

Information Systems Analysis as a Preliminary Study for Smart Campus Development

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Abstract

The trend of smart campus development has increased over the past 10 years, marked by digital transformation and the implementation of IoT and big data. This trend is not limited to state and private universities; civil service universities are also participating in the development of smart campuses. Unlike state and private universities, civil service universities face limitations in internal institutional management that pose significant challenges for planning and building large projects, such as smart campuses. The smart campus development plan at the Institut Pemerintahan Dalam Negeri (IPDN) is still hampered by various issues related to the management of scattered information and low use of information systems within the campus environment. Various stakeholders hold different opinions on these issues, so the nature of the problems faced remains unclear. These issues require special attention in follow-up and solution-finding, given that the implementation and use of information technology and information systems are the core of smart campus projects. This study analyzes the problem, organizes it more clearly, and identifies the root cause of the problem from scattered issues using Soft Systems Methodology (SSM) integrated with several stages of Root Cause Analysis (RCA). The identified root causes were then mapped into the smart campus dimensions: smart economy, smart society, smart environment, and smart governance. The analysis identified 27 root causes, divided into three categories: human resources, management, and policy. Of these 27 root causes, nine fall within the smart campus dimension, namely the smart economy, smart society, and smart governance subdimensions.

Keywords: information management, information systems, root cause analysis, soft systems methodology, smart campus.

1 Introduction

In developing countries, Information Technology (IT) and Information Systems (IS) are fundamental to advancing the quality of higher education. IT and IS enhance learning, streamline business processes, strengthen research capabilities, modernise libraries, optimise information services, and improve university management [1].

Over the past 10 years, the use of IT and IS in higher education has driven the development of digital campuses, with the Internet of Things (IoT) transforming digital services within the university environment into smart services [2]. The transformation of higher education into a digital campus, also referred to as a "smart campus" [2], models a smart city ecosystem, integrating teaching, learning, and research functions, promoting continuous learning, innovation, and entrepreneurship, and offering various laboratory programs [3].

Experts and academics have various definitions of a smart campus. A literature review [3] identified three main focuses of a smart campus: the development of smart city elements, advanced technology infrastructure, and the enhancement of the learning experience. A smart campus consists of four domains: smart economy, smart society, smart governance, and smart environment. These four domains are aligned and utilise smart technology and data [3]. Smart technology and data implemented in the four smart campus domains include big data and storage technology, decision-making support technology, information dissemination technology, and sensing technology [3].

Implementing smart technology and data across each dimension of a smart campus can create data integration and facilitate the development of appropriate applications or services to improve higher education performance in teaching, management, and service [2], [4], [5]. The implementation of a smart campus will enhance service quality and campus life in the Industry 4.0 era, thereby supporting the Tri Dharma of Higher Education [5]. Improved service quality, campus life, and graduate quality will enhance higher education.

Institut Pemerintahan Dalam Negeri (IPDN), as a civil service higher education institution, needs to adapt to advances in IT/IS, improve service quality, and strengthen human resources to achieve higher education quality aligned with IPDN's vision of becoming a world-class university. This is stated in IPDN's 8th mission, namely "Improving the Quality of Education Provider Performance Leading to Fulfilment of National Higher Education Quality Standards Based on Information and Communication Technology."

The realisation of this mission is outlined in the IPDN master plan, which calls for the development of a smart campus. Smart campus development at IPDN began with the establishment of a central institutional database, the Smart Campus Database (SCDB). The SCDB is an integrated electronic database and information system, connected to the main IPDN website, accessible to the academic community and the general public for data and information about IPDN.

Smart campus development at IPDN is currently partial, as IT and IS infrastructure development is ongoing. This results in teaching and learning activities and education management not being integrated, leading to suboptimal operation.

The utilisation of IT/IS to realise a smart campus at IPDN is still considered less than optimal, and numerous shortcomings remain, demonstrated by obstacles in the information management process, including data collection, incomplete data, lack of integration, and difficult data retrieval both within the central campus and between the central and regional campuses. For example: 1) student grades are still manually calculated by lecturers and submitted to study programs at the end of the semester via email; 2) grades are still sent from regional campuses to the central campus via email and utilize file sharing platforms such as Google Drive; 3) questions are sent by lecturers via email (there is no question bank using SI yet); 4) teaching instruments such as syllabi, semester learning plan (RPS), and modules are still collected using Google Drive; 5) despite the availability of Academic Information System (SIKAD), there are still redundant student identities; 6) the status of students who have been demoted is not updated in SIKAD; 7) there is no use of IS to record care and training agendas; 8) searching for information related to the number and list of new lecturers, lecturers with certain positions, the number of lecturers on study leave, etc. still requires confirmation of data recorded in documents.

