptual model to better characterize SoIS scenario understanding;
- Investigation of metrics to be used as mechanisms for sustain evaluation to aid quantitative data to AESoIS solutions;
- Separation of indicators by groups that indicate the type of professional in the organization responsible for their implementation and developing research for stimulating user experience;
- Incorporation of new elements to the framework, such as those responsible for the execution, there are pre-conditions and/or post-conditions in the sub-processes; and
- Investigation of other systems thinking tools, such as stock and flows to improve computational rates among variables in the diagram.

8.5 Publications

The knowledge produced in this Ph.D. thesis was partially disseminated through international and national publications and some additional contributions.

International Publications

Cordeiro, F. P., & Santos, R. P. (2019b). Systems Thinking as a Resource for Supporting Accountability in System-of-Information-Systems: Exploring a Brazilian School Case. *2019 IEEE/ACM 7th International Workshop on Software Engineering for Systems-of-Systems (SESoS) and 13th Workshop on Distributed Software Development, Software Ecosystems and Systems-of-Systems (WDES)*, 42-49.

Fernandes, J. C., Ferreira, F., Cordeiro, F. C., Graciano Neto, V. V., & Santos, R. P. (2019). A Conceptual Model for Systems-of-Information Systems. *2019 IEEE 20th International Conference on Information Reuse and Integration for Data Science (IRI)*, 364-371.

Fernandes, J. C., Ferreira, F., Cordeiro, F., Graciano Neto, V. V., & Santos, R.P. (2020). How can interoperability approaches impact on Systems-of-Information Systems characteristics? *XVI Brazilian Symposium on Information Systems (SBSI)*, 1-8.

Cordeiro, F. P., Santos, R. P., Vasconcelos, A., & Lago, P. (2020). Towards an Accountability Suggestion Map for Supporting Information Systems Management Based on Systems Thinking. *2020 IEEE 21st International Conference on Information Reuse and Integration for Data Science (IRI). IEEE, 2020. p. 295-300.*

Brazilian Publications

Cordeiro, F. P., & Santos, R. P. (2019a). Accountability in Information Systems. *Anais Estendidos do XV Simpósio Brasileiro de Sistemas de Informação (SBSI)*. XII WTDSI - XII Workshop de Teses e Dissertações em Sistemas de Informação, Aracaju/SE, 57-62.

Fernandes, J. C., Cordeiro, F.P., Ferreira, F., Graciano Neto, V. V. G., & Santos, R.P. (2021). A Method for the Identification of Interoperability Links between Information Systems towards a System-of-Information Systems. *iSys - Brazilian Journal of Information Systems,* (under evaluation).

Others

Cordeiro, F. P., & Araujo, R. (2018). Technologies in the School Daily Life: Patent Survey in Brazil and the United States from 2000 to 2017. *2018 XLIV Latin American Computer Conference (CLEI)*, 378-387.

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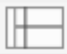
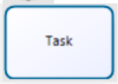
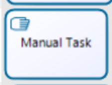
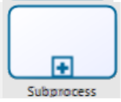
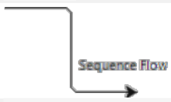
APPENDIX I

This appendix presents the BPM notation for supporting business process modeling.

<u>BPM NOTATION</u>

Element	Description	Notation
Pool	A Pool is a container of a single Process (contains the sequence flows between activities). A Process is fully contained within the Pool. There is always at least one Pool.	
Lane	Is a sub-partition within the Process. Lanes are used to differentiate elements as internal roles, position, department etc. They represent functional areas that may be responsible for tasks.	
Start Event	Indicates where a particular Process starts. It does not have any particular behavior.	
Intermediate Event	Indicates where something happens somewhere between the start and end of a Process. It will affect the flow of the Process but will not start or (directly) terminate the Process.	
End Event	Indicates when the Process ends.	
Task	Is an atomic Activity within a Process flow. It is used when the work in the Process cannot be broken down to a finer level of detail.	
User Task	Is a typical workflow Task where a person performs the Task with the assistance of a software application.	
Service Task	Is a Task that uses some sort of service that could be a Web service or an automated application.	
Manual Task	Is a Task that is expected to be performed without the aid of any business process execution or any application.	
Sub-process	Is an Activity in which internal details have been modeled using activities, gateways, Events, and sequence flows. The elements have a thin border.	
Exclusive Gateway	As Divergence: It is used to create alternative paths within the Process, but only one is chosen. As Convergence: it is used to merge alternative paths.	
Data Objects	Provides information about how documents, data, and other objects are used and updated during the Process.	
Data Store	Provides a mechanism for activities to retrieve or update stored information that will exist beyond the scope of the Process.	
Annotation	Is a mechanism for a modeler to provide additional information for the reader of a BPMN Diagram.	
Sequence Flow	A Sequence Flow is used to show the order in that Activities will be performed in the Process.	
Association	Its used to associate information and Artifacts with Flow Objects. It also shows the activities used to compensate for an activity.	
Message Flow	Is used to show the flow of messages between two entities that are prepared to send and receive them.	

Reference: https://download.bizagi.com/docs/modeler/3300/en/Modeler_user_Guide.pdf

APPENDIX II

This appendix organizes the exploratory study survey in forms: consent form, characterization form, and execution form.

EXPLORATORY STUDY SURVEY

A. *Consent Form (In Portuguese)*

TERMO DE CONSENTIMENTO LIVRE ESCLARECIDO

PESQUISA PARA DIAGNOSTICAR PROBLEMAS NO COTIDIANO ESCOLAR

A avaliação ocorrerá de forma virtual e será dividida em duas etapas:

ETAPA 1: Uma seção (Seção 2) coletando informações demográficas do participante (dez questões); e

ETAPA 2: Execução de uma estudo em grupo para coletar informações sobre o cotidiano escolar e seus problemas.

Solicitamos a sua especial colaboração em: (1) participar do debate de idéias sobre o cotidiano escolar; e (2) permitir que os dados resultantes da sua participação sejam estudados.

Estima-se que, para realizar a avaliação virtual, sejam necessários cerca de 1 hora.

CONFIDENCIALIDADE

Eu estou ciente de que os dados obtidos por meio deste estudo serão mantidos sob confidencialidade e os resultados serão posteriormente apresentados de forma agregada, de modo que um participante não seja associado a um dado específico. Da mesma forma, me comprometo a não comunicar meus resultados enquanto o estudo não for concluído, bem como manter sigilo das informações fornecidas e documentos apresentados.

BENEFÍCIOS E LIBERDADE DE DESISTÊNCIA

Eu entendo que, uma vez que as respostas tenham sido encaminhadas, serão desenvolvidos trabalhos visando trazer melhorias para avaliação de accountability em sistemas de informação.

Entendo que sou livre para (1) comentar as perguntas por meio dos campos comentários de cada item da entrevista semiestruturada e (2) solicitar que qualquer informação relacionada à minha pessoa não seja incluída no estudo.

Por fim, declaro que participo de livre e espontânea vontade com o único intuito de contribuir para a avaliação e posterior melhora do modelo conceitual de accountability em sistemas de informação.

B. *Characterization Form (In Portuguese)*

1. Nome: ____

2. E-mail: ____

3. Idade: ____

4. Qual sua escolaridade mais alta?

◯ Ensino Médio/Superior Incompleto
◯ Superior Completo
◯ Especialização
◯ Mestrado
◯ Doutorado

5. De que forma atua (atuou) no cotidiano escolar na organização? *

◯ Professor
◯ Coordenação de Curso
◯ Direção
◯ Coordenação de Turno
◯ Inspeção de Turno
◯ Supervisor Educacional
◯ Orientador Educacional

6. Há quanto tempo você atua (atuou) na função?

◯ 1 ano ◯ 2-3 anos ◯ 4-5 anos ◯ 5-6 anos ◯ Mais de 6 anos.

7. Qual sua jornada de trabalho na organização?

◯ Integral (40h) ◯ Parcial (20h)

8. Em uma escala de 1 a 5, com 1 sendo o menos confortável e 5 sendo o mais confortável, até que ponto você está confortável e familiarizado (a) ao termo accountability?

Menos ◯1 ◯2 ◯3 ◯4 ◯5 Mais

9. Em uma escala de 1 a 5, com 1 sendo o menos confortável e 5 sendo o mais confortável, até que ponto você está confortável e familiarizado ao termo (a) sistemas de informação?

Menos ◯1 ◯2 ◯3 ◯4 ◯5 Mais

10. Em uma escala de 1 a 5, com 1 sendo o menos confortável e 5 sendo o mais confortável, até que ponto você está confortável e familiarizado(a) ao termo sistemas de informação complexos?

Menos ◯1 ◯2 ◯3 ◯4 ◯5 Mais

C. Execution Form (In Portuguese)

Diagnóstico do Problema

Nesta fase, dois grupos focais serão formados e você poderá contribuir coletivamente com informações sobre o cotidiano escolar de sua organização.

Em grupo, você deve responder um conjunto de perguntas relativas ao cotidiano escolar, considerando as dinâmicas entre pessoas, processos e tecnologia.

A conclusão da pesquisa se dá com os registrados dos comentários formalizados em ata de reunião.

1. Quem são as partes interessadas e quais são as responsabilidades dos membros do CAp-Iserj?

2. Relate sua trajetória profissional e experiência no cotidiano escolar.

3. Relate situações que ocorrem no cotidiano escolar que influenciam a qualidade da educação?

APPENDIX III

This appendix presents the AEM propositions feedbacks from participants of conceptual model fragments, feedbacks from participants addressing the complete AEM version, AEM elements and descriptions, and glossary of AEM relationships.

AEM PROPOSITIONS FEEDBACKS

CQ	PARTICIPANT	FEEDBACK
CQ1	P11	"*in my opinion, the objectives of a system and some organizations are not the same because their objectives are at different levels. I believe that in a model, the objective class needs to be specified with subtypes because as it stands, it appears that organizational (strategic) objectives may be the same as those of a system (tactical and operational)*".
CQ1	P02	"*how are the stakeholders? shouldn't they be represented as internal or external?*"
CQ1	P15	"*in the model presented, the focus is on the objective, but the relationship between the stakeholder and the organization is not presented, since they have a strong connection, I believe it should be represented. I missed that connection*".
CQ1	P20	"*I believe that that class system should focus on information system domain*".
CQ2	P06	"*the model does not represent who has the 'ownership' of Accountability. Is it the SI? Is it the stakeholder? Is the stakeholder using the SI?*"
CQ2	P09	"*from what I understand, it is vital that quality requirements talk to each other in the proposed model*".
CQ3	P02	"*I think it would be interesting to adjust the text to reflect the participation of the right class since it is close tasks' requirements*".
CQ3	P03	"*I'm not sure about the branch of responsiveness, mainly considering the impacts if the elements Right regarding the pre-conditions, resources to support some objective*".
CQ3	P20	"*responsibility is expected to accountability*".
CQ3	P21	"*responsibility and accountability are intrinsic; furthermore, I believe that responsibility is part of accountability; in other words, the existence of accountability has a responsibility as a status of been accountable*".
CQ3	P00*	"*since accountability criteria are open, they should be defined strategy; moreover, mechanisms are intrinsic to some strategy. For example, a strategy of improving management use some mechanisms*".
CQ4	P05	"*I am in doubt as to whether there should be a connection between the element accountability and system*".
CQ4	P18	"*stakeholders must be called upon so that the demands for accountability are met most effectively*".
CQ5	P05	"*are there various types of Accountability? If so, the relationship between accountability and accountability strategy should be detailed*".
CQ6	P05	"*where did the monitoring go? It would not be a subclass, but I believe that it has to be evident within the model, being an essential mandatory part of the evaluation strategy*".
CQ6	P14	"*well-defined processes, especially with IS support, are fundamental for the regulation and management of accountability*".
CQ7	P14	"*activities and the role of each actor when well-defined help in understanding how a problem occurs. Investigating how things happen and effects on the organizational environment are essential key for the success*".

AEM COMPLETE FEEDBACKS

CRITERION	PARTICIPANT	FEEDBACK
Testability	P05	"*I believe that the relationship between accountability and system should be demonstrated*".
	P08	"*considering that stakeholders can be different types of participants, I believe a better representation between system and stakeholder would be useful*".
	P11	"*maybe the seen of responsibility should be integrated as an attribute in accountability element, and this could be associated with the sanction and some objective*".
Empirical Support	P07	"*I know the theme, but I don't know any model for representing evaluation*".
	P10	"*this is my first time seen an evaluation about accountability associated do information systems*".
Explanatory power	P02	"*the model elements are understandable, but some technical and explanatory text may be necessary depending on the professional's area of specialists*".
	P07	"*despite using techniques (UML) already known to the community, understanding the model depends on an intermediate capacity for abstraction*".
	P08	"*In my assessment, I needed the support of the interviewer to understand some concepts that were not my domain*".
	P14	"*I believe that the more technical IS developers may not deeply know some elements of the model (mainly the responsiveness branch and accountability evaluation). However, IS managers may be more familiar with these elements (UML)*".
Parsimony	P08	"*the model is quite objective, and it helps to understand accountability and the relevance of investigating strategies to support accountability in organizations*".
	P15	"*it is difficult to assess the parsimony has been achieved without knowing what the purpose of the diagram is. How can it be used and solve what problem?*"
Generality	P03	"*I can't think of anything that refutes the idea presented in the proposed model*".
	P07	"*engagement, management and regulation strategies can provide great mechanisms for stimulating accountability and supporting IS use*".
	P15	"*my questions are related to stakeholders not being linked to an organization, and obligation, sanction, responsibilities, and rights must also be associated with* "*who*" *and not only* "*what,*" *so I believe that there is to be demonstrated in the model*".
	P20	"*an organizational objective should be described with somethings to be achieved, for example, tasks are related to an objective and information systems and stakeholders support them*".
	P21	"*I believe those information systems and stakeholders affect more elements; thus, maybe the element objective could be more detailed*".
Utility	P05	"*I am not entirely sure about the practical applicability. Understanding a conceptual model is not trivial for those who are not used to reading one*".
	P07	"*I consider it more useful for theory than for practice. My answer is justified by the fact that I do not know other models for accountability, but I believe that with maturity and application in other organizations, the proposal will become more useful for practice*".
	P09	"*I believe that this model has a vast scope, and it is up to the academy*".
	P11	"*in the case of practice, it can be transformed into real processes within an organization*".
	P13	"*it is critical research; for example, just the contact with the topic can create a possibility for a paradigm shift*".
	P14	"*the model encourages the formation of theories and practices on accountability in information systems domain*".
	P15	"*I believe that an instantiation of this theoretical model would be very valid, including to evolve or make adjustments*".
	P16	"*if the intention is to know the topic, I believe it is a good starting point. But if the intention is to define procedures, it seems that examples and details are missing from the diagram to supporting accountability*".

AEM ELEMENTS AND DESCRIPTIONS

INITIAL AEM	FINAL AEM	DEFINITION	REFERENCES
Organization	Organization	A person or group of people has its functions with responsibilities, authorities, and relationships to achieve its objectives. The concept of an organization includes, but is not limited to, company, corporation, firm, enterprise, association, whether incorporated or not, public or private.	(Gortmaker *et al.,* 2005; Chuan-hui & Bing, 2011; Pearson, 2014; ISO/IEC 9000, 2015;)
Objective	Objective	Interest relevant to one or more stakeholders, organizations, or systems.	(Stahl, 2006; Zou *et al.,* 2009; ISO/IEC 42030, 2013;)
Information System	Information System	It is a set of interrelated or interacting elements with a purpose(s). It includes but is not limited, information systems (and their constituents) and systems-of-information systems.	(Eriksén, 2002; Campagnolo & Jacucci, 2006; ISO/IEC 42030, 2013)
Stakeholder	Actor	Individual, team, or classes thereof, having an interest in a system.	(Campagnolo & Jacucci, 2006; Eriksén, 2002; ISO/IEC 42030, 2013)
Accountability	Accountability	Accountability is a non-functional requirement for holding responsible actions in organizations, and the results of those actions consider regulations and sanctions. It encompasses responsibility diagnosing aiming to support Accountability among actors, business processes, and information systems.	(Feigenbaum *et al.,* 2011; Gajanayake *et al.,* 2011a; Pearson, 2011)
Evaluation Criteria	Quality Criteria	It is a principle, standard, rule, or test on which a judgment or decision can be based. It encompasses other quality requirements such as sustainability, performance, and security that may influence and influence each other.	(Campagnolo & Jacucci, 2006; ISO/IEC 42030, 2013; Lourenço & Serra, 2014; Pearson, 2014)
Accountability Evaluation Mechanisms	Evaluation Strategy	It is a strategy to identify accountability activities to evaluate behavior efforts in information systems to address evaluation criteria.	(Pearson, 2014)
Engagement	Engagement	It involves taking part in an activity, event, or situation and contributing to actions to achieve shared objectives.	(Gajanayake *et al.,* 2011a; ISO/IEC 9000, 2015; Anagnostopoulos *et al.,* 2013)
Management	Management	It involves the exercise of control and supervision within the authority and Accountability established by governance. The term management is often used as a collective term for those who have responsibility for controlling an organization or subunits.	(Madon *et al.,* 2010; ISO/IEC 38500, 2015)
Regulation	Regulation	It involves meeting the organization's requirements to comply with (and enforce) legal and regulatory standards (e.g., policies, guidelines, laws, and rules). It aims to support regulation activities (either formal or informal) in systems' processes. It means addressing parameters for sanctions/obligations aiming to assist engagement and management.	(Madon *et al.,* 2010; ISO/IEC 9000, 2015)
Right	Condition	It encompasses facilities required by an organization to fulfill its accountabilities. These facilities could include, amongst others, capabilities, authorities, or the right to delegate.	(Feltus *et al.,* 2009; Khadraoui & Feltus, 2012)
Sanction	Sanction	It involves an Intense action is taken to make people obey a law or rule, or even punishment is given when they do not attend.	(Feltus *et al.,* 2009; Feigenbaum *et al.,* 2011; Pearson, 2011; Khadraoui & Feltus, 2012)
Obligation	Obligation	It is a role of “must-do” that is a concerning state of affairs (e.g., executing an activity) and includes what a part must do to fulfill a responsibility, such as directing, supervising, and monitoring obligation a right is delegated.	(Feigenbaum *et al.,* 2011; Gajanayake *et al.,* 2011a; Pearson, 2011; Khadraoui & Feltus, 2012;)
Responsibility	*	Obligation to act and make decisions to achieve required outcomes.	(Feltus *et al.,* 2009; 2012)

* The entity “responsibility” was used in the preliminary model; however, after the model evaluation, the entity was incorporated as an attribute to the entity “Accountability”.