Regarding some of the obstacles outlined above, the IPDN ICT unit stated that the development of the SCDB, which should have addressed these issues, was not optimal because it focused solely on developing an IS to monitor data updated manually by administrators and to display data visualisation output that could be directly monitored by management for decision-making. Therefore, there was no comprehensive data integration from various database sources at the institute.

The issues described above tend to relate to IS utilisation rather than IT. IS is a system that utilises people, hardware, software, communication networks, data resources, policies, and procedures to collect, retrieve, transform, and disseminate information within an organisation [6]. In campus life, IS plays a crucial role as the operational basis for various academic and non-academic processes. Before moving towards a smart campus that implements cutting-edge technologies, IS governance is a crucial first step, as it concerns data and information, as well as business process operations.

The issues outlined above are unstructured, involve differing stakeholder perspectives, have unpredictable objectives, and offer unclear solutions. Therefore, a conceptual framework is needed that can accommodate stakeholder relationships by viewing the problem holistically and comprehensively, rather than piecemeal, a practice known as systems thinking. However, the case study in this research is not a technical problem with a clear problem definition and objectives typically solved using hard systems thinking. Therefore, it offers a different solution: soft systems thinking. Soft systems thinking is a way of thinking that accommodates unstructured problems and unknown objectives [7].

Based on this problem description, the appropriate approach that can guide researchers in analysing the problem situation is Soft Systems Methodology (SSM). SSM is an approach used to analyse, describe, and interpret problems from various stakeholder perspectives to develop new conceptual ideas needed to transform the situation [[8].

In this study, the authors used SSM combined with Root Cause Analysis (RCA), as adapted from research [1], to analyse and describe the problem and identify corrective measures to support the realisation of a smart campus at IPDN. This study resulted in a structured description of the problem and its root causes in information management and IS use at IPDN. The exploratory analysis focused on the fundamentals of technology use, particularly the flow of data and information, which is a key issue.

This study aims to analyze the problems related to the development of information systems at IPDN to support the development of smart campuses, identify structured problems and their root causes using SSM combined with RCA, and map the root causes to the dimensions of smart campuses. This study is expected to contribute to the body of knowledge on SSM implementation in higher education, providing insights into solutions to information management problems and the use of information systems.

2 Literature Review

2.1. Soft Systems Methodology (SSM)

Soft Systems Methodology (SSM) is a qualitative research method that uses image modeling to structure or map conflicting opinions, needs, goals, interests, and values so they can be discussed and resolved [7]. SSM assumes that a complex set of behaviors has unique properties that are better viewed as characteristics of the system as a whole, rather than specific aspects. From this perspective, SSM is a systemic (rather than systematic) methodology that focuses on the whole rather than the parts. As a systems-based methodology for addressing real-world problems, SSM enables analysts and stakeholders to understand different perspectives on a situation, and problem-solving is achieved through learning rather than replacing the current situation with an ideal one.

SSM is also an action research method [9], a research process that integrates knowledge of human behavior with knowledge of organizations, then applies both to solve real-world problems within an organization. In action research, researchers seek to bring about change within the organization, develop the internal competencies of organizational members to solve their own problems, and contribute scientific knowledge [8].

To conduct an SSM analysis, the author followed 2 stages, as shown in Figure 1. In the figure, the SSM model consists of two main types of activities: real-world activities in stages 1, 2, 5, 6, and 7, and systems-thinking activities in stages 3 and 4. However, in the research process, not all SSM stages must be followed, depending on the needs of completing the case study being researched.

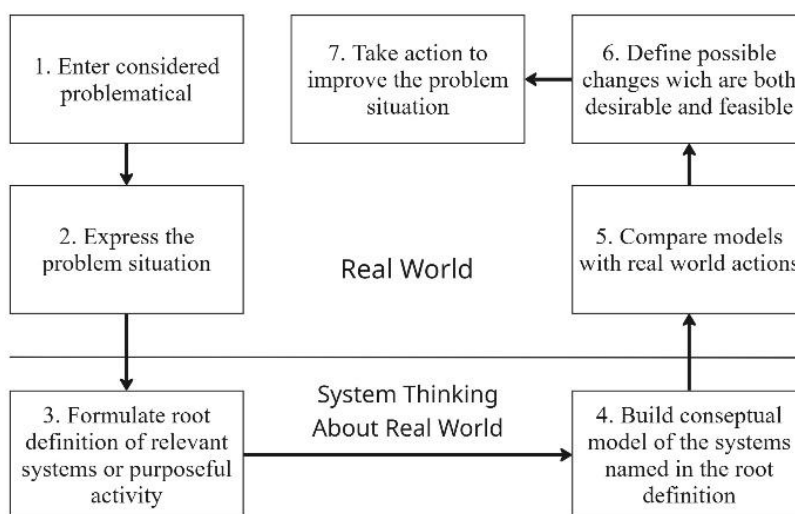


Figure 1 Seven stages in the soft systems methodology [7]

Stage (1) is "enter considered problematic," which examines unstructured, complex problems that still have multiple perspectives (worldviews). Next, stage (2) is "expressing the problem situation," which describes the problem's complexity through rich pictures that capture various perceptions of the

problem. Rich pictures are made as comprehensive as possible to show the problem map, relationships between actors, and perspectives on the problem being studied [7], [10].

Stage (3) is formulating the root definition of relevant systems or purposeful activities, which defines the root problem and encompasses specific views of the problematic situation from relevant perspectives. This stage is assisted by the definition of CATWOE (Customers, Actors, Transformation Process, Worldview, Owner, and Environmental Constraints). Customers are the parties who benefit from the transformation process. Actors are the parties who can carry out the transformation if the created model is applied to the real world. The Transformation Process is the activity that demonstrates transformation, improvement, or repair. The worldview is the paradigm that justifies the root definition. The owner is the decision-maker responsible for improvement efforts and can stop the transformation. Environmental Constraints are elements outside the system that can hinder the transformation process [7], [10].

Stage (4) is building conceptual models of the systems named in the root definitions. This involves constructing conceptual models to improve, repair, or transform the problem. This conceptual model is constructed by describing the inputs and outputs in the transformation process. Stage (5) is comparing models with real-world actions [7].

Stage (6) defines possible changes that are both desirable and feasible. This involves assessing stakeholder interviews to identify improvements or transformations that can realistically be achieved to address the problem situation. These changes can be structures, procedures, or stakeholder attitudes. After defining feasible changes, the next step is stage (7), which involves taking action to improve the problem situation and implementing the transformation action plan [7].

Checkland stated that SSM is a flexible methodology rather than a fixed method [7], [10]. It can be applied based on the user's motivation, without always following the seven stages. This is supported by the constitutive rules of SSM developed by Checkland in the late 1980s. These rules consist of five criteria outlining the assumptions and uses of SSM [11]:

1. SSM is a structured way of thinking that seeks to bring tangible improvements to real-world situations perceived as problematic.
2. The thinking structure of SSM is based on the idea of systems and their overall processes.
3. The use of SSM can only be claimed if:
 - There is no automatic assumption that the real world is systemic.
 - The distinction between systems thinking and the real world is clearly made.
 - Constructing 'holons,' which are multiple perspectives on the same problem.
 - Holons are used to help articulate debates about desired and feasible real-world changes.
4. The use of SSM needs to be understood and categorized for application to specific situations.
5. Each use will provide insight into the methodology.

The rules for using SSM above further demonstrate its flexibility. The breadth and flexibility of SSM's application across various industrial fields, the ease with which other methods and techniques can be added to its stages, and its ability to be combined with other methodologies demonstrate that SSM was developed with this goal in mind. Therefore, the use of SSM with additional techniques or a combination of methodologies can be flexible, depending on the needs and creativity of researchers or practitioners. Therefore, the perceived shortcomings of SSM, related to its implementation difficulty, can be overcome with various techniques outside SSM.