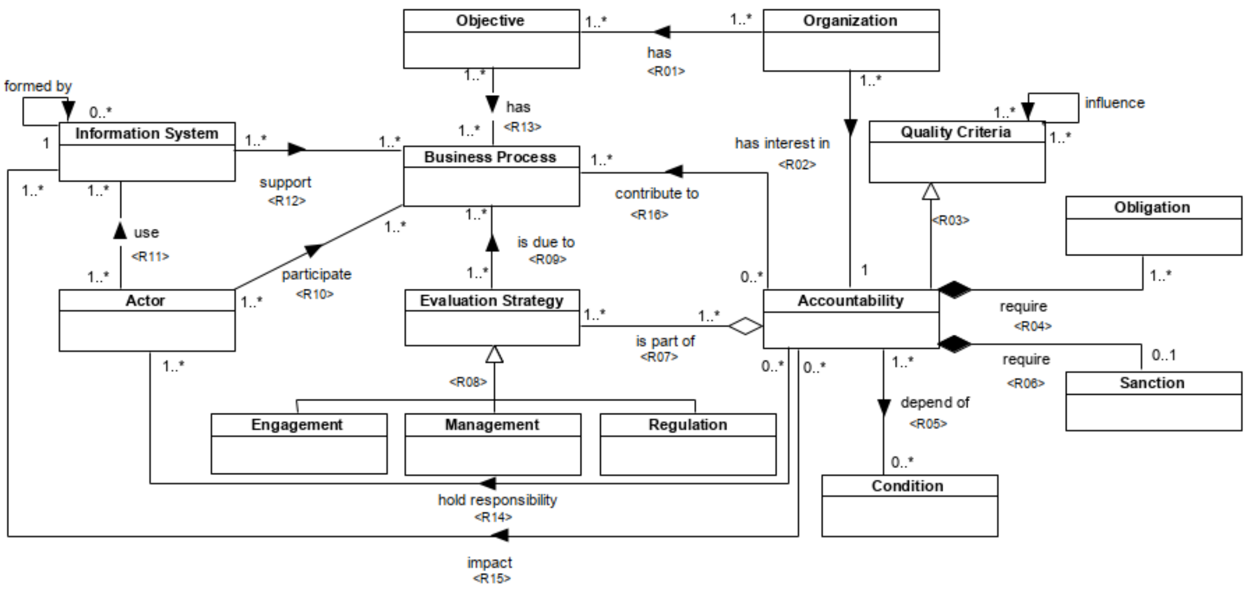


Figure 70 - Accountability Evaluation Model.

GLOSSARY OF RELATIONSHIPS

ID	DEFINITION	SOURCE
R01	An organization has at least one objective.	S12, S13
R02	An organization has an interest in one accountability.	S03, S05, S15
R03	An accountability is a type of quality criterion.	S12, S13
R04	Accountability require at least one obligation.	S07, S26, S27
R05	Accountability depends on various (or not) conditions.	S18
R06	Accountability may require one (or not) sanction.	S07, S26, S27
R07	An evaluation strategy is part of at least Accountability.	S25
R08	An evaluation strategy is a set of accountability strategies.	S25
R09	An evaluation strategy is due to at least one business process.	S01
R10	An actor participates in at least one business process.	S14, S19, S24
R11	An actor uses at least one information system.	S07, S21
R12	An information system supports at least one business process.	S03, S04, S05
R13	An objective has at least one business process.	S01
R14	Accountability holds responsibility in at least one actor.	S19, S23, S25
R15	Accountability impacts at least one information system.	S16, S27
R16	Accountability may contribute (or not) to a business process.	S01

APPENDIX IV

This appendix presents the AESoIS framework guidelines. Table 47 presents a template for organizing data regarding the BPMN tasks in each sub-process.

Table 47 - Task template.

Identifier	<identifier name>
Task	<task name>
Description	<activity description>
Input	<description of input data>
Output	<description of output data>

Prepare AESoIS Data Gathering Sub-process

Figure 71 the AESoIS data gathering sub-process. The BPSoIS data retrieval process starts at **import BPSoIS data**. This activity is performed in parallel with defining an investigated problem to **identify a business problem associated with an organizational objective**.

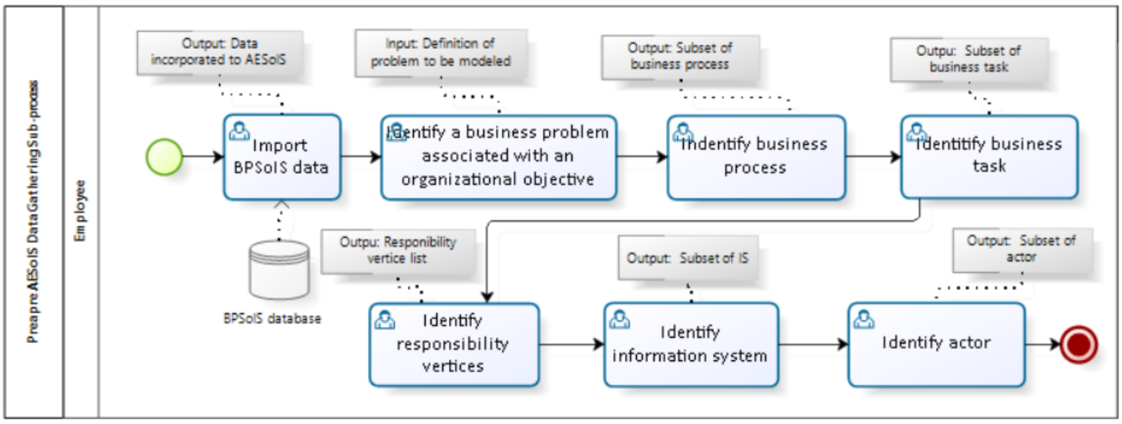


Figure 71 - AESoIS Data Gathering sub-process.

Moreover, the analysis is done by an organization employee who defines a problem and the data to be incorporated. At this point, the approach focuses on AEM elements, namely constituent IS, actor, business process to be incorporated into AESoIS. In this context, the following tasks describe a respective subset from a SoIS scenario in the context of problem modeling: **identify business process**, **identify business task**, **identify responsibility vertices**, **identify information system**, and **identify actor**. In this context, Table 48 to Table 54 show detail on each task from these sub-processes that integrate the AESoIS Generation Macro-process.

Table 48 - Import BPSoIS data.

Identifier	**STEP 1**
Task	Import BPSoIS data
Description	It focuses on BPSoIS relevant data. The tool automatically extracts the constituent IS, actor, and business task elements and incorporates them into a database.
Input	BPSoIS database.
Output	Framework processing.

Table 49 - Identify a business problem associated with an organizational objective.

Identifier	**STEP 2**
Task	Identify a business problem associated with an organizational objective

Table 49 - Identify a business problem associated with an organizational objective (Part 2).

Description	A survey is carried out with organizations at this stage. First, the employees must identify an organizational problem to be modeled. This questionnaire aims to collect employees' perceptions regarding the problems and potential elements from the SoIS contributing to the problem. The problem diagnosis must encompass information concerning the project name, project author, organizational objective, investigate the problem, and description.
Input	A questionnaire about employee profiles and collecting information about existing business processes and possible problems supports AESoIS modeling.
Output	Employee answers.

Table 50 - Identify business process.

Identifier	**STEP 3**
Task	Identify business process
Description	From the definition of a problem in Step 2, the employee must inform, among the existing business processes, those which participate positively/negatively in contributing to the business processes analysis. For example, let’s assume that a SoIS have ten business processes, but a particular problem is influenced by two business process. Thus the employee in identify business process must select the two cases, as they are relevant for problem-solving modeling.
Input	Employee answers.
Output	Subset of business problem.

Table 51 - Identify business task.

Identifier	**STEP 4**
Task	Identify business task
Description	From the definition of a problem in Step 2, employees must inform, among the existing business processes, those business tasks that participate positively/negatively in contributing to the business task analysis. For example, let’s assume that a SoIS is formed by one business process, encompassing ten business tasks. However, not every business task is related to the problem. Thus, the employee must identify relevant business tasks for problem-solving modeling.
Input	Employee answers.
Output	Subset of business task.

Table 52 - Identify responsibility vertices.

Identifier	**STEP 5**
Task	Identify responsibility vertices
Description	From the definition of tasks in Step 4, this step considers that some business task labels may be too large to be inserted into the diagram. Therefore, vertices of responsibility allow labels to be renamed. The act of renaming aims to simplify task elements in the design phase.
Input	Employee answers.
Output	Subset of responsibility vertices.

Table 53 - Identify information system.

Identifier	**STEP 6**
Task	Identify information system
Description	From the definition of a problem in Step 2, the employee must inform, among the existing IS, those IS that participate positively/negatively in contributing to the constituent IS analysis. For example, the strategy presented in Step 3 is the same for IS context and its subset.
Input	Employee answers.
Output	Subset of constituent IS.

Table 54 - Identify actor.

Identifier	**STEP 7**
Task	Identify actor.
Description	From the definition of a problem in Step 2, the employee must inform among the existing actors, those actors that participate positively/negatively in contributing to actor analysis. For example, the strategy presented in Step 3 is the same for actor and its subset.

Table 54 - Identify actor (Part 2).

Input	Employee answers.
Output	Subset of actor.

Define Accountability Indicator Sub-process

Figure 72 presents the accountability indicator sub-process. It encompasses a strategy for supporting the creation and edition of the evaluation strategy, as proposed in AEM. The AESoIS data retrieval process starts at **check the existence of an indicator**, which is supported by the AESoIS indicator database. At this point, the task verifies indicators and presents a list containing their data. As a result, the gateway icon presents two ways.

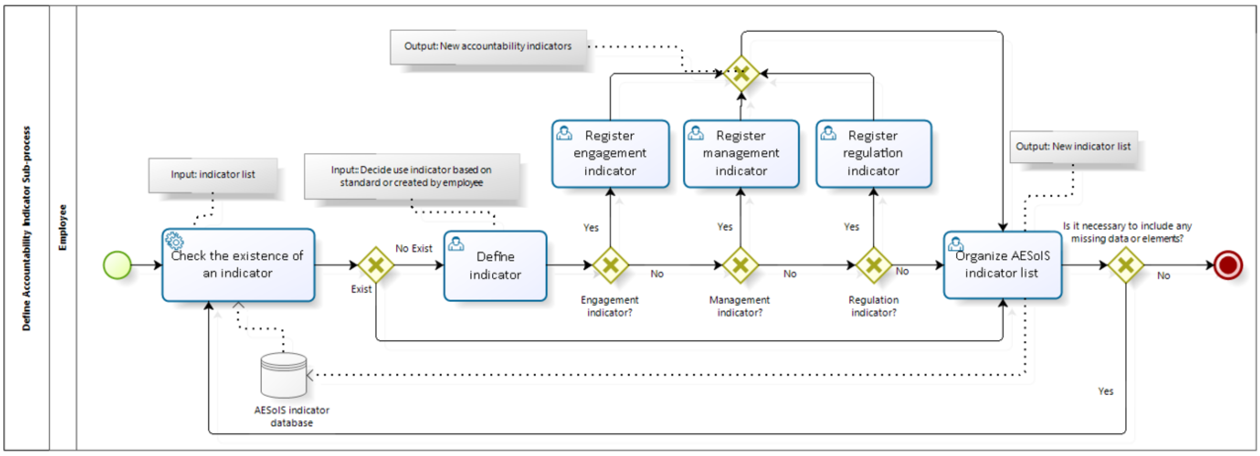


Figure 72 - Define Accountability Indicator sub-process.

First, if the employee comprehends that no new indicators are relevant for evaluation, then **organize AESoIS indicator list** presents a subset of accountability indicators for an investigated scenario. Second, if the employee comprehends some new indicators are relevant for evaluation, then **define indicator** starts a process for building new indicators. As a result, the following tasks, **register engagement indicator**, **register management indicator**, and **register regulation indicator**, respectively focus on a definition of new elements to be incorporated. It is worth mentioning that in this thesis, the evaluation strategy bases on three standards (e.g., ISO) for supporting engagement - AA1000 Stakeholder Engagement Standard (AccountAbility, 2015), management - ISO 21001 (2018), and regulation - ISO 38500 (2015). This evaluation strategy is a preliminary approach to be evaluated during the tool's execution. It is not the thesis focus to detail all evaluation indicators for the SoIS, but rather to indicate the relevance of the indicators to improve accountability. Therefore, the task organizes AESoIS indicator list encompasses the subset indicators list formed by the new indicator (if created) or the standard selected indicators defined by the employee at the AESoIS indicator database. As a final result, this task updates de database. Thus, Table 55 to Table 60 show details on each task.

Table 55 - Check the existence of an indicator.

Identifier	**STEP 1**
Task	Check the existence of an indicator
Description	In this step, the employee must perform the data analysis procedure using the pre-defined elements from AESoIS indicator database. As a result, the employee must decide to define new indicators (or not). This analysis presents a list of indicators (i.e. accountability suggestions) focusing on the ISO standard approach or user experience.
Input	Employee answers.
Output	Framework processing.

Table 56 - Define indicator.

Identifier	STEP 2
Task	Define indicator
Description	In this step, the employee must define new indicators to be incorporated into the AESoIS indicator database. As a result, this task lists all indicators organized and defines a new subset of indicators. The creation process is organized into two options. First creation process focuses on using a standard for supporting each accountability criteria, e.g., AA1000 standard providing engagement indicator. At this point, an employee must inform the accountability criteria type, standard type, indicator label, and description. Second, the employees may be interest in defining their own indicators. In this example, the employee must inform the criteria type, a label, and its description. Such an approach aims to incorporate strategies beyond the standard, such as ISO.
Input	AESoIS indicator from a database.
Output	Framework processing.

Table 57 - Register engagement indicator.

Identifier	STEP 3
Task	Register engagement indicator
Description	In this step, the employee must define at least one engagement indicator to be incorporated into the AESoIS indicator database. It considers all indicators and defines a new subset of indicators.
Input	AESoIS indicator database.
Output	Engagement indicator.

Table 58 - Register management indicator.

Identifier	STEP 4
Task	Register management indicator
Description	In this step, the employee must define at least one management indicator to be incorporated into the AESoIS indicator database. It considers all indicators and represents a new subset of indicators.
Input	AESoIS indicator database.
Output	Management indicator.

Table 59 - Register regulation indicator.

Identifier	STEP 5
Task	Register management indicator
Description	In this step, the employee must define at least one regulation indicator to incorporate into the AESoIS indicator database. It considers all indicators organized, and it defines a new subset of indicators.
Input	AESoIS indicator database.
Output	Regulation indicator.

Table 60 - Organize AESoIS indicator list.

Identifier	STEP 6
Task	Organize AESoIS indicator list
Description	It considers the definition of a new indicator (or not) focusing on AESoIS indicator database update. As a result, the accountability criteria in AESoIS use this information for contributing to AESoIS elements analysis.
Input	Engagement Indicator. Management Indicator. Regulation Indicator. AESoIS indicator from database.
Output	Framework processing.

Generate AESoIS Presentation Sub-process

Figure 73 presents the Generate AESoIS presentation sub-process. It encompasses the ASM layout and the AESoIS elements used in the **take design plan**. In this line, **select elements from upper bar** details modeling resources. In this context, the employee can identify AESoIS elements that are relevant for modeling the investigated scenario. As a result, in **manage elements and their properties,** the employee must use the AESoIS elements previously defined.

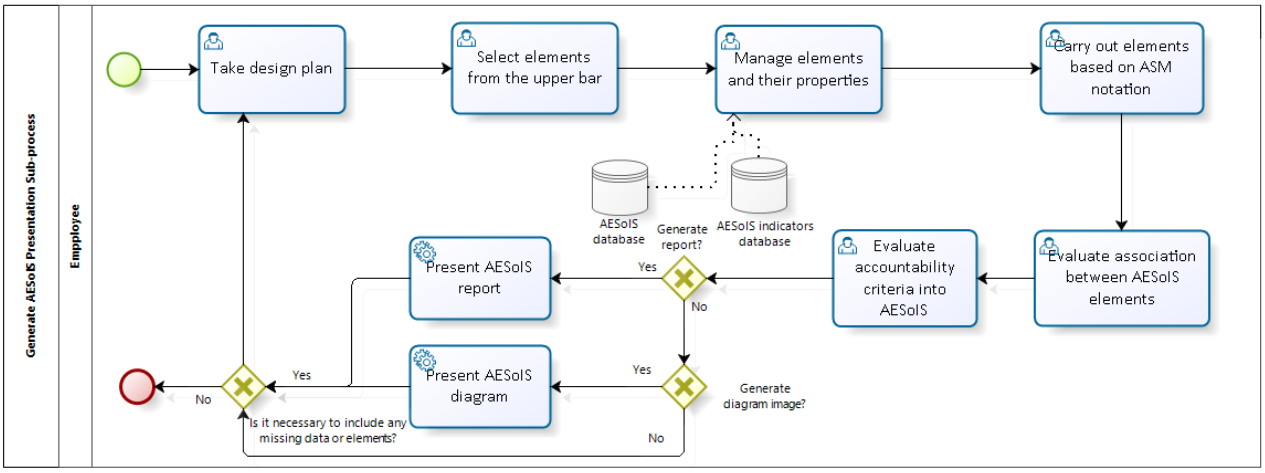


Figure 73 - Generate the AESoIS Presentation Sub-process.

At this point, an employee has available in the **carry out element based on ASM notation** the modeling strategies provided by the AESoIS module to support problem modeling in scenarios supported by SoIS. It encompasses the following modeling resources as part of **evaluate association between AESoIS elements**: (i) Manage constituent IS and its relationships, considering respective editing data; (ii) Manage actor and its relationships, considering editing respectively data; (iii) Manage responsibility vertices and their relationships, considering respective editing data; (iv) Manage accountability criteria and their relationships, considering editing respectively data; and (v) Manage responsibility association, considering positive and negative causal links, accountability criteria links, interoperability links, and standard links.

In addition to the scenario modeling problem, the framework provides the accountability criteria analysis, as proposed in **evaluate accountability criteria into AESoIS elements**. It is based on assessment considering engagement, management, and regulation indicators and their influences on elements. At this point, the employee can find improvement for the analyzed elements based on recommendations from standards or employee experience. Finally, the employee can decide between the tasks **present AESoIS report** and **present AESoIS diagram**. In both tasks, the core presents information about the diagram, as follows: (i) the first report organizes metadata from the model and aims to explore information from databases textually, and (ii) the second reports focus on generating a picture from the generated model. In this context, Table 61 to Table 68 details each task from this sub-process that integrates the AESoIS Generation Macro-process.

Table 61 - Take design plan.

Identifier	STEP 1
Task	Take design plan
Description	In this step, all the design elements proposed in the ASM layout and AEM elements are available for modeling. The employee has the drag and drop capabilities available and can perform the modeling of the problem with visuals resources and respective database connections that have been incorporated from the BPSoIS and AESoIS indicators database.
Input	Employee answers.
Output	AESoIS processing.

Table 62 - Select elements from upper bar.

Identifier	STEP 2
Task	Select elements from upper bar
Description	In this step, the employee selects elements for modeling. For each element, there is a label and a brief description of it.
Input	Icon list based on ASM layout.
Output	Icon in modeling area.

Table 63 - Manage elements and their properties.

Identifier	STEP 3
Task	Manage elements and their properties
Description	In this step, the employee customizes elements. The employee must define whether to use the data from previously registered elements or whether to insert new ones. For example, when analyzing potential modeling candidates, considering the subset of actors defined in the initial data load, the employee can select an actor from the list or create a new actor that was not previously thought of. Furthermore, it is possible to select the element and define its properties, i.e., condition, sanction, obligation, and properties.
Input	List of elements with interoperability links.
Output	List of elements and list of visual representation.

Table 64 - Carry out elements based on ASM notation.

Identifier	STEP 4
Task	Carry out elements based on ASM notation.
Description	This step indicates the modeling resource for elements relationships understanding. It considers the relationships between elements. Thus, the framework presents different associations and a design area that considers temporal effects (gray gates) and a support area (blue). The selected elements must be represented in the gray area or the drawing area for accountability suggestions. However, the accountability criteria can only be inserted in the area dedicated to the evaluation with indicators.
Input	List of modeled elements.
Output	List of customized modeled elements.

Table 65 - Evaluate association between AESoIS elements.

Identifier	STEP 5
Task	Evaluate association between AESoIS elements
Description	From the definition of modeling elements in previous steps, employees must identify among the existing elements, those which participate positively/negatively in contributing to the evaluation approach considering accountability criteria analysis.
Input	List of elements with interoperability links.
Output	List of elements and list of visual representation.

Table 66 - Evaluate accountability criteria into AESoIS elements.

Identifier	STEP 6
Task	Evaluate accountability criteria into AESoIS elements
Description	At this point, an employee must decide between select indicators from the AESoIS indicator database, define new indicators based on employee experience, or even new standards indicators (e.g., ISO). In the case of new indicators, the employee must define the type of indicator to be created and describe how it can be applied or its influence on the investigated problem. It should be noted that once a new indicator is created, at run time, it is permanently inserted into the AESoIS indicator database.
Input	All modeled elements.
Output	Association between accountability criteria and selected design elements.

Table 67 - Prepare AESoIS report.

Identifier	STEP 7
Task	Prepare AESoIS report

Table 68 - Prepare AESoIS report (Part 2).

Description	In this step, the framework presents the AESoIS reporting. It contains textual information regarding the modeled elements, and it encompasses their associations. Additionally, it presents the accountability criteria report based on selected indicators.
Input	Employee answers.
Output	AESoIS processing.

Table 68 - Prepare AESoIS diagram.

Identifier	**STEP 8**
Task	Prepare AESoIS diagram
Description	In this step, the framework presents the AESoIS diagram reporting. It contains visual information regarding the modeled elements, as a PDF file.
Input	Employee answers.
Output	AESoIS processing.

APPENDIX V

This appendix presents the AESoIS tool and the process-driven support to develop front-end and back-end programming. We are using a variety of models and modeling languages, as previous chapters introduced.

Introduction

Chapter 6 presented the framework proposal to analyze and model SoIS scenario concerning problem-solving from the point of view of SoIS users. As described, the approach is composed of three processes, executed through AESoIS: prepare AESoIS data gathering, accountability indicators, and AESoIS presentation. In addition, this chapter presents the tools built to support the three processes of the AESoIS framework. Regarding the BPSoIS data recovery data, the requirements established in the previous chapter are evaluated in this chapter. It focuses on reducing efforts to execute process activities and comprehend an investigated scenario so that the retrieved BPMN process can be reused for a problem-solving. BPSoIS was selected since it offers resources for supporting the proposed approach, and it had been developed in the same research context as this thesis, i.e., Lab ESC from UNIRIO.

To meet the second AESoIS process, the tools developed in this thesis present an evaluation strategy based on accountability criteria concerning standards and user experience aligned with ST. The standard was selected as a starting point for investigating accountability criteria (i.e., engagement, management, and regulation). In contrast, the proposed tool sustains data collected from SoIS actors (such as employees, managers, and practitioners) based on their user experience and potential ideas that may influence the investigated SoIS scenario. Furthermore, from the point of view of AESoIS modeling and evaluation, the tool presents a building node approach for illustrating SoIS elements and their associations, which are elements for supporting ST.

In this context, an example of a problem modeling scenario is presented. This example involves retrieving the BPSoIS analysis as part of the tool data gathering process combined with the AESoIS modeling approach. The support for AESoIS activities is illustrated through a hypothetical example in an academic department in a real case study involving data collection from a Master's work by Oliveira (2021).

AESoIS Project

AESoIS project encompasses modeling techniques approaches, called as ST, causal loop, and feedbacks. ST approach aims to look at things systemically think in terms of feedback. One of the major tools of ST is the causal loop diagram. A causal loop represents associations containing directed arrows connecting to words, usually with one closed-loop representing feedback (Checkland, 2000). Feedback is a process in which a decision or action causes changes that cause a revision of the decision or action (Checkland, 2000). Feedback typically involves more than one people-process-technology, each responding to the efforts of another in such a way as to, eventually, change the behavior of others.

Initially, the AESoIS solution consisted of infrastructure with notation and an interview plan to comprehend SoIS scenario and to generate AESoIS. In 2021, with the partnership with Oliveira (2021), it evolves from a physical to a computation solution, becoming a module for BPSoIS. In its creation, the instruments and programming described in Section 6.3 are used. The construction process of these elements is considered the ASM layout (Cordeiro *et al.*, 2020) and the framework strategy for mapping accountability.

In the context of Oliveira’s (2021), the proposed model is inspired by the SoIS conceptual model (Fernandes *et al.*, 2019). Such a conceptual model captures the high-level abstractions of the domain, representing its conceptual, functional, and technological capabilities. Oliveira (2021) extended the proposed model and method to incorporate business process analysis for SoIS infrastructure.

In contrast, BPSoIS does not have resources for the dynamic representation of elements and mechanisms to assess SoIS arrangements modeling. These factors motivated the restructuring of the BPSoIS tool by analyzing its functionalities as essential, secondary, and the parallels between the tool’s conceptual model and the AEM. As a result, the essential features started to compose the tool, and then secondary functionalities were extracted from BPSoIS tool and database.

Furthermore, the programming language is Python[12]. Python is a clear and powerful object-oriented programming language comparable to other programming languages. In addition, the Django[13] development framework is used to create a visual environment for the tool. Finally, Django is a high-level Python Web framework that encourages rapid development and clean, pragmatic design.

In addition to these technologies, data storage is realized with SQLite[14], and the React Flow Library[15] is used as a design template. React flow is a library for building node-based applications. These can be simple static diagrams or complex node-based editors. Therefore, with the inclusion of these technologies, the static functions from BPSoIS tool are enhanced with the resources of reacting. As a result, the AESoIS is based on customized node types and edge types, and it comes with components such as a mini-map and graph controls. This restructuring resulted in a new version of BPSoIS available online (bit.ly/AESoIS).

AESoIS module interface considers the upload of BPMN files and the interaction process necessary to define business processes, as proposed by the framework. AESoIS module has an area that lists business processes, their attributes (actors, tasks), and IS that make up SoIS. Each of the analyzed processes is presented in the process listing area, and a list of the tasks that participate in the process is displayed. In the association area is presented a list of actors, constituent IS, tasks, and a respective area to renaming it as vertices of responsibility. These settings make it possible for each of the selected elements to be incorporated as design elements. For example, a certain IS is presented when an employee chooses the element to be modeled in AESoIS.

Development process

One way to incorporate user requirements is to involve domain specialists in all project phases (Gerasimov *et al.*, 2020). Gerasimov *et al.* (2020) propose an approach for modeling enterprise IS considering front-end and backend, which is the programming strategy used in this thesis. Authors assert that abstract models can be created to ease the communication basis and reduce misunderstanding. Gerasimov *et al.* (2020) argue that models are used as specifications

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[12] https://www.python.org/

[13] https://www.djangoproject.com/

[14] https://www.sqlite.org/index.html - SQLite is the most used database engine in the world.

[15] https://reactflow.dev/

or guidelines for the developer for documentation purposes, static analysis, automated tests, rapid prototyping, and code generation.

In this context, the AESoIS solution is suited for domain context problem-solving to help domain specialists easily read investigated scenarios concerning their business processes. Different kinds of artifacts are used to describe the SoIS abstract structure. They are created at the analysis and design phase and throughout the understanding of an investigated scenario. Based on these artifacts, the tool is evaluated, planned, and developed. In the following, we present the set of elementary models used to generate the core of the AESoIS, the tool backbone, organized as follows:

- **Class diagram for analysis (CD4A)**. CD4A is a textual language based on BPMN, which enables to model intended analysis. They are based on XML features and have a Python syntax, precisely elementTree library. In BPSoIS, CD4A is used to describe the data structure of the business process file. Line 1 to Line 3 describes, a package elementTree that implements a simple and efficient API for parsing and creating XML data. CD4A considers classes, definitions, and associations from SoIS conceptual model, proposed by Fernandes *et al.* (2019) and extended by Oliveira (2021). The following fragment shows a Python code example.

```
11    tree = ET.parse(file)
12    root = tree.getroot()
13    [...]
14    name_process = root.find("./bizagi:collaboration", notation).attrib.get("name")
15    process = Process(name=name_process)
16    process.save()
17    for lanes in root.findall("./bizagi:process/bizagi:laneSet/bizagi:lane", notation):
18    lane = lanes.attrib.get("name")
19    actor = add_actor(lane, process)
[..]
```

- **Aggregates**. Aggregates are based on Django Rest Framework[16]. It is a toolkit for building Web APIs that aids in developers' usability and has a system for authentication and data serialization. For example, consider developing an API, and React Flow is the main type of feature available.

Transmitting data between React Flow and Python via JSON format is made simple with Django. Thus, they are used for two things: (1) The data exchange between the application front-end and back-end, and (2) provide connections structures for the front-end and backend. Gerasimov *et al.* (2020) argue that aggregate is used to keep data sovereignty on the backend, while the front-end provides filters or show/hide options but doesn't need any logic for the data itself. At this point, the domain specialist executes a module converting BPSoIS data to the AESoIS database. The following fragment shows a Python code example.

```
1 class Accountability_CriteriaViewSet (viewsets.ModelViewSet):
2 queryset = Accountability_Criteria.objects.all()
3 serializer_class = Accountability_CriteriaSerializer
4 class ConditionViewSet(viewsets.ModelViewSet):
5 queryset = Condition.objects.all()
6 serializer_class = ConditionSerializer [..]
```

- **GUI**. A Graphical User Interface (GUI) description language is developed to simplify and generify the front-end's GUI-creation. It is intended to describe a webpage view. It includes interactions, such as a click or writes events. The language uses ASM layout, as a notation. For example, in the following example, Line 2 in List 3

[16] https://www.django-rest-framework.org/

defines the Toolbar view. It demonstrates behaviors associated with toolbar elements, as they are elements from the React Flow library, described as events on Line 4 and Line 5. The programming language used is JavaScript, CSS, and markup language HTML. The following fragment shows a Python code example:

```
1 import styles from "./styles.module.scss"
2 const Toobar = ({onSave, onRestore}) => {
3 const onDragStart = (event, nodeType) => {
4 event.dataTransfer.setData('application/reactflow', nodeType);
5 event.dataTransfer.effectAllowed = 'move';
6 };
```

Generator scenario. The generator process considers files (BPMN files, aggregate method, and data structure models) and generates source code based on them, as shown in Figure 74, which is inspired by Gerasimov *et al.* (2020). This code is extended with business logic implementation focusing on BPMN files. It compares BPSoIS elements to certain aspects of AESoIS to provide a functional prototype with BPMN elements with minimal manual effort. Additionally, much code is omitted and moved to the generated code, as it considers data analysis such as mapping constituent IS, business process, actor, and business task. Changes in a model cascade naturally through the entire code base.

Furthermore, **AESoIS Project** processes the input models and produces an application that reflects each aspect defined by domain specialists. Thus, the proposed diagram provides a common basis for discussions on SoIS problem-solving. The generator layer supports the iterative and incremental development of the application by allowing continuous regeneration using the ASM layout. The described artifacts only show the generated structure. It contains a specific business logic focusing on mapping AEM elements. The generated code can be adapted by adding BPSoIS elements, resulting in integrating databases. In contrast, the AESoIS code extends the generated structure and provides business logic regarding problem-solving for investigated scenarios. Moreover, the extension is achieved by logic in the generator, which evaluates SoIS elements parts regarding the accountability evaluation.

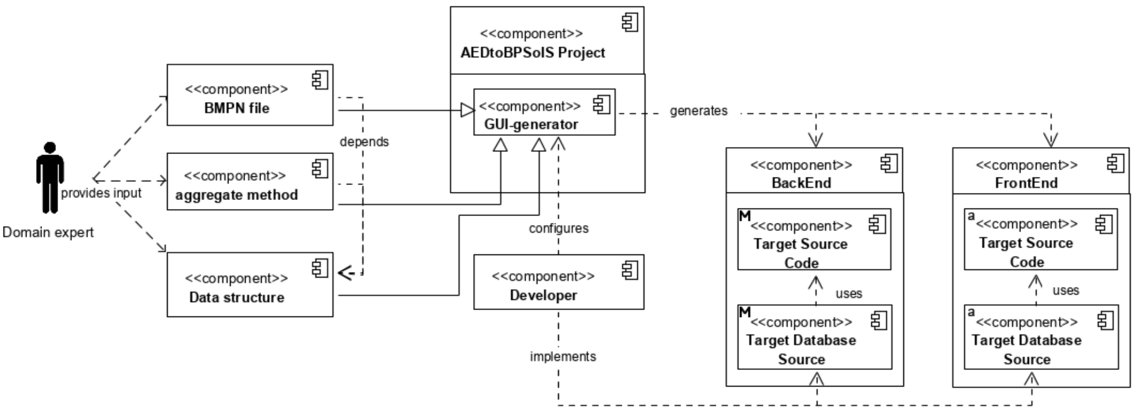


Figure 74 - Simplified overview of AESoIS components.