Several studies can serve as references for combining the SSM method with other methods. These studies were conducted by [12], [13], [11], and [1]. [12] Applied Soft Systems Dynamics Methodology (SSDM), a combination of System Dynamics (SD) and Soft Systems Methodology (SSM), to a case study of a small company engaged in domestic and imported steel trade in Peru. The SSDM method has 10 stages resulting from the combination of SD and SSM methodologies.

[13] combined Fuzzy Cognitive Maps (FCM) with SSM. In this study, the authors used SSM from a systems development perspective and FCM from a modeling perspective. FCM was used as a modeling tool embedded within SSM.

[11] developed a combination of SSM with Discrete Event Simulation (DES) methodology. DES is a simulation modeling concept for discrete systems, representing a system model as a variable that changes over time, whose changes can be calculated. In the developed methodology, the DES model is used in the final steps of the SSM to identify possible areas for improvement.

[1] Added the Root Cause Analysis (RCA) method to the SSM. The addition of the RCA stage in stage 2 successfully helped illustrate the problem more clearly by identifying and analyzing potential causes. Meanwhile, the addition of RCA in stage 3 successfully helped researchers identify the problem's root causes and outline possible solutions.

Based on the literature review, this study adapts the research methodology by adding the RCA stage to the SSM, as done in [1] research, as it was deemed appropriate for exploring problems and identifying root causes, as well as obtaining a comprehensive overview of the state of Information System usage at IPDN to support smart campus development.

2.2. Root Cause Analysis (RCA)

Root Cause Analysis (RCA) is an approach that provides guidance for diagnosing and resolving problems, thereby improving corrective processes in many organizations [14].

The primary objectives of RCA include [15]: 1) identifying the root causes of problems; 2) establishing common terminology within the corporate community to facilitate better communication and understanding; and 3) enabling learning from past problems, failures, and issues.

There are many versions of the RCA stages, with the general stages including: 1) identifying the problem, 2) conducting a diagnosis, 3) selecting and implementing a solution, and 4) improving and sustaining results. The primary emphasis is on the diagnosis stage, which is conducted through logical, deductive analysis using critical thinking [14].

2.3. Smart Campus

A smart campus is a concept that emerged from opportunities for digital transformation in higher education. Based on a literature review by [3], it was concluded that a smart campus is a cultural paradigm, or "smartization," process in which universities adopt smart technologies to create a comfortable, safe, and sustainable environment. [3] formulated the concept of a smart campus based on a literature review of 123 selected articles, concluding that a smart campus consists of four domains, as shown in Figure 2, namely smart economy, smart society, smart environment, and smart governance. However, smart technology & data are not treated as a separate dimension. Instead, they are integrated with the dimensions of smart economy, smart society, smart environment, and smart governance. Each of these dimensions uses smart technologies and data, including big data, storage, decision support, dissemination, and sensing.

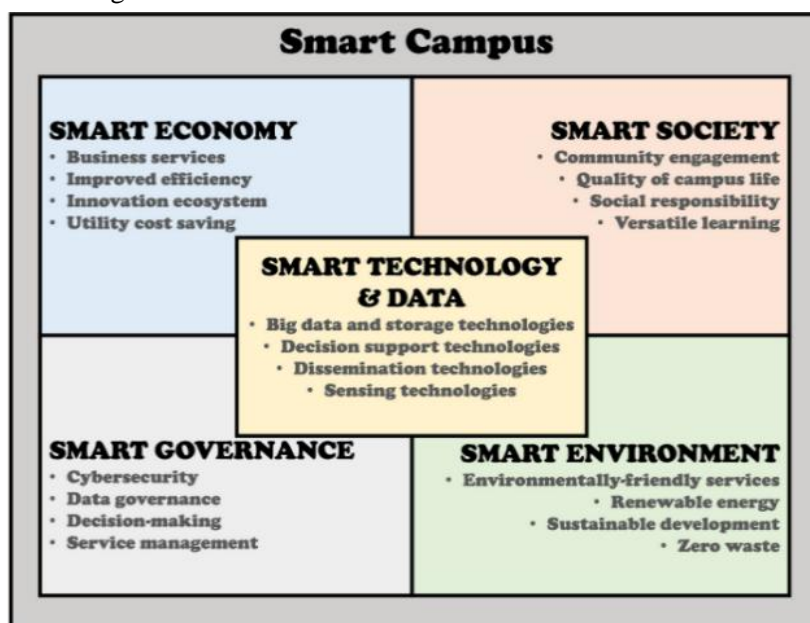


Figure 2 Conceptual framework of smart campus[3]

The smart campus dimensions used as references are derived from research [3], as shown in Table 1.