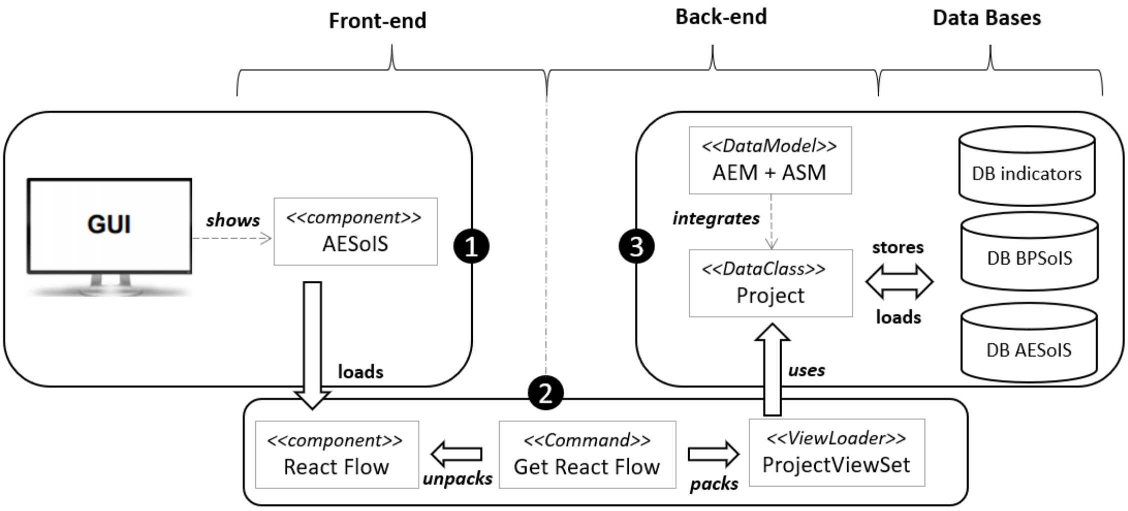
Architecture

Based on the provided artifacts, AESoIS creates a complete application infrastructure covering the backend and front-end (see Figure 75). It shows a simple overview of the generated data structure and corresponding artifacts from the database up to the views inspired by Gerasimov *et al.* (2020). In this context, the AESoIS application is split into three parts. A front-end client provides a tailored view of the underlying data structure as part of the input to the tool. The application back-end contains the tool logic and connects to the databases (AESoIS indicator database, BPSoIS database, and AESoIS database). Finally, the systems' architecture enables to provision AESoIS module as a web application. The software solution needs to be tailored for the needs of their organizational structure, focusing on organizational mapping problems and finding solutions considering the proposed accountability evaluation approach. Thus, the following goal are identified, as proposed by Gerasimov *et al.* (2020).

1. Provide adaptability understanding. Regulations and responsibilities underline the SoIS arrangement to accomplish organizational objectives and facing continuous changes. Thus, frequent changes should be investigated;

2. Ensure systemic understanding. SoIS dynamics is influenced by the impacts of people-process-technology in their routines. Change that should affect all SoIS elements should be available for understanding, e.g., change on complaints due to new enrollment; and

3. Data memory. Each domain specialist should have information about the solutions for investigated problems. It means that evaluation strategies must be stimulating, and a repository for registering feedbacks and insights should be provided.



[17]

Figure 75 - Simplified overview of the main artifacts generated by AESoIS Project.

Moreover, the AESoIS module persistence tier contains and manages all the user data and provides general settings for all the instances. It is organized in SQLite, as it is stable, cross-platform, and backward compatible. Additionally, from the scalability and reusability point of view, each component is wrapped insider a docker container and kept stateless (Gerasimov *et al.*, 2020). As a result, it enables easy management for each software component, separated by back-end, and frontend. For instance, the component-related container can be easily updated and restarted individually. Thus, it is possible for different upgrades in backends and frontends running.

Implications

This appendix presented the AESoIS tool for modeling SoIS scenarios based on a problem-solving. AESoIS represents an academic prototype that aims to be constantly refined as new studies are carried out. It is a thesis

[17] (1) components from GUI model, (2) view-model from aggregate artifacts, and (3) data-classes.

contribution, as it includes the ASM layout (Chapter 3), AEM conceptual model (Chapter 5), and AESoIS framework and tool (Chapter 6).

AESoIS data gathering is based on BPSoIS, and it uses BPMN files as an input strategy for incorporate actor, business process, and IS. Therefore, AESoIS combined with BPSoIS metadata allows that SoIS elements from a particular problem to be investigated. In addition to this preliminary selection of elements extracted from business processes, the tool provides the option of defining new elements. For example, consider that in the initial survey of elements for modeling, only two IS are included in AESoIS, and during the AESoIS modeling, the user realizes the need of representing a third IS. In this case, the tool has the option to create a new IS, in addition to those initially loaded from BPSoIS. The developed tools can be used in organizations with SoIS, supporting domain modeling for scenario understanding.

Requirements

AESoIS was developed based on the AEM elements identified from our three RQs, which were stated as requirements (R0 to R10) for a SoIS context modeling (Table 69). Regarding RQ1 (How can an accountability evaluation identify behaviors among SoIS elements to support an organizational objective?), R0 was derived as the elementary requirement: support AESoIS modeling. Next, RQ2 (How to generate the representation of SoIS arrangement based on accountability evaluation?) derived seven requirements to address the accountability evaluation approach. Finally, RQ3 (Is the proposed AESoIS tool feasible to aid practitioners in performing accountability analysis with effectiveness?) allowed us to derive the last four requirements related to problem-solving and the accountability indicators.

Table 69 - Requirements of AESoIS.

Source	ID	Description
RQ1	R0	Support AESoIS modeling.
RQ2	R1	Manage data from project
	R2	Manage constituent IS for AESoIS modeling.
	R3	Manage actor for AESoIS modeling.
	R4	Manage business process and task for AESoIS modeling.
	R5	Manage file storage for AESoIS modeling
	R6	Manage modeling elements from AESoIs.
	R7	Manage indicator database.
RQ3	R8	Support analysis of the educational problem: SoIS context understanding.
	R9	Report accountability criteria.
	R10	Report visual presentation.
	R11	Report modeled elements from AESoIS.

A. Tool Guide

BPSoIS Guide

The BPSoIS tool interface is divided into two main modules, the business process data analysis combined with the SoIS architecture module and the AESoIS modeling module (see Figure 76). BPSoIS presents a general list of business processes and their attributes (actors, tasks, gateways, and sub-processes). Additionally, it reports actors related to respective business processes and business tasks performed in these respective processes (as well as the inputs, outputs, type, and responsible actor for each one). Furthermore, a list of the gateways that occur during the execution of the process and a list of the sub-processes are included in it. It is worth mentioning that all these data are collected from BPMN files, and it displays SoIS related elements based on mapping actors, showing their intensity of interaction, the tasks they perform, and the respective processes of these tasks.

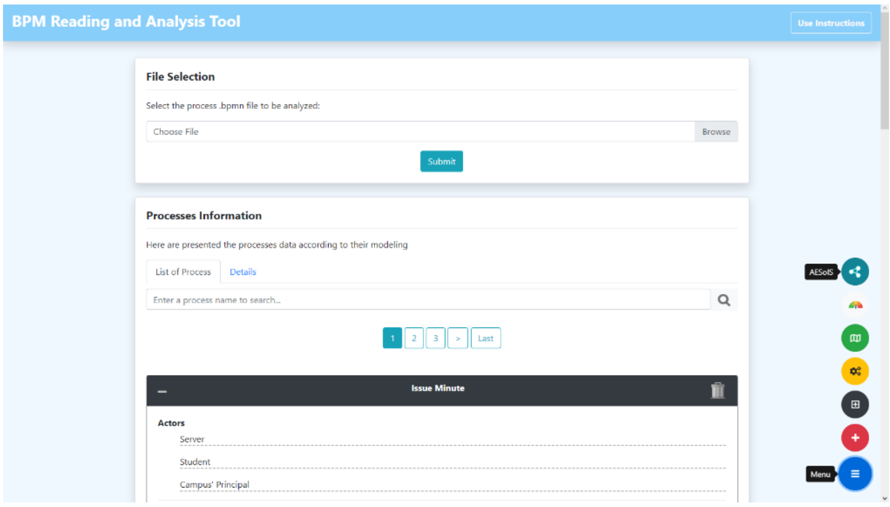


Figure 76 - Tool’s Interface: Main area.

Regarding the BPSoIS management panel, a navigation menu is presented at the lower right side of the tool screen. By clicking on the circular menu button, the user is presented with a set of options. Through these, the user has access to the other modules of the tool. From the options presented in the menu, “Add Goals”, “Add Sectors”, “Analyze Links” and “Instantiate Architecture” refer to the SoIS architecture modeling module and “Manage Accountability Indicator” and “AESoIS” belonging to the AESoIS module.

SoIS Architecture Modeling Module

By clicking on the “Add Goals” option, the user is directed to the organizational goals management screen, presented in Figure 77. It demonstrates the tool strategy for defining (create/update) goals in the IS arrangement. The option “Add Sectors” directs the user to the organizational sectors' management screen (see Figure 78). On this screen, the user can create/update the identification information of a sector and inform which of the business processes that had their models analyzed are related to the investigated sector.

By clicking on the “Analyze Links” option, the user is directed to the Business Process analysis’ wizard screen, a set of screens referring to the process data analysis procedure. On the first screen (see Figure 79), the user must select which process they want to describe the tasks from. Thus, the user is automatically directed to the task description screen, in which they must enter text descriptions for the tasks. The user is presented with some IS suggestions that were automatically extracted by the tool from the task descriptions on this screen. The user must manage any erroneous suggestion and add any additional constituent IS that have not been suggested and explanations for both the correctly suggested SI and those entered by the user.

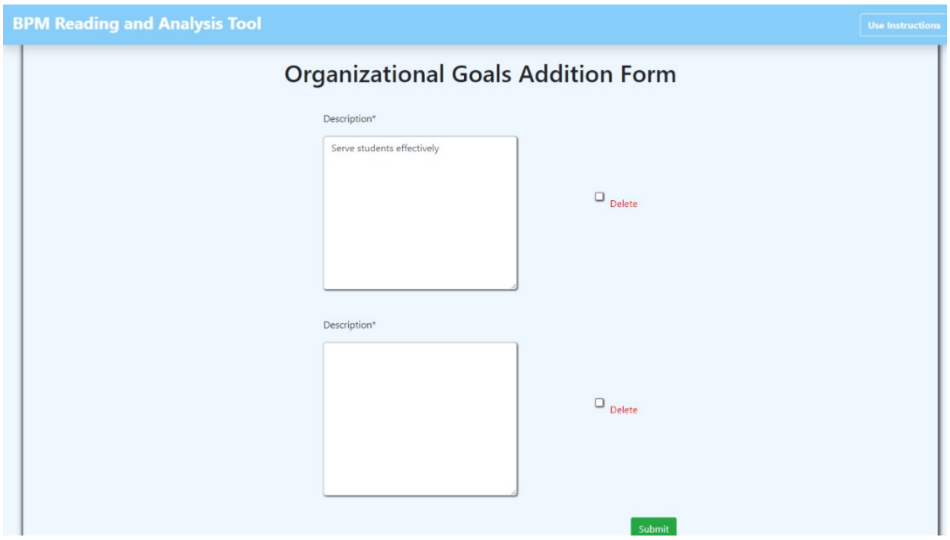


Figure 77 - Wizard screen - Organizational goals' management screen.

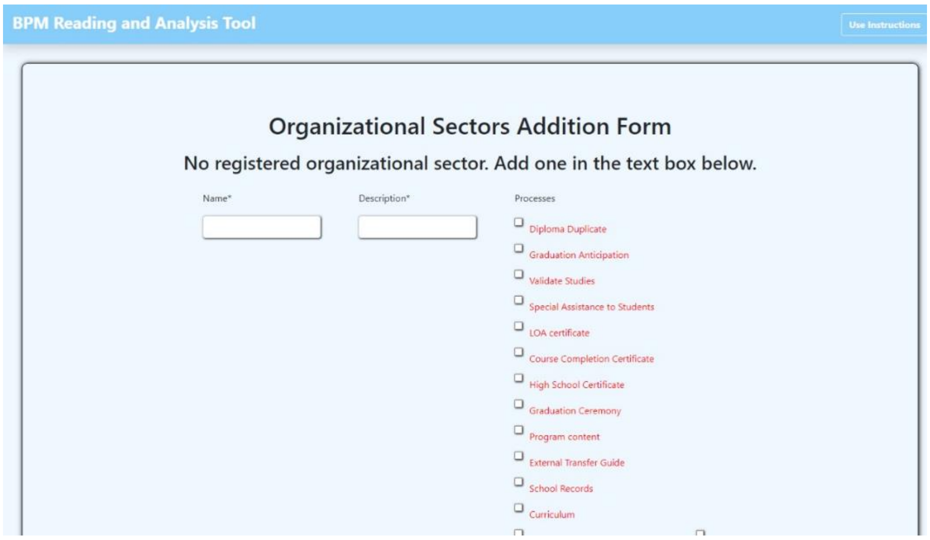


Figure 78 - Wizard screen - Sectors' management screen.

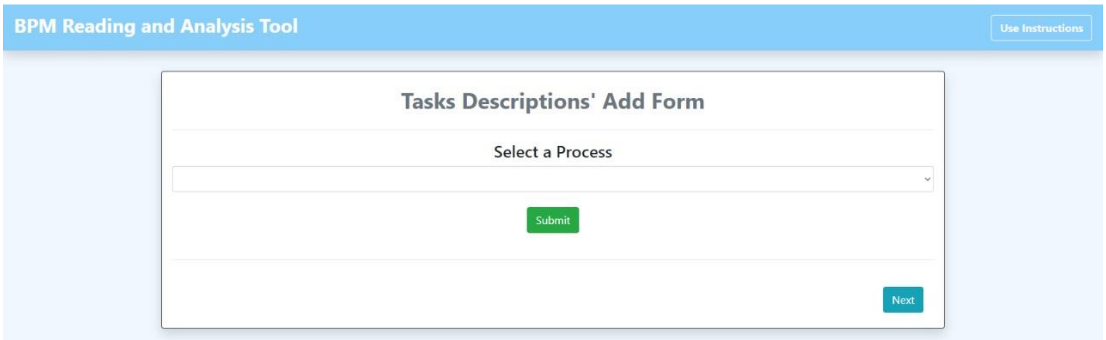


Figure 79 - Wizard screen - Add tasks.

On the next screen (see Figure 80), the tool presents some suggestions for associations of IS that support them, made automatically from the comparison of the descriptions of both, and allows the user to validate such associations and insert new ones if needed.

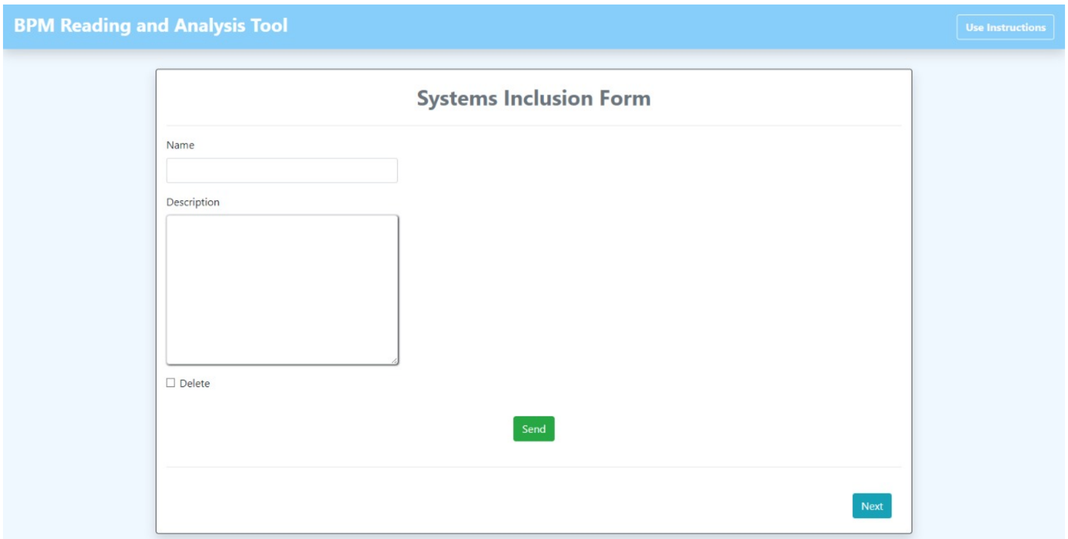


Figure 80 - Wizard screen - IS Management.

After associating tasks and SI, the user is directed to the equivalent actors matching screen (see Figure 81). Thus, the user is presented with a list of all the actors that are extracted from the processes. In the case of actors representing the same role in the execution of business processes, but with different names, the user can choose the main actor representing this role and indicate the other actors that are equivalent to it. The tool will transfer the data related to the equivalent actors to the main actor by doing this.

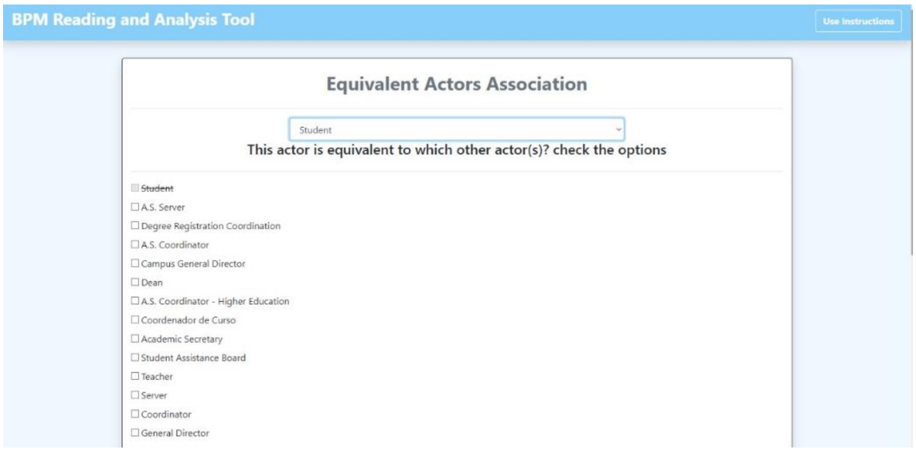


Figure 81 - Wizard screen - Equivalent actors' relations.

Then, the user is presented with the task matching screen (see Figure 82). On this screen, the user can choose a task, see if there are tasks in different processes with the same name, and validate if they represent the same action in all processes. If so, the tool will standardize the descriptions of these tasks by matching the descriptions of the tasks equivalent to the description of the main task. Finally, the user is presented with a screen containing suggestions for interoperability links between the different SI (see Figure 83). The user can validate the suggestions and add new ones if necessary. On this screen, the user is presented with a set of lists that identify the systems that interoperate and the tasks in which this interoperability appears.

Upon confirming the links, the user returns to the main area to proceed to the architecture instantiation. To do this, the user clicks again on the circular menu button on the lower right side of the screen. This time, clicking on "Instantiate Architecture", the user is directed to the Architecture Instantiation Wizard area. This area consists of screens where the user is presented with the results of the business processes analysis and a set of heuristics to guide the user in the instantiation of the resulting SoIS architectural representation.

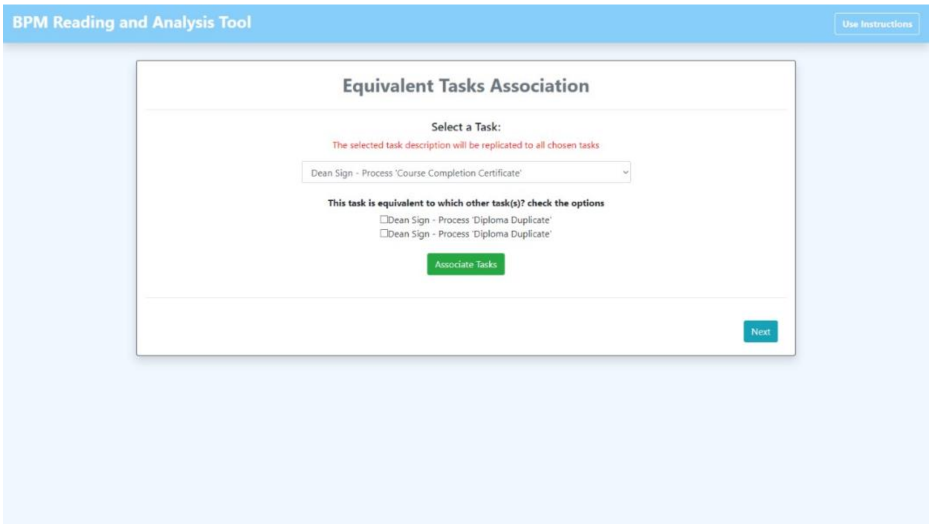


Figure 82 - Wizard screen - Equivalent tasks relations.

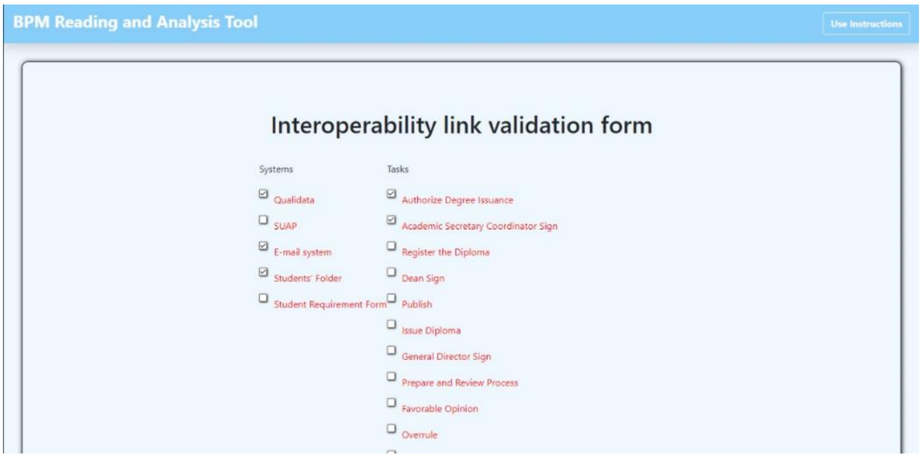


Figure 83 - Wizard screen - Interoperability links.

AESoIS Module

The AESoIS solution encompasses two tool resources for supporting SoIS modeling: Manage Accountability Indicator and AESoIS modeling. Manage Accountability Indicator in support a definition of two strategies for supporting engagement, management, and regulation indicators: 'Standard' (e.g., ISO patterns) or 'User Experience' (e.g., organizational strategy defined by employees) in Figure 84.

Moreover, in AESoIS modeling , the user is directed to a set of screens referring to the registration procedure of a new accountability evaluation project. First, the user is presented to the AESoIS Welcome Screen). By pressing 'New Project', the user is taken to the AESoIS Project registration screen (see Figure 85). In this screen, the user must indicate the project's 'Owner' and 'Title', the organizational objective that is related to this project, focusing on the definition of an investigated problem related to some organizational demand (such a problem with some business process) and a description.

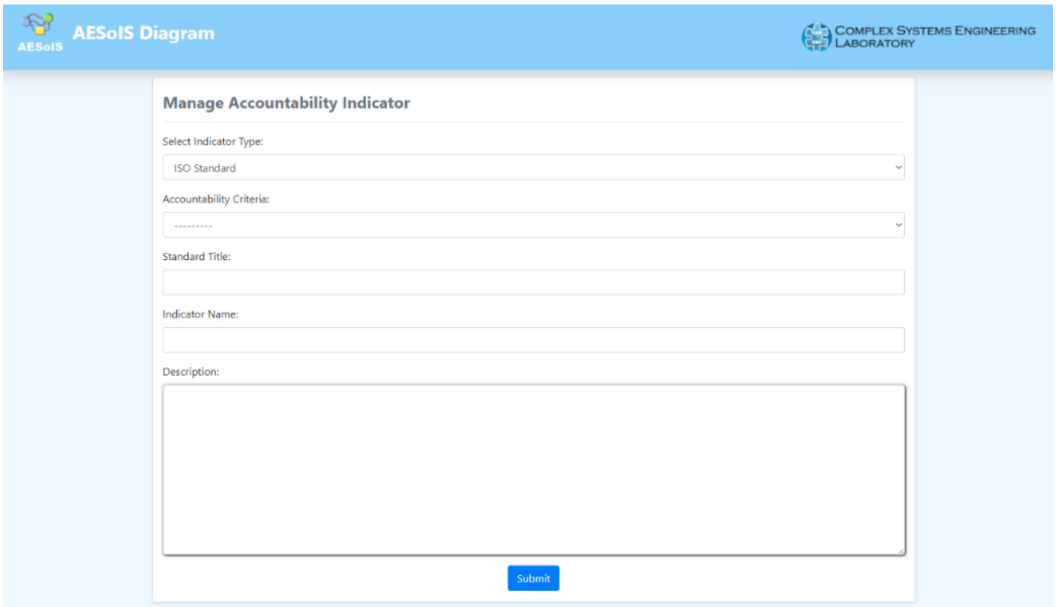


Figure 84 - Manage accountability indicator.

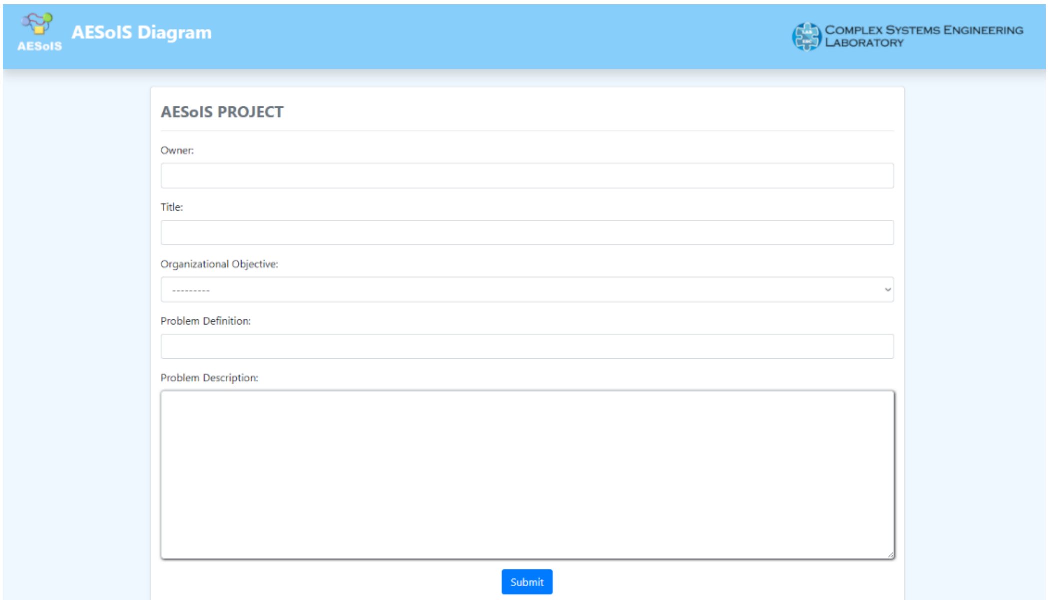


Figure 85 - New AESoIS project registration.

After registering the investigated problem, the user is directed to the Business Process Definition Screen (see Figure 86). Thus, the tool presents the user with a list of business processes from BPSoIS database. The user must then select the business processes related to the problem investigated. AESoIS presents the user with the lists of the respective tasks of each of the processes selected in Figure 87. The user must select which of the presented tasks are related to the investigated problem.

After choosing the tasks, the user is presented with the business process' actor definition screen (see Figure 88). Here, the user is presented with the list of actors responsible for executing the tasks selected on the previous screen. The user must then select which actor(s) is(are) relevant to the investigated problem. When proceeding, the user will find the IS definition screen (see Figure 89). In this screen, similarly to the previous one, the user is presented with a list of systems that support executing the previously selected tasks. The user must then identify, among the systems offered, which system(s) is(are) related to the investigated problem.

Additionally, the user is presented with the screen for defining vertices of responsibility (see Figure 90), where the user must create a vertex referring to each task previously selected. This step aims to alleviate the problem of working with tasks with long names, thus making it possible to create a representation with a shorter term.

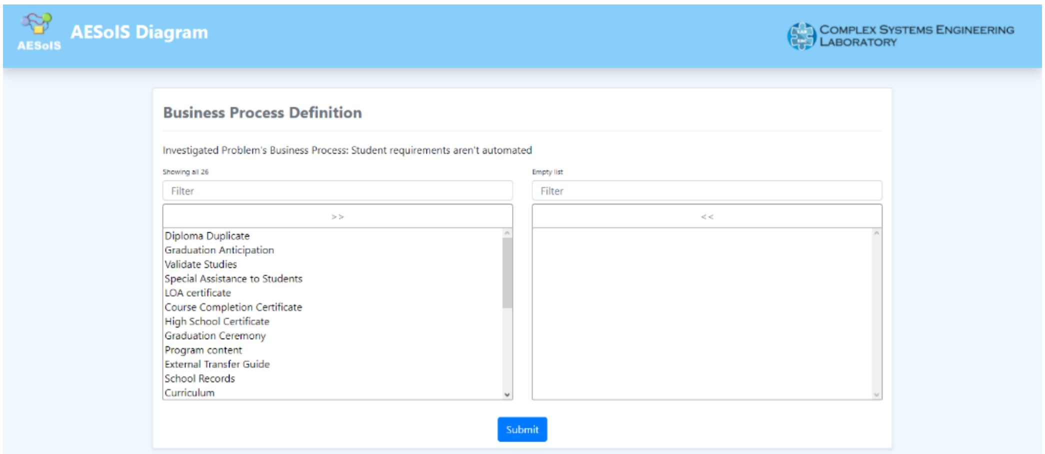


Figure 86 - Business process definition.

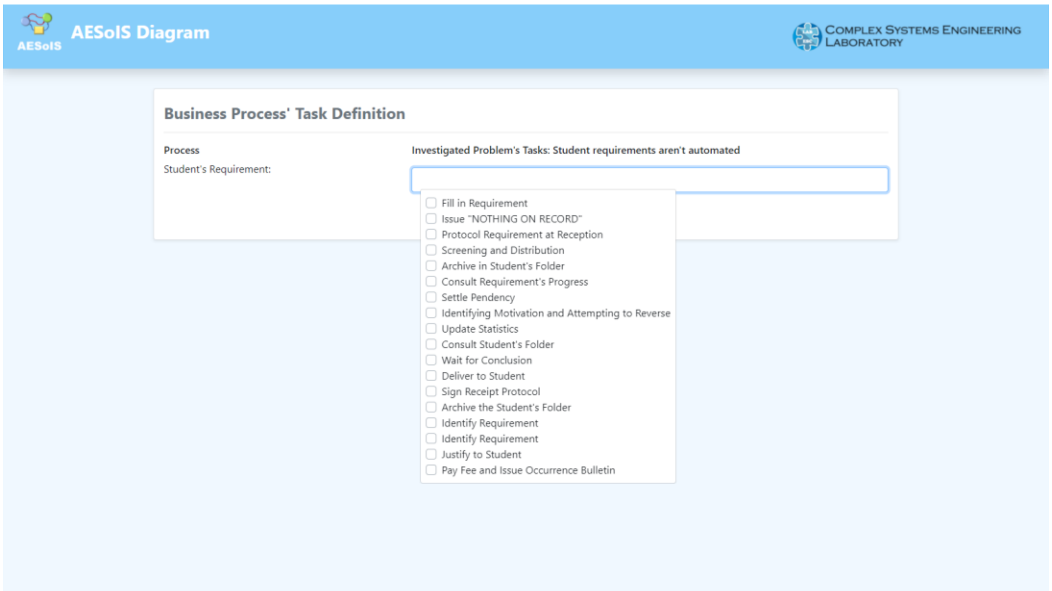


Figure 87 - Business task definition.

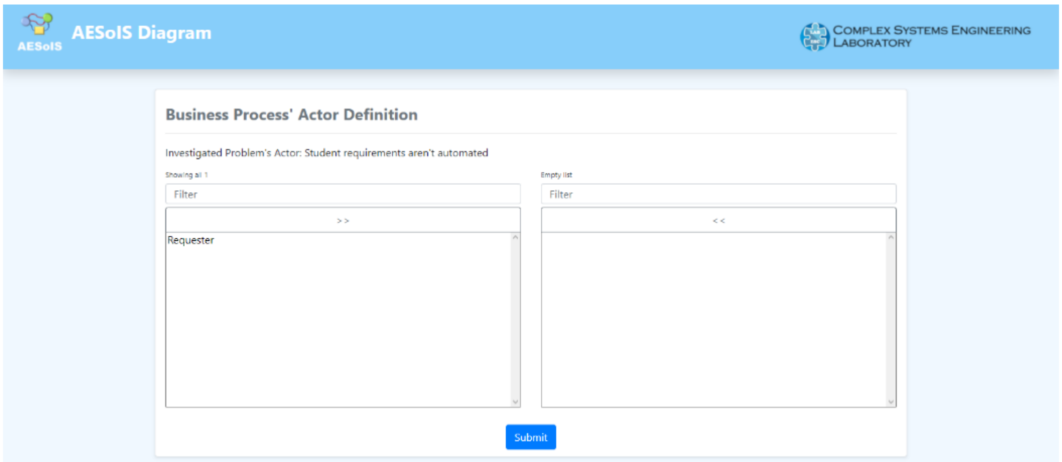


Figure 88 - Business process' actor definition.

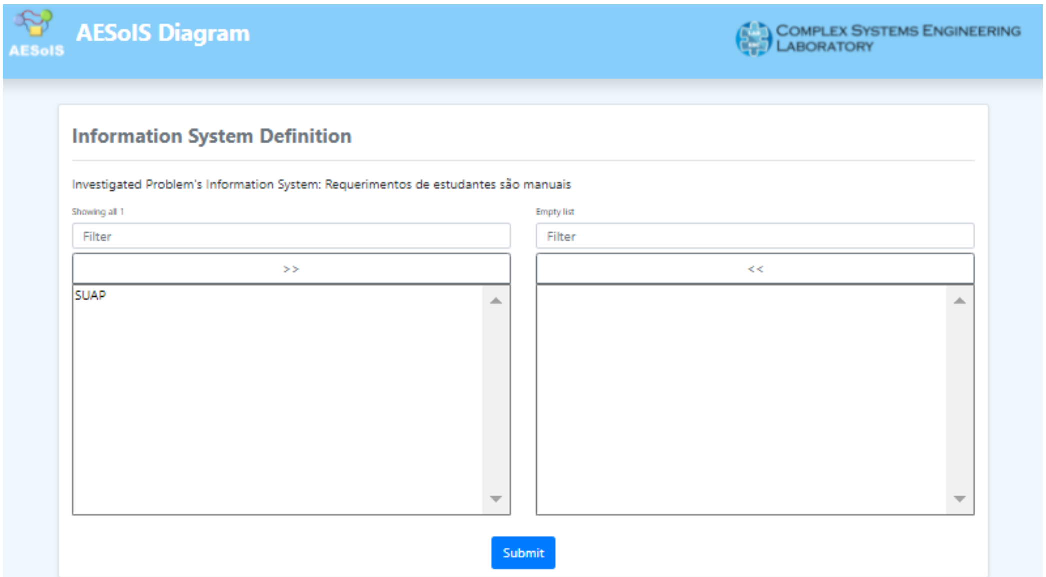


Figure 89 - Information system definition.