Table 1 Smart campus dimensions

| No | Dimension | Sub Dimension | Description |
|----|-------------------|-----------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1. | Smart Economy | Business services | Providing business services to the academic community in the form of or derived from economic benefits, the application of which utilises technology. |
| | | Improved efficiency | Improving information and communication efficiency through the application of AI. This efficiency results in lower costs. |
| | | Innovation ecosystem | Innovations in sustainable and green campuses are being implemented, utilising various technologies to generate renewable energy. |
| | | Utility cost saving | Various smart technologies are being utilised to reduce electricity consumption. |
| 2. | Smart Society | Community engagement | Integrated involvement of the academic community and partners through IoT, Big Data, networking, and AI technologies creates responsive campus services, thereby forming a robust communication network ecosystem. |
| | | Quality of campus life | Improved academic life through the application of technology. |
| | | Social responsibility | The community is working together to create human-centred value to enhance the smart campus experience, facilitated by technology. |
| | | Versatile learning | Various digital learning platforms are available. |
| 3. | Smart Environment | Environmentally-friendly services | Environmentally friendly services are being implemented to minimise energy use and the use of other environmentally unfriendly materials. |
| | | Renewable energy | Projects or technological applications are being implemented to help reduce electricity consumption and utilise renewable energy. |
| | | Sustainable development | Projects or research are being planned to facilitate experiments on the use of renewable energy enabled by digital technology. |
| | | Zero waste | Waste reduction is essential to improve environmental conditions. |
| 4. | Smart Governance | Cybersecurity | Strong cybersecurity is guaranteed. |
| | | Data governance | A data governance platform is in place to objectively manage data resources. |
| | | Decision making | Technology development is essential for decision-making. |
| | | Service management | Technology-based services for the academic community are available, such as automation and the use of IoT and AI. |

3 Research Method

3.1. Research Stages

This research uses Soft Systems Methodology (SSM) stages 1 through 2, with the addition of Root Cause Analysis (RCA) in stage 2, resulting in six research stages. The addition of RCA to this research stage is adapted from the research method [1], where RCA is an additional method attached to stage 2 of SSM, becoming stages 2.1, 2.2, and 2.3.

Over the past two decades, numerous SSM research publications have combined SSM with various other methods [1]. Some researchers assume this is because SSM has several weaknesses, such as the lack of tools to convert the root definition (in stage 3) into a conceptual model (in stage 4), and the conceptual model built in stage 4 is based on a specific perspective, not expert knowledge [12], [13].

Meanwhile, [10] and [7] state that SSM is a flexible methodology that can be applied to meet users' needs and does not require following the seven stages. This flexibility includes the freedom to add other methods and techniques to the SSM stages, depending on the creativity of researchers and practitioners who adopt SSM [1]. The stages of this research are shown in Figure 3.

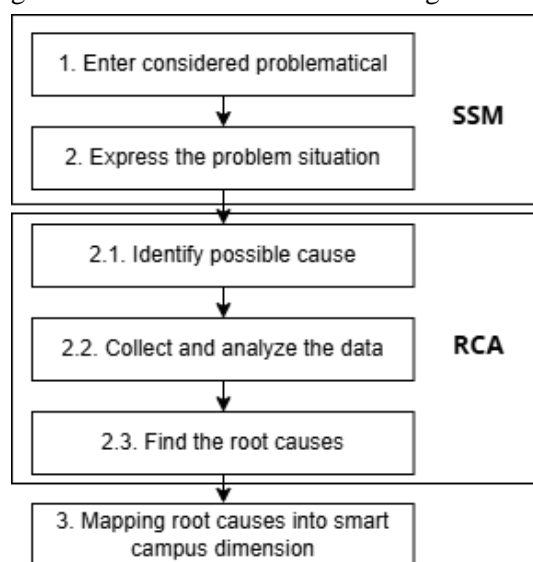


Figure 3 Research flowchart

The description of the research stages using the combination of SSM and RCA methodologies proposed in this study is as follows:

1) Step 1: Enter the considered problematic

In step 1, information and perspectives are gathered on situations deemed problematic and in need of improvement. The problem description is presented briefly but comprehensively, encompassing the entire problem.