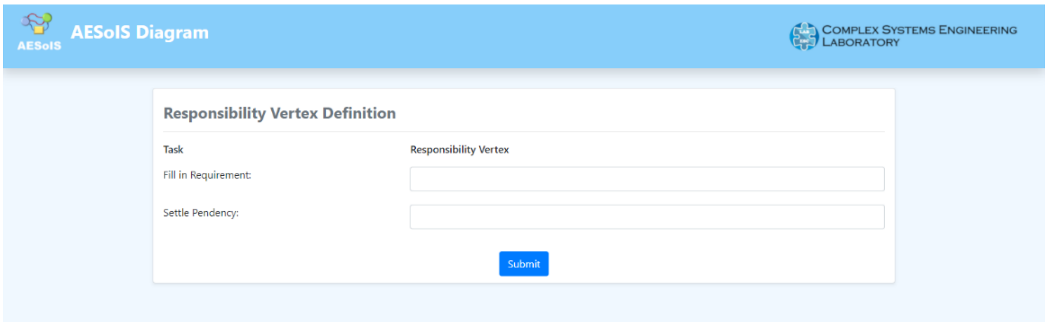


Figure 90 - Responsibility vertex definition.

After the AESoIS project definition screens, the user is directed to the diagram drawing screen (see Figure 91). In this context, Table 70 describes the AESoIS modeling elements and resources in detail.

Figure 91 - AESoIS drawing screen.

Table 70 - AESoIS notation.

Time Impacts	Description
Immediate impacts	It refers to some activity close to, or a cause of, or even an effect of something. These impacts are felt without any delay and include self-reacted behaviors (Lago, 2019).
Gradual impacts	It arises from the use over time. It represents the impacts that different types of monitoring must report on demand when activities are coordinated. Such impacts are felt by the dependency of events/behaviors (Lago, 2019).
Structural impacts	It refers to some facts in an extended period and summarizes systemic actions that had grown in an environment. Usually, structural impacts are not open to changes (Lago, 2019).
Accountability Criteria	**Description**
Accountability Criteria Engagement	It involves participating in an activity, event, or situation in and contributing to actions to achieve shared objectives (ISO/IEC 9000, 2015).
Accountability Criteria Management	It involves the exercise of control and supervision within the authority and accountability established by governance. The term management is often used as a collective term for those responsible for controlling an organization or subunits (ISO/IEC 38500, 2015).
Accountability Criteria Regulation	It involves meeting the organization's requirements to comply with (and enforce) legal and regulatory standards (e.g., policies, guidelines, laws, and rules). It aims to support regulation activities (either formal or informal) in systems' processes. It means addressing parameters for sanctions/obligations (ISO/IEC 9000, 2015).
Form	**Description**
Positive flow	It signs that variables' changes occur in the same direction (sign +) (Cordeiro & Santos, 2019b).
Negative flow	It signs that variables' changes occur in the opposite direction (sign -) (Cordeiro & Santos, 2019b).
Suggestion flow	The blue arrows associate accountability with suggestions from managers, developers, and users to indicate accountability interventions.
System flow	The red arrows associate systems. System icon is associated with a system goal.
IS System icon	It represents "IS" icon for incorporating elements from BPSoIS or constituent IS element defined in tool runtime.
Actor node	It represents "Actor" icon for incorporating elements from BPSoIS or actor element defined in tool runtime.
Vn Vertex node	It represents "Business Task" icon for incorporating elements from BPSoIS.
T Text node	It represents "Text" icon that addresses textual element in tool runtime.
Save flowchart	It saves the diagram.
Restore flowchart	It presents saved AESoIS modeling in tool runtime.
Generate report	It supports the AESoIS modeling with data from each modeled element from the diagram. Data is organized in a PDF template.
Tool Guide	It presents a guide of BPSoIS

In it, the user has access to a set of elements that must be used to create the accountability evaluation diagram, namely: 'System Node' IS, 'Actor Node', 'Vertex Node' Vn, 'Text Node' T and 'Accountability Criteria' Accountability Criteria. To use these elements, the user must click and drag them to the drawing area. In addition to the drawing elements, the user is also presented with a set of diagram control buttons, namely: 'Save flowchart', 'Restore flowchart', 'Change time impacts', 'Generate report' and 'Help'.

When placing a 'System Node', an 'Actor Node', or a 'Vertex Node' in the drawing area, the user is presented with the management window of the respective node. The IS management window is shown in Figure 92, while the actor and responsibility vertex management windows are shown respectively in Figure 93 and Figure 94. At these points, the user must identify the respective AESoIS element (IS, Actor or Responsibility Vertex) that will be represented at AESoIS modeling. In common, the manage element pop-up presents two options: (i) select one of the elements previously defined in each definition screen, or (ii) add a new element to the list (it considers the possibility of defining new elements for modeling, beyond BPSoIS data). It is worth mentioning that a newly created element to be accessed, need to access the Select option. In this context, all AESoIS elements (from BPSoIS or new) must be accessed through "Select".

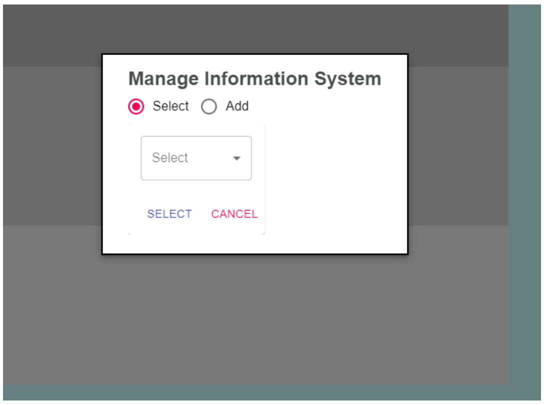


Figure 92 - Manage information system screen.

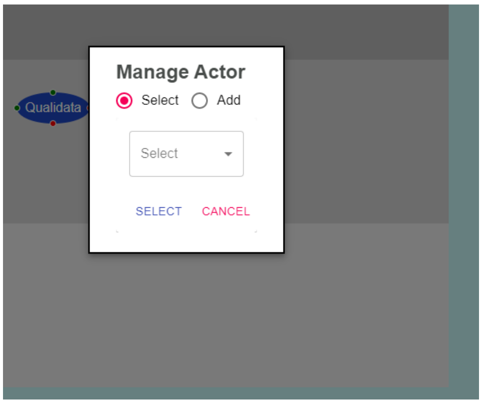


Figure 93 - Manage actor management screen.

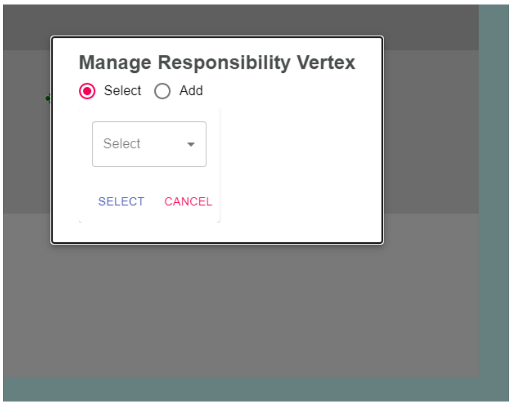


Figure 94 - Manage responsibility vertex screen.

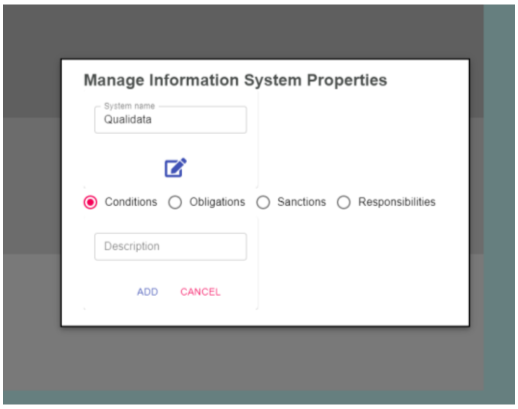


Figure 95 - Manage information system screen.

Once positioned on the diagram, the user is allowed to manage the properties of the elements. For this, the user must click on the node of the respective element. This functionality is present in the nodes of the IS, Actor, and Responsibility Vertex elements. When performing this action, the element properties management window is opened, Figure 95 shows the information system properties management window. The windows of the other elements use the same pattern and work in the same way. In this window, the user can edit the element identification text as well as add different properties to it, namely:

Condition - Covers the prerequisites needed by an organization to fulfill its responsibilities. These prerequisites may include information on capabilities, authorities, right to delegate human and technological resources;

Obligation - Covers the need to oblige and be obligated to take action. It includes what a party must do to fulfill a responsibility, e.g., how to direct, supervise and monitor the obligation of a delegated right;

Sanction - Involves an action to make people obey a law or rule. Covers potential punishment in cases of disobedience; and

Responsibility - Obligation to answer for one's actions or those of others to achieve goals.

By placing a 'Text Node' on the diagram, the text management window opens (see Figure 96). The 'Text Node' is a node of free use by the user, and in this screen, the user can define the text he wants for the node. Unlike the nodes presented above, the text node does not have a properties pop-up. Responsibility - Obligation to answer for one's actions or those of others to achieve goals. Additionally, when the user places an 'Accountability Criteria' node on AESoIS, its management window opens (see Figure 97). In this screen, the user can select previously registered elements or add new ones, such as the previous nodes. But this element has two types, 'Standard' and 'UX' (from User Experience). Thus, the user must select the type of element that will be related to the node

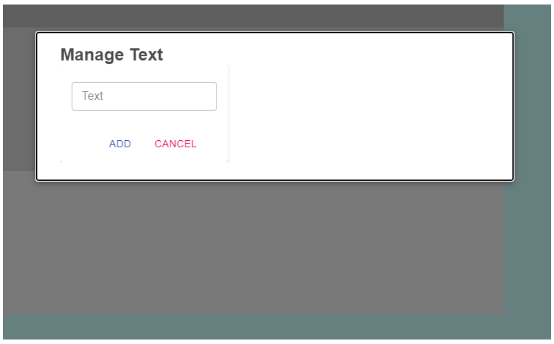


Figure 96 - Add text screen.

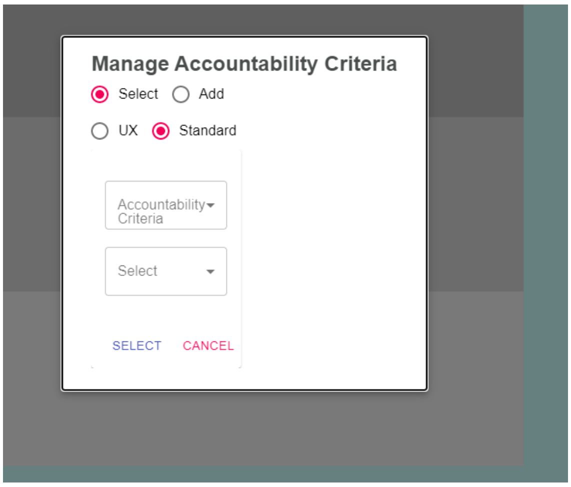


Figure 97 - Manage accountability criteria screen.

After that, the user must select whether the criterion refers to "Engagement", "Management" or "Regulation". This way, the tool automatically filters the respective criteria. Finally, the user must select which of the listed criteria will be related to the node. Similar to the "Text' node", "Accountability Criteria" nodes do not display a properties window. When the user clicks on the "Save flowchart" control button, the tool saves the state of the diagram at that given moment in the database. The diagram is restored to the last state saved in the database by clicking on the "Restore flowchart" button. Clicking in the "Change time impacts" in Figure 98 opens the diagram management window. In this window, it is possible to modify the size, color, text, and text color of each one of the three-time impacts of the diagram (gray gradient area in the diagram). By clicking on the "Generate report" button, the tool generates a report with all the diagram's metadata and presents it in the format of a PDF file that is made available for download to the user.

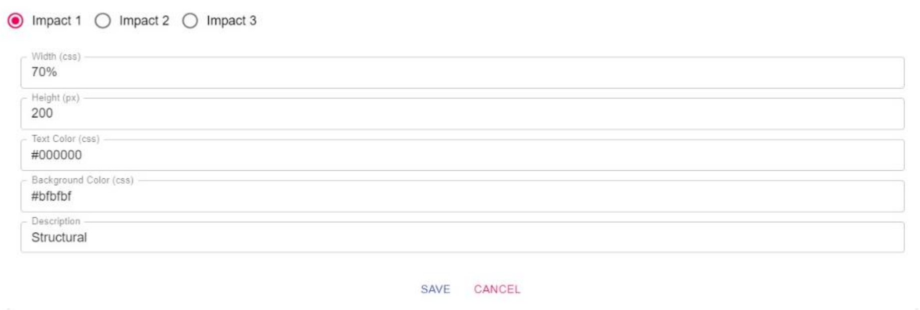


Figure 98 - Manage time impacts.

APPENDIX VI

This appendix addresses the feasibility study conducted in two educational organizational, and it is formed by the following documents: (i) Consent Form, (ii) Characterization Form, (iii) Execution Form, (iv) Execution Form Extension, and (v) Evaluation of Study.

A. Consent Form (In Portuguese)

TERMO DE CONSENTIMENTO LIVRE ESCLARECIDO

OBJETIVO DO ESTUDO

Este estudo visa realizar uma investigação sobre Avaliação de Accountability em Sistemas de Informação, notadamente sistemas de sistemas de informação.

PROCEDIMENTO

A pesquisa será realizada em duas etapas.

Na primeira etapa, pedimos que você responda sobre sua experiência em alguns temas. Assim, caso concorde em participar do estudo, realize esta primeira etapa respondendo ao questionário enviado.

Na segunda etapa (que será agendada diretamente com você), você será convidado a realizar algumas tarefas relacionadas o domínio de Gestão Acadêmica e os respectivos sistemas de informação que a apoiam. Você receberá orientações sobre como realizar as atividades, bem como os dados de acesso para realização do estudo.

Para participar deste estudo solicitamos a sua especial colaboração em:

(1) fornecer informações sobre sua experiência;
(2) permitir que os dados resultantes da sua participação sejam estudados;
(3) informar o tempo gasto nas atividades; e
(4) responder um questionário final com as suas impressões. Quando os dados forem coletados, seu nome será removido destes e não será utilizado em nenhum momento durante a apresentação dos resultados.

Estima-se que, para realizar a primeira etapa, sejam necessários cerca de 5 (cinco) minutos e que para realizar a segunda etapa, cerca de 60 (sessenta) minutos.

CONFIDENCIALIDADE

Eu estou ciente de que meu nome não será divulgado em hipótese alguma. Também estou ciente de que os dados obtidos por meio deste estudo serão mantidos sob confidencialidade, e os resultados serão posteriormente apresentados de forma agregada, de modo que um participante não seja associado a um dado específico. Os resultados não possuirão informações sobre nome ou qualquer informação que possa revelar a identidade do participante da pesquisa. Da mesma forma, me comprometo a não comunicar meus resultados enquanto o estudo não for concluído, bem como manter sigilo das informações fornecidas e documentos apresentados e que fazem parte do experimento.

BENEFÍCIOS E LIBERDADE DE DESISTÊNCIA

Eu entendo que, uma vez o experimento tenha terminado, as atividades que realizei serão estudadas visando entender a eficiência dos procedimentos e as técnicas que me foram apresentadas. Os benefícios que receberei deste estudo são limitados ao aprendizado do material que é distribuído e apresentado.

Estou ciente que terei direito a uma via do TCLE e, caso queira, posso entrar em contato com o pesquisador responsável pela pesquisa. Para contato com a pesquisadora responsável, deverei entrar em contato com Felipe Cordeiro de Paula por meio do e-mail: felipe.paula@uniriotec.br.

Também entendo que sou livre para realizar perguntas a qualquer momento, solicitar que qualquer informação relacionada à minha pessoa não seja incluída no estudo ou comunicar minha desistência de participação, sem qualquer penalidade. Por fim, declaro que participo de livre e espontânea vontade com o único intuito de contribuir para o avanço e desenvolvimento de técnicas e processos para a área de Sistemas de Informação.

PESQUISADOR RESPONSÁVEL

Felipe Cordeiro de Paula (felipe.paula@uniriotec.br)

Programa de Pós-Graduação em Informática (PPGI/UNIRIO)

CPF: 08710747702

PROFESSORES RESPONSÁVEIS

Prof. Dr. Rodrigo Pereira dos Santos (rps@uniriotec.br)
Programa de Pós-Graduação em Informática (PPGI/UNIRIO)

Profª. Drª. Aline Pires Vieira de Vasconcelos (apires@iff.edu.br)
Instituto Federal de Educação, Ciência e Tecnologia Fluminense (IFF)

ACEITE DO PARTICIPANTE

Tendo sido esclarecido todas as informações quanto ao estudo, manifesto meu livre consentimento em participar de um estudo conduzido por Felipe Cordeiro de Paula, sob a orientação dos Professores Rodrigo Pereira dos Santos (UNIRIO/PPGI) e Aline Pires Vieira de Vasconcelos (IFF). Eu estou totalmente ciente de que não há nenhum valor econômico, a receber ou a pagar, por minha participação.

Nome do Participante: ______________________________________

Assinatura: ____

Data: ______________________

B. Characterization Form (In Portuguese)

Formulário de Caracterização do Participante

Prezado(a) participante,

Este formulário contém algumas perguntas sobre sua experiência acadêmica e profissional.

1. Nome:

2. Contato (e-mail): Formação Acadêmica:

3. Organização (trabalha ou trabalhou):

4. Formação Acadêmica

( ) Doutorado concluído
( ) Doutorado em andamento
( ) Mestrado concluído
( ) Mestrado em andamento
( ) Especialização concluída
( ) Especialização em andamento
( ) Graduação concluída
( ) Graduação em andamento

5. Experiência Profissional

a) Grau de Experiência

Por favor, indique o seu grau de experiência nas áreas de conhecimento a seguir, com base na escala abaixo:

Área de Conhecimento	Grau de Experiência					
5.1. Tecnologia da Informação	0	1	2	3	4	5
5.2. Sistemas de Informação	0	1	2	3	4	5
5.3. Accountability	0	1	2	3	4	5
5.4. Engenharia de Requisitos	0	1	2	3	4	5
5.5. Ciência da Computação	0	1	2	3	4	5
5.6. Engenharia de Software						

Escala:
0 = nenhum (nunca participou de atividades deste tipo)
1 = estudei em aula ou em livro (possui conhecimento teórico apenas)
2 = pratiquei em projetos em sala de aula (possui conhecimento teórico aplicado apenas no contexto acadêmico)
3 = usei em projetos pessoais (possui conhecimento teórico somado de experiências práticas individuais)
4 = usei em poucos projetos na indústria (possui conhecimento teórico somado de poucas experiências práticas reais)
5 = usei em muitos projetos na indústria (possui conhecimento teórico somado de muitas experiências práticas reais)

b) Tempo de Experiência

Por favor, detalhe sua resposta. Inclua o número de meses de experiência para cada uma das áreas de conhecimento.

Área de Conhecimento	Grau de Experiência (em anos)					
5.1. Tecnologia da Informação	> 1	1-2	2-3	3-4	4-5	>5
5.2. Sistemas de Informação	> 1	1-2	2-3	3-4	4-5	>5
5.3. Accountability	> 1	1-2	2-3	3-4	4-5	>5
5.4. Engenharia de Requisitos	> 1	1-2	2-3	3-4	4-5	>5
5.5. Ciência da Computação	> 1	1-2	2-3	3-4	4-5	>5
5.6. Engenharia de Software	> 1	1-2	2-3	3-4	4-5	>5

3. Experiência com Ferramentas Similares

Esta seção será utilizada para compreender quão familiar você está com os tipos de ferramentas que serão utilizadas no estudo. Por favor, indique o seu grau de experiência seguindo a escala abaixo:

Ferramenta	Grau de Experiência		
2.1. Ferramentas de visão sistêmica (Vensim, por exemplo)	0	1	2
2.2. Ferramentas de mapa mental (Coogle, por exemplo)	0	1	2

Escala:
0 - Eu não tenho familiaridade com este tipo de ferramenta.
1- Eu tenho alguma familiaridade com este tipo de ferramenta.
2- Eu tenho muita familiaridade com este tipo de ferramenta.

C. Execution Form Study #1 (In Portuguese)

Formulário de Execução do Estudo

CONTEXTUALIZAÇÃO

Você é um dos especialistas em sistemas de informação da sua organização, atuando nos sistemas de Gestão Acadêmica formado por atores, processos de negócios e diferentes sistemas de informação (SI) que interagem entre si. A organização onde você atua fornece apoio a uma variedade de tarefas de processos de negócio, visando atender seus objetivos organizacionais. Sua tarefa principal é analisar demandas dos atores em relação a problemas relacionados à prestação de serviços da Gestão Acadêmica, com base em duas premissas que são apoiadas pela ferramenta ***Accountability Evaluation Diagram* (AED)**, a saber:

i. executar avaliação de accountability; e
ii. emitir relatório de análise sobre o problema e sugestões propostas.

INSTRUÇÕES

Para a execução desta atividade, siga as instruções abaixo:

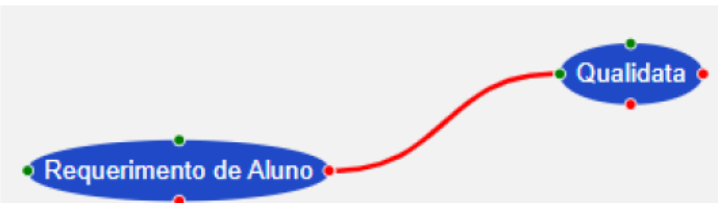
- Resolva as tarefas do formulário **na ordem em que elas são apresentadas;**
- Registre o horário de início e o horário de término de cada atividade;
- **Caso não consiga determinar a resposta, mas tenha uma medida de quanto tempo levaria para executá-la, por favor, responda com o valor em questão e com a palavra "estimativa" entre parêntesis e some as estimativas ao horário de término.**
- Cada tarefa do formulário **possui um ranking de confiança na resposta**. O ranking vai de zero a dez, onde zero representa sem confiança alguma na resposta e dez representa confiança total na resposta. Registre o valor de confiança para efetivação da tarefa solicitada.

O problema de interesse investigado neste estudo é o Requerimentos de estudantes são manuais. Deste modo, um conjunto de atores, tarefas de processos de negócios e sistemas de informação são utilizados para demonstrar os efeitos do problema ao longo do tempo em uma organização. Você deve executar nove tarefas e avaliar o grau de conformidade.

1. a. Selecionar na barra de botões, a opção ***System Node***, e então escolher os Qualidata posicionando na área de efeito imediato.

   b. Selecionar na barra de botões, a opção ***System Node***, e então escolher os Requerimento de Aluno posicionando na área de efeito imediato.

   c. Se você considera que exista uma relação entre os SI, então criar a associação: Qualidata (.) e Requerimento de Aluno (.).

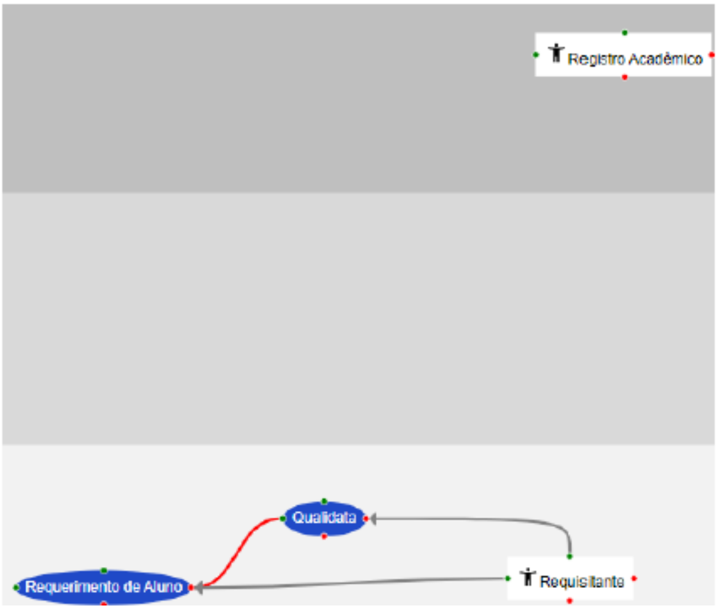


2. Selecionar na barra de botões, a opção ***Actor node*** , escolher a opção de Ator Requisitante posicionado na área de tempo imediato.

a. Se você considerar a existência de uma relação entre o Requisitante (.) e Qualidata (.), então criar a associação default.

b. Se você considera que exista uma relação entre o Requisitante (.) e Requerimento de Aluno (.), então criar associação default.

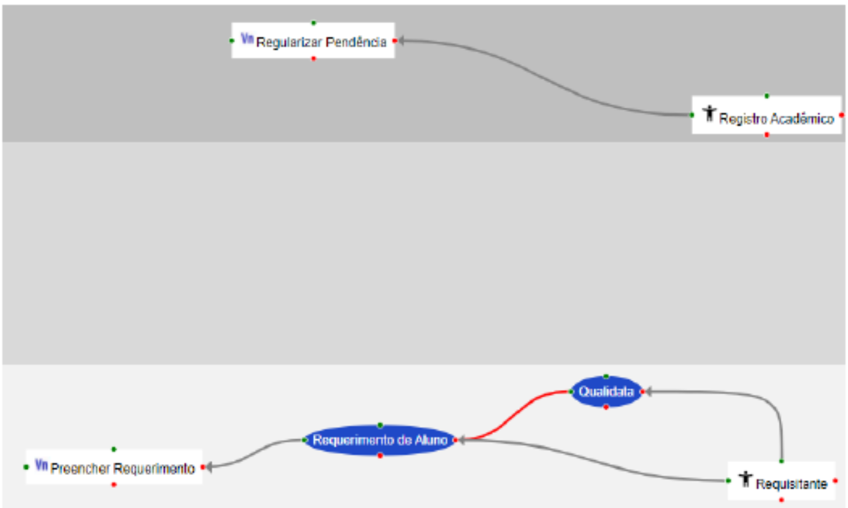
c. Selecionar na barra de botões, a opção ***Actor node***, adicionar o Registro Acadêmico posicionando na área de tempo estrutural.



3. Selecionar na barra de botões, a opção ***Vertex node*** Vn, e então selecionar os seguintes vértices de reponsabilidade que são baseados em tarefas de processos de negócios: (i) Vn Preencher Requerimento, posicionando na área de tempo imediato; e (ii) Vn Regularizar Pendência, posicionando na área de tempo estrutural.

a. Se você considera que exista uma relação entre o Requerimento de Aluno (.) e Vn Preencher Requerimento (.), então criar a associação default.

b. Se você considera que exista uma relação entre o Registro Acadêmico (.) e Vn Regularizar Pendência (.), então criar a associação default.



4. Considerando que os elementos (Ator, SI e Vn Vértices de Responsabilidade) possuem propriedades de accountability, então você deve definir ao menos uma instância de propriedades para o Qualidata. Menu propriedades é acionado com a seleção do elemento, considerando os seguintes itens:

a. **Condição** - Abrange os pré-requisitos necessários por uma organização para cumprir suas responsabilidades. Esses pré-requisitos podem incluir informações sobre capacidades, autoridades, direito de delegar recursos humanos e tecnológicos. Desta forma, é um exemplo de condição: Necessidade de conexão com internet para comunicação entre sistemas de informação;

b. **Obrigação** – Abrange a necessidade de obrigar e ser obrigado a fazer uma ação. Inclui o que uma parte deve fazer para cumprir uma responsabilidade, e.g., como dirigir, supervisionar e monitorar a obrigação de um direito delegado. Desta forma, é um exemplo de condição: Atender demandas de estudantes;

c. **Sanção** - Envolve uma ação para fazer as pessoas obedecerem a uma lei ou regra. Abrange, potencial punição em casos de desobediência. Desta forma, é um exemplo de condição: Bloquear acessos com três tentativas seguidas de insucesso em 24h;

d. **Responsabilidade** – Obrigação de responder pelas ações próprias ou dos outros para alcançar objetivos. Desta forma, é um exemplo de condição: Gerir o registro de dados de estudantes.

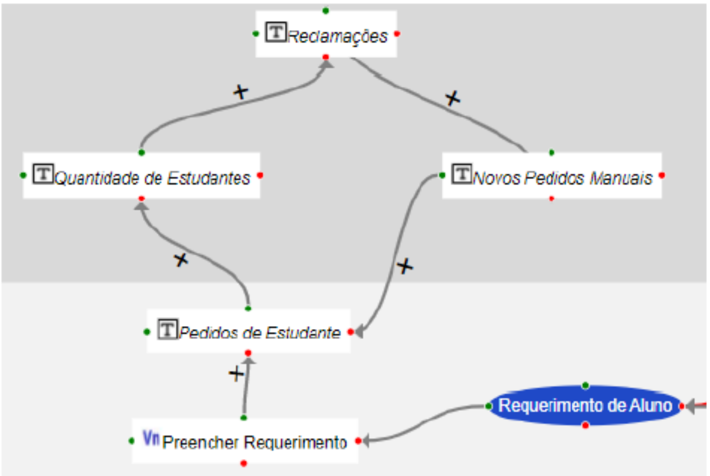
5. Selecionar na barra de botões, a opção ***Text node*** [T], então:

a. Criar a variável [T] Pedidos de Estudante e posicionar na área de tempo imediato. Se você considera que exista uma relação entre o Vn Preencher Requerimento (.) e [T] Pedidos de Estudante (.), então definir a associação do tipo positivo. Você concorda com a associação, senão qual deveria ser implementada?

b. Criar a variável [T] Novos Pedidos Manuais e posicionar na área de tempo gradual. Se você considera que exista uma relação entre [T] Pedidos de Estudante (.) e [T] Novos Pedidos Manuais (.), então definir a associação do tipo positivo. Você concorda com a associação, senão qual deveria ser implementada?

c. Criar a variável [T] Reclamações e posicionar na área de tempo gradual. Se você considera que exista uma relação entre [T] Novos Pedidos Manuais (.) e [T] Reclamações (.), então definir a associação do tipo positivo. Você concorda com a associação, senão qual deveria ser implementada?

d. Criar a variável [T] Quantidade de Estudantes e posicionar na área de tempo gradual. Se você considera que exista uma relação entre o [T] Quantidade de Estudantes (.) e [T] Reclamações (.), então definir a associação do tipo positivo. Você concorda com a associação, senão qual deveria ser implementada?



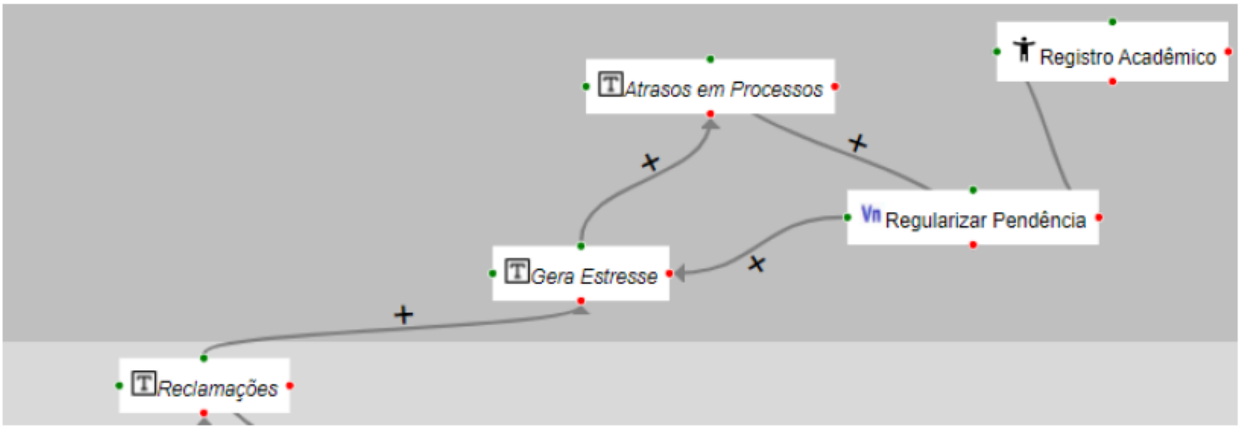
6. Selecionar na barra de botões, a opção ***Text node*** 🅃, então:

a. Criar a variável 🅃 Gera Estresse e posicionar na área de tempo estrutural. Se você considera que exista uma relação entre 🅃 Reclamações (.) e 🅃 Gera Estresse (.), então definir a associação do tipo positivo. Você concorda com a associação, senão qual deveria ser implementada?

b. Criar a variável 🅃 Atrasos em Processo e posicionar na área de tempo gradual. Se você considera que exista uma relação entre 🅃 Gera Estresse (.) e 🅃 Atrasos em Processos (.) , então definir a associação do tipo positivo. Você concorda com a associação, senão qual deveria ser implementada?

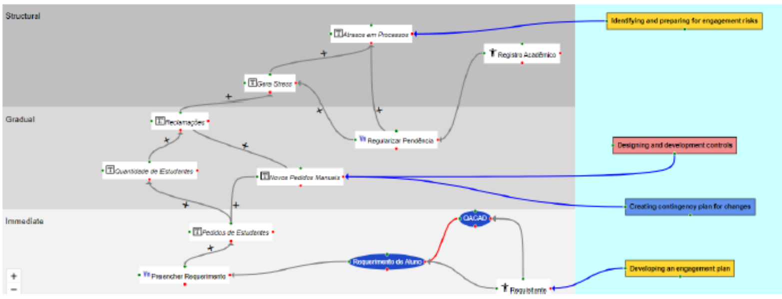
c. Se você considera que exista uma relação entre o 🅃 Atrasos em Processo (.) e 🅃 Gera Estresse (.), então definir a associação do tipo positivo. Você concorda com a associação, senão qual deveria ser implementada?

d. Se você considera que exista uma relação entre o 🅃 Regularizar Pendência (.) e 🅃 Atrasos em Processo (.), então definir a associação do tipo positivo. Você concorda com a associação, senão qual deveria ser implementada?



7. Selecionar na barra de botões, a opção *Accountability Criteria* e reproduza as informações da tabela, na área de design azul, conforme figura abaixo.

Tipo do Indicador	Nome	Descrição	Origem/Destino
Engajamento	Developing an engagement plan	Managers shall develop an engagement plan. The engagement plan shall be made available to stakeholders. Stakeholders shall have the opportunity to provide input into the plan.	O: Developing an engagement plan (.) D: Ator Requisitante (.)
Gerenciamento	Designing and developming controls	The organization shall apply controls to the design and development process to ensure that: (i) the results to be achieved are defined; (ii) reviews are conducted to evaluate the ability of the results of design and development to meet requirements; (iii) verification, and validation activities are conducted to ensure that the resulting educational products and services meet the requirements for the specified application or intended use; and (iv) any necessary actions are taken on problems determined during the reviews, or verification and validation activities.	O: Designing and developing controls (.) D: Novos Pedidos Manuais (.)
Regulação	Creating contingency plan for changes	Define a strategic plan for change situations in the organization so that operations are planned and managed. The impacts of the change on the business and on operational practices, information systems, existing and expected infrastructure, and the interested parties that participate must be considered.	O: Creating contingency plan for changes (.) D: Novos Pedidos Manuais (.)
Engajamento	Identifying and preparing for engagement risks	Managers and stakeholders shall identify and address engagement risks, such as: (i) conflict between participating stakeholders; (ii) unwillingness to engage; (iii) participation fatigue; (iv) creating expectations of change that the organization is unwilling or unable to fulfill; (v) lack of balance between weak and strong stakeholders; disruptive stakeholders;(vi) uninformed stakeholders; and disempowered stakeholders. Managers should make contingency plans to deal with the most likely or damaging risks.	O: Identifying and preparing for engagement risks (.) D: Atrasos em Processos (.)