2) Step 2: Express the problem situation

Stage 2 involves capturing various perspectives on the situation. At this stage, the understood problem is comprehensively interpreted as a rich picture.

3) Step 2.1: Identify possible causes

In this stage, possible factors contributing to the problem are identified based on the process understanding in step 2, using deductive thinking. This stage utilises brainstorming techniques with cause-and-effect diagrams, also known as Ishikawa (fishbone) diagrams. The problems identified in the previous stage are analysed, and their categories are defined; then, possible causes are identified within each category.

4) Step 2.2: Collect and analyse the data

In this stage, data were collected through interviews with work units, faculties, study programs, civil service personnel, and collaborators; research; and facilities and infrastructure. Data collection aimed to explore the problem and identify the root cause based on the brainstorming conducted in step 2.1. Interviews were conducted with heads of centers at several institutions, heads of institutions, deans, heads of study programs, lecturers, IT experts, and staff from several work units, totaling 26 informants. These informants were selected because the identification of issues and problems focused on the core activities of state universities, namely the Tri Dharma of Higher Education (Tri Dharma Perguruan Tinggi), namely teaching, research, and community service. The interview data were collected and analysed, interpreted through diagrams, and used as material for analysing the problem's root cause.

5) Step 2.3: Find the root cause

In this stage, an analysis was conducted to identify the problem's root cause using a cause-and-effect diagram, also known as a "Why-Why" diagram. The analysis was conducted for each identified problem category using a fishbone diagram.

6) Step 3: Mapping root causes into smart campus dimensions

In this stage, the root causes of the identified problems are mapped to smart campus dimensions to determine which aspects of each dimension require further improvement and should be focused on.

3.2. Data Collections

This study emphasizes the importance of involving multiple perspectives because the problems faced are unstructured and involve many stakeholders. Data collection through interviews was conducted with academics, as detailed in Table 2. The study's informants represent academic implementation work units (faculties and study programs) and supporting academic implementation work units (work units, bureaus, and institutions), not the total number of employees in those units.

Table 2 List of informants

| Informant Code | Informant Position | Research Stage | Total |
|----------------|--------------------------------------------------------------------------|----------------|-----------|
| I1 | Head of Data and Information Systems Center | 1, 2, 2.2, 3 | 1 |
| I2 | Head of Computer and Information Systems Laboratory Center | 1, 2, 2.2, 3 | 1 |
| I3 | IT Expert Team of Computer and Information Systems Laboratory Center | 1, 2, 2.2, 3 | 2 |
| I4 | Dean of the Faculty of Governmental Management | 1, 2, 2.2 | 1 |
| I5 | Head of Study Program | 1, 2, 2.2 | 4 |
| I6 | Lecturer | 1, 2 | 8 |
| I7 | Faculty Administrative Staff | 1, 2 | 5 |
| I8 | Head of Strategic Research Center | 1, 2, 2.2 | 1 |
| I9 | Head of Study Program Based Community Service Center | 1, 2, 2.2 | 1 |
| I10 | Staff of Academic Administration | 1, 2 | 1 |
| I11 | Head of Civil Service, Student Affairs, and Alumni Administration Bureau | 1, 2, 2.2 | 1 |
| Total | | | 26 |

The interviews were conducted in three stages: first, to explore issues and perspectives related to information flow and the use of information systems in stages 1 and 2; second, to identify the root cause of the problem; and third, to validate the smart campus dimensions. All interviews were informal and semi-structured. The interview instruments for the problem situation exploration (SSM stages 1 and 2) are shown in Table 3. Probing questions were used to clarify and deepen informants' responses.

Table 3 Interview instruments in stages 1 and 2 of the research

| No | Main Questions | Probing Questions |
|----|-----------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------|
| 1. | How are your work unit's business/operational processes carried out? | Are there SOPs related to work unit operations? If so, can you show them? |
| 2. | How is important data collected in your work unit? | How is the data collected after collection? What media and tools are used? |
| 3. | What is the flow of coordination and data exchange between the work units you currently lead? | How long does it take to collect data between work units? |
| 4. | Does the current information system (IS) meet your daily operational needs? | If not, which parts are still done manually? (Examples: inputting values, archiving documents in Google Drive) |
| 5. | What challenges do you encounter when working with IS in your work unit? | What are the main challenges you face when accessing strategic data from other work units? |

Meanwhile, the interview instrument for finding the root cause of the problem (stage 2.2) is shown in Table 4 below. The root cause of the problem was identified through an in-depth analysis of the questions.