8. Selecionar na barra de botões o *Generate Report* que é responsável pela exibição dos metadados que compõe o diagrama de avaliação de accountability.

ACCOUNTABILITY EVALUATION DIAGRAM REPORT

Project:	Conferência de adequabilidade de modelos de processos
Author:	Lucas
Organizational Objective:	Aperfeiçoar os Processos de Trabalho
Investigated Problem:	Variação de detalhes dos processos entre descrição e modelagem
Investigated Problem Description:	Alguns processos apresentam dados conflitantes entre suas descrições textuais e seus modelos

ACCOUNTABILITY EVALUATION MAPPING

Identified Information System and Properties:

Information System	Condition	Obligation	Sanction	Responsibility
QACAD	-	-	-	-

Identified Actor:

Actor	Condition	Obligation	Sanction	Responsibility
Requisitante	-	-	-	-
Requisitante	-	-	-	-

D. Evaluation Form (In Portuguese)

Formulário de Avaliação do Estudo

Prezado(a) participante,

Esta é a última parte do estudo. O objetivo deste questionário é obter informações adicionais e a sua percepção sobre o estudo, a partir das respostas às questões listadas a seguir:

1. Você executou todo o conjunto de tarefas propostas? ( ) Sim ( ) Parcialmente ( ) Não

2. Você fiqucou satisfeito com o resultado? ( ) Sim( ) Parcialmente ( ) Não

3. É possível perceber que a abordagem contribuiu para a avaliação do AESoIS, considerando os aspectos sistêmicos, as interações entre elementos e influências da accountability, a partir das informações apresentadas?

( ) Sim ( ) Parcialmente ( ) Não

4. Qual o grau de dificuldade na realização das tarefas?

( ) A execução das tarefas é muito difícil **( )** A execução das tarefas é difícil.

( ) A execução das tarefas é fácil. ( ) A execução das tarefas é muito fácil.

5. Questões de Facilidade de Uso e Usabilidade.

Item		**ID**	**Concordo Totalmente**	**Concordo**	**Não Concordo nem Discordo**	**Discordo**	**Discordo Totalmente**
Facilidade de uso	5. Eu aprendi facilmente como usar a abordagem.						
	6. Eu usei a abordagem da maneira que queria.						
	7. Eu entendi o que aconteceu na interação com a ferramenta.						
	8. Eu executei facilmente as tarefas propostas com a ferramenta.						
Usabilidade	9, Eu acho que a abordagem é útil para modelar a demanda e as soluções de arranjo de SI?						
	10. A solução AESoIS me permitiu perceber como a compreensão do contexto SoIS depende dos elementos SoIS.						
	11. A solução AESoIS melhorou meu desempenho em relação à execução das tarefas propostas.						
	12. A solução AESoIS ofereceu suporte às atividades de gerenciamento de SoIS.						

13. Quais as funcionalidades da ferramenta AESoIS que foram mais úteis na realização das tarefas?

14. De acordo com sua opinião, liste os aspectos positivos da utilização da ferramenta.

15. De acordo com sua opinião, liste os aspectos negativos da utilização da ferramenta.

16. Você possui alguma sugestão para melhoria da ferramenta AESoIS? Em caso positivo, por favor, especifique-a(s).

17. Quais conclusões ou observações você pode extrair sobre o grau de importância da accountability como requisito para avaliar os relacionamento e suas influências sobre os elementos que descrevem o diagrama construído?

D1. Execution Form Study #2 (In Portuguese)

Prezado(a) participante, esta é a última parte do estudo. O objetivo deste formulário é avaliar o uso da ferramenta AESoIS, a partir de dois diagramas que vocês previamente modelaram. Neste estudo, você é convidado(a) a modelar os problemas apresentados diretamente na ferramenta.

De forma a contribuir com a pesquisa e apoiar a consulta durante a ferramenta, seguem os dois diagramas previamente elabordos e servem de guia para resolução das tarefas.

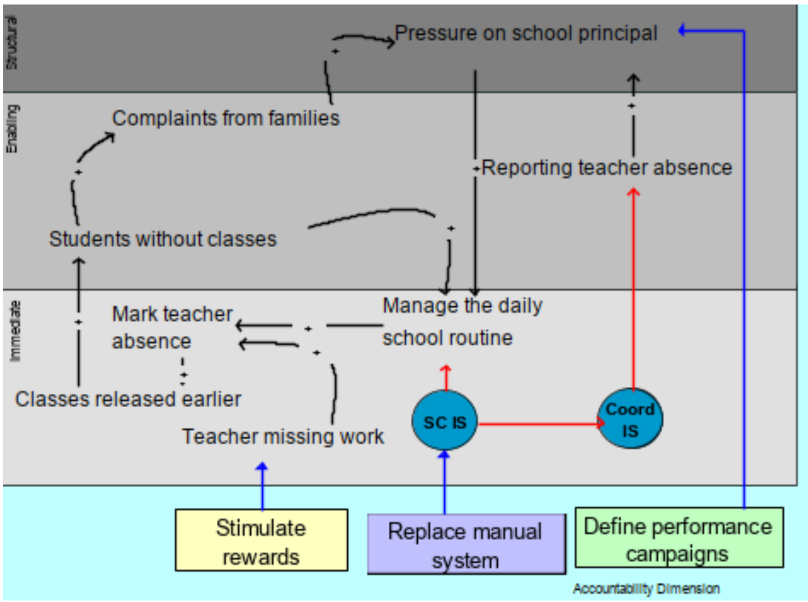
Para cada um dos problemas propostos, realizer tarefas abaixo considerando o seu grau de confiança em realizar a tarefa solicitada. O ranking vai de zero à dez, onde zero representa sem confiança alguma na resposta e dez total confiança na resposta. Registre o valor de confiança para efetivação da tarefa solicita.

1. **Identificar e modelar os Sistemas de Informação que influenciam o problema investigado**. Grau de Confiaça na tarefa: ________
2. **Identificar e modelar atores que influenciam o problema investigado**. Grau de Confiaça na tarefa: ________
3. **Identificar e modelar tarefas de processos de negócio que influenciam o problema investigado**. Grau de Confiaça na tarefa: ________
4. **Definir um exemplo de propriedades de accountability (Condição, Sanção, Obrigação e Responsabilidades) para ao menos um Sistema de Informação escolhido.** Grau de Confiaça na tarefa: ________
5. **Criar um ciclo causal (efeito positivo ou efeito negative) relacionado a um Sistema de Informação, utilizando os nós to tipo texto.** Grau de Confiaça na tarefa: ________
6. **Criar um segundo ciclo causal (efeito positivo ou efeito negative) relacionado a um Sistema de Informação, utilizando os nós do tipo texto.** Grau de Confiaça na tarefa: ________
7. **Gerir a opção de accountability criteria (engajamento, gerenciamento e regulação) de forma que você escolha ou crie indicadores com base na sua experiência para elementos modelados.** Grau de Confiaça na tarefa: ________
8. **Gerar um relatório com os metatados do problema investigado.** Grau de Confiaça na tarefa: ________

TAREFA 1 - PROBLEMA AUSÊNCIA DE PROFESSORES

Nesta tarefa você deve avaliar se os elementos representando apresentam o problema de ausência de professores no cotidiano escolar. Desta forma, você deve criar um diagrama para o problema proposto.

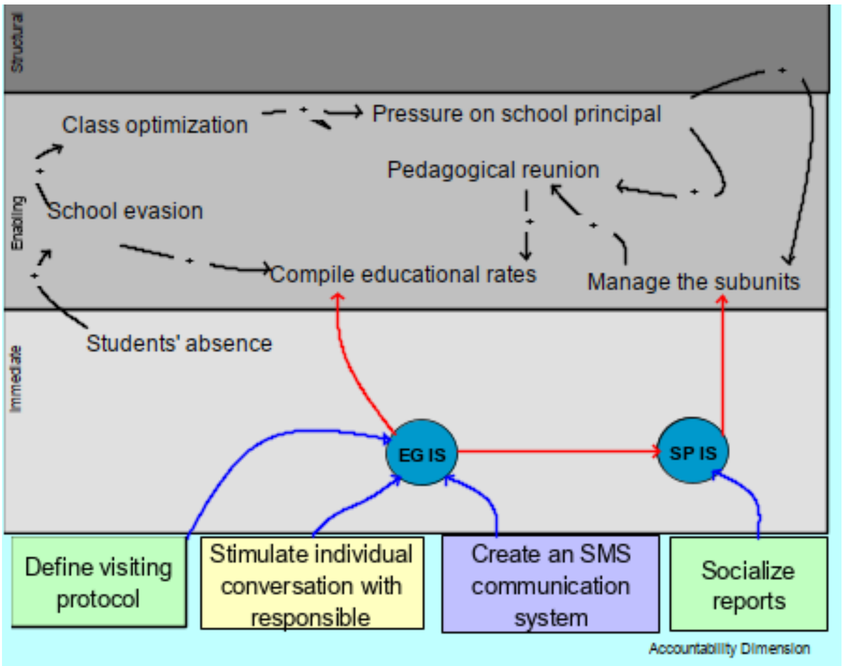
Durante a execução do estudo, você é livre para alterar o diagrama, pois ele tem a função de ser um esboço de modelagem. Isto porque, a ferramenta possui funcionalidades e representações que complementam os recursos.



TAREFA 2 - PROBLEMA EVASÃO ESCOLAR

Nesta tarefa você deve avaliar se os elementos representando apresentam o problema de evasão escolar no cotidiano escolar. Desta forma, você deve criar um diagrama para o problema proposto.

Durante a execução do estudo, você é livre para alterar o diagrama, pois ele tem a função de ser um esboço de modelagem. Isto porque, a ferramenta possui funcionalidades e representações que vão além da imagem a seguir.



APPENDIX VII

This appendix summarizes findings from the feasibility study, conducted in two educational organizations, as scenarios.

AESoIS FEEDBACKS FROM EXECUTION FORM

PART A - AESoIS STUDY #1

QUESTION	PARTICIPANT	FEEDBACK
Q01	P2	"*I didn't feel confident in carrying out this task, not being able to understand the meaning of it so far*".
Q01	P1	"*I managed to carry out all the tasks, and I believe it was effective*".
Q02	P1	"*Although I am confident in my answer, the answer was based on the proposed scenario. I believe I would need more time to adapt to comprehend association types. It does not mean to say that it was difficult, just that I would need more training to perform this part more fluently*".
Q02	P2	"*I can't see the contribution of the accountability module so far, since I'm using information that was filtered and selected in a previous BPSoIS*".
Q02	P2	"*QADAD is not right. The name is Qualidata*".
Q02	P3	"*I don't understand that 'Registro Acadêmico' is a constituent IS*".
Q03	P2	"*Filling out an application could also be linked to 'Requisitante'*".
Q03	P1	"*This step took a little longer, perhaps because of the amount of information. Also, I had a small error because instead of moving Regularize Pending from structural to gradual, I created a new one. After I realized this, I remade it, and it worked*".
Q04	P2	*I"have no real conditions to assess confidence in a copy and paste task*".
Q04	P2	"*I'm not really in a position to assess confidence in a copy-and-paste task*".
Q05	P2	"*I agreed with most causal relationships, with the exception of 'Quantidade de Estudante'*".
Q05	P2	"*I understand that this association should be in another sense*".
Q06	P2	"*now that I'm modeling, I can see the accountability evaluation proposal. Initially, the relationship with the BPSoIS was not clear*".
Q07	P2	"*I enjoy the suggestion repository*".
Q08	P3	"*Visually pleasing and quick in actions*".
Q08	P3	"*I understood the report without difficulty*".

PART B - AESoIS STUDY #2

PARTICIPANT	FEEDBACK
P4	"*We don't have the business processes mapped*".
P5	"*the tool is very nice and practical to use*", "*associations are very easy to use and aligned with elements*".
P4	"*Unfortunately we don't have business process tasks, but we do have tasks. In this case, I will use text representation*".
P5	"*The tool is fast, but it would be interesting to increase the connection point between elements. Sometimes it is difficult to position the cursor*".
P5	"*It is interesting to see how a previous diagram can be explored with more information about the school's daily life*".
P4	"*It is important to point out that crossing associations are not ideal*".

PART A - AESoIS STUDY #1

QUESTION	PARTICIPANT	FEEDBACK
Q01	P1	"*Execution is easy as long as prior training takes place*".
Q01	P1	"*If the study was not with some to guide, I would need to check documents to understand the propose*".
Q03	P2	"*I didn't have any difficulties as a user of the tool; however, I had conceptual doubts*".
Q03	P3	"*the highest difficulty was the lack of familiarity with the tool's components since it is new software. But this is normal in any first experience*", "
Q03	P2	"*there is a lack of semantic explanation of the problem addressed and the elements of the graphical interface*".
Q05	P1	"*a bit of difficulty clicking, dragging and dropping associations. (The first officer is limited in height). The biggest difficulty was the lack of familiarity with the tool's components, since it is new software. But this is normal in any first experience with a software. There is a lack of semantic explanation of the problem addressed and the elements of the graphical interface*".
Q07	P2	"*I was pleased although a little unsure about the diagram because I noticed some different points in the model image. I believe that as the tool handles a lot of information, it requires very minute attention from the user*".
Q11	P3	"*The execution of the AESoIS tasks are excellent, but I believe the tool could be used in an observational study*".
Q12	P3	"*VVsually pleasing and quick in actions*".
Q14	P1	"*The functionality of extending actor, business process tasks and IS automatically from BPSoIS is interesting*".
Q14	P3	"*drag and drop menu is relevant, as visual design is difficult to implement*".
Q14	P1	"*I believe that the perception of how the responsibilities of the elements are related and how these influences can be represented to better understand the whole of a problem can be better performed if the tool presents a legend indicating what represents the green, red dots and the signs of x. While we operate the tool with the model table, it is easy to understand, but when we visualize the diagram, we have to force our memory to remember. Perhaps this is also since it is the first contact with the tool.*"
Q15	P2	"*the importance degree is high, but the manager or user of the tool needs to have a theoretical background to understand the modeling*".
Q15	P1	"*the usability of click and drag. The nodes of systems, actors and Vertex*".
Q16	P3	"*a user need to obtain better understanding of the elements of a BPMN in order to understand how relationships happen*",
Q16	P1	"*the high learning system thinking curve from beginners, although it decreases over time*".
Q16	P1	"*the interface facilitates the use of the tool as well as the possible resolutions presented for each case. Better understanding of the elements of a BPMN in order to understand how relationships happen*"
Q17	P1	"*It would be relevant to add captions to explain the meaning of the types of associations between the elements*".
Q17	P2	"*the learning curve in drawing the diagram seems to need more time. I say this because the initial phases are very simple. The diagram part tends to be more pleasant after learning consolidation.*"
Q18	P3	"*an observational study would be very interesting for evaluating the tool*"
Q18	P1	"*extending BPSoIS with accountability evaluation opportune several explicit misunderstandings that may be happening during the execution of processes over time*".
Q18	P1	"*I conclude that the presentation of the scenario for improving responsibilities is well designed and developed for its purpose. High degree of importance regarding the influences of the elements described. I say this because the diagram helps in making decisions related to changes hat are often made to improve processes in an immediate, gradual or even structural way.*"
Q19	P2	"*the learning curve in drawing the diagram seems to need more time. I say this because the initial phases are very simple. The diagram part tends to be more pleasant after learning consolidation*".
Q19	P1	"*I congratulate the study. In fact, this extension of accountability will be able to make several explicit misunderstandings that may be occurring during the execution of organizational processes.*"

PART B - AESoIS STUDY #2

QUESTION	PARTICIPANT	FEEDBACK
Q03	P5	"*associations are very easy to use and aligned with elements.*"
Q04	P4	"*If there was no previous training, I would not be able to understand the concepts correctly, but I would be able to model a scenario, even if not using the notation correctly*".
Q04	P5	"*The training was enough to understand the use of the tool.*"
Q05	P4	"*I was in doubt whether the tool should be exclusive to BPSoIS, when in fact I didn't use business processes, it might be worth reviewing the tool's name*".
Q14	P4	"*the tool is very nice and practical to use*"
Q14	P5	"*the possibility of creating own indicators is interesting, because, despite the ISO standards being ideal for organizations, unfortunately, we don't have people to evaluate ISO*".
Q14	P4	"*it is easy to create associations. I imagine the automation of the association types was designed to reduce the effort of understanding the notation*"
Q16	P5	"*I was curious, then I opened the study invitation email in the expectation of being able to access it through the cell phone, but the features did not work*".
Q18	P4	"*the tool is very practical and beautiful. I see there were new elements incorporated*".
Q15	P5	"*Although the tool requires systems thinking knowledge, the solutions found such as colors, labels and selections help to resolve doubts.*"
Q16	P4	"*as we don't have the processes mapped with BPMN, I got the feeling that I didn't use the tool as much as possible, even though I managed to change and carry out the proposed scenarios effectively*".