Table 4 Interview instruments in stage 2.2

| No. | Main Questions | Informant Code |
|-----|-----------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------|
| 1. | In your opinion, what are the causes of the lack of awareness and desire to use Information Systems within work units and the institute? | I1, I2, I3, I4, I5, I8, I9, I11 |
| 2. | In your opinion, what are the causes of the lack of alumni data management? | I1, I2, I3, I4, I5, I8, I9, I11 |
| 3. | In your opinion, what are the causes of the lack of IT and IS service helpdesks at the institute? | I1, I2, I3, I4, I5, I8, I9, I11 |
| 4. | In your opinion, what are the causes of the lack of system backup mechanisms available at the institute? | I1, I2, I3 |
| 5. | In your opinion, what are the causes of the lack of authentication and authorization mechanisms for application user registration at the institute? | I1, I2, I3 |
| 6. | In your opinion, what are the causes of data disintegration at the institute? | I1, I2, I3 |
| 7. | In your opinion, what are the causes of the lack of a master plan for information systems development at the institute? | I1, I2, I3 |
| 8. | In your opinion, what are the causes of the lack of regulations regarding the continued use of applications? | I1, I2, I3, I4, I5, I8, I9, I11 |
| 9. | In your opinion, what are the causes of the lack of IS that do not meet the needs of work units? | I1, I2, I3, I4, I5, I8, I9, I11 |
| 10. | In your opinion, what are the causes of the lack of credential access regulations for various IS at the institute? | I1, I2, I3 |
| 11. | In your opinion, what are the causes of the lack of cybersecurity prevention mechanisms at the institute? | I1, I2, I3 |

4 Results and Discussion

4.1. Enter Considered Problematical

Based on interviews with the IPDN Data and Information Systems Centre (LPDSI), several issues were identified related to the use of information systems to support IPDN's smart campus program. LPDSI stated that the primary challenge IPDN faces in pursuing a smart campus is integrating data across different information systems. This occurs because there is no centralised database. As a result, discrepancies and incomplete data are recorded in various databases across different information systems. These issues also make it difficult to locate critical data needed to improve the quality and accreditation of study programs and institutions. Examples of such data include the number of doctoral graduates, the number of lecturers with professorships, advanced classes or learning facilities, and national or international collaborations.

Another issue relates to the need for information system development. LPDSI stated that several operational needs of IPDN work units are not yet supported by information systems. For example, document management and archiving, which almost entirely rely on conventional, non-computerised record-keeping or Google Drive storage. Another example is the lack of an information system to manage student activities and to monitor, by leadership, institutional quality achievement targets, displaying strategic information with real-time data.

Another equally significant issue is the large number of information systems that have been developed but are not being used, amounting to 33 out of 75 existing information systems/applications. This is because there has never been a review and evaluation of information system development, or of employee and lecturer satisfaction with the use of information systems, making it difficult to develop an information system development plan that meets long-term needs.

The LPDSI also stated that the use of institutional email accounts by employees and lecturers remains suboptimal because not all are aware of their use. Meanwhile, institutional email accounts are needed as reference email addresses used for various internal information systems. Furthermore,

<http://sistemasi.ftik.unisi.ac.id>

institutional email has a very large storage capacity, enabling it to manage various work-related data. However, the institution also lacks a policy limiting the annual provision of new email accounts to 10,000. Therefore, if there are additional cadets, employee additions and removals, or changes to work units that require email, the quota is insufficient.

Another issue that requires attention in addressing the shift toward a smart campus is the lack of willingness and ability of IPDN lecturers and staff to operate information systems, both within operational units and for individual staff members. In each work unit, certain employees are designated to operate applications but are not supported by other staff in learning how to use them. Similarly, the limited number of lecturers, many of whom are middle-aged, makes it difficult to learn application operations quickly. This is compounded by the established culture of delegating the input and editing of individual data to staff.

In addition to the visible or directly reported issues within departmental operations described above, numerous technical issues related to applications, technology, and infrastructure also require attention to implement the smart campus program. These problems include the need to build an enterprise information system, namely an information system that connects all departments in the institution in terms of business processes, data and architecture, there is no official mandate for regulating access rights for all structured and trustworthy applications, there are no official regulations regarding application rental services to vendors so there is no certainty of continuity if there is a change in related leadership.

4.2. Express The Problem Situation

The problems described above are presented as a rich picture in Figure 4, along with information about the picture in Table 5.

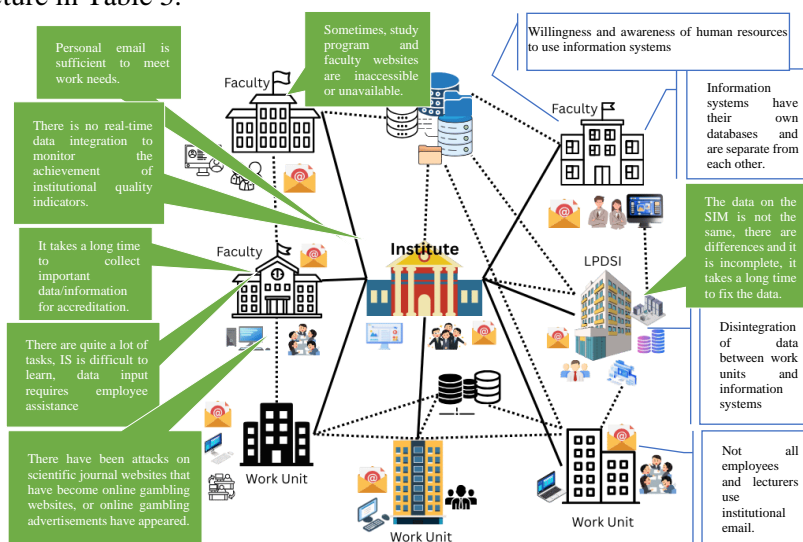


Figure 4 Rich picture

Table 5 Symbol description in rich picture

| Symbol | Description |
|--------|-----------------------------------------------------------------------------------------------------------------------------------------|
| | Describes the direction of regulations and information |
| | Describes the direction of the relationship between the flow of information and the regulations and information within the information. |
| | Contains information about the status of tasks performed by stakeholders. |
| | A situation that reflects unmet stakeholder needs. |

Based on the rich picture in Figure 4, the problems can be grouped into several categories, as shown in Table 3.

Table 6 Problem identification based on figure 4

| No | Problem Description | Problem Category |
|----|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------|
| 1 | Use of information systems is suboptimal in most units. Only designated employees can operate applications, resulting in slow, incomplete, and error-prone data updates. | Lack of awareness and willingness to use Information Systems |
| 2 | The utilisation of the personal information system is not yet optimal; not all employees and lecturers are willing to use the application consistently. | Lack of awareness and willingness to use Information Systems |
| 3 | The tracer study mechanism is suboptimal, and alumni contact data is not managed sustainably. | No alumni data management mechanism available |
| 4 | IPDN lacks a formal complaint process for IT and IS service issues. | No IT and IS helpdesk services available |
| 5 | There is no disaster recovery plan or system for backing up critical data. | No backup system mechanism is available |
| 6 | There is no authentication, authorisation, or user and IT application registration system within IPDN. | No authentication and authorisation mechanisms for recording application users |
| 7 | Applications and databases for the same sector vary, creating information islands. Integration is a key challenge for institute-wide IS implementation. | Data disintegration |
| 8 | Sustainable large-scale use of the application has not yet been achieved. A case study can be taken from the Academic/SIAP application. | No policy for sustainable application use |
| 9 | There are still discrepancies in the SI/SCDB data, for example, for academic, civil service, faculty, and certain work units. This data is caused by civil servants taking leave, being demoted, or being held back, etc. Furthermore, there is no mechanism to validate the most up-to-date data or to determine who to consult. | Data disintegration |
| 10 | Information system developments are not reviewed or evaluated, leading to inactive, unused systems. | No master plan for information system development |
| 11 | Strategic information for decision-making, such as data on doctoral-qualified lecturers or collaboration, is difficult to obtain. | Data disintegration |
| 12 | The need for information systems to support work unit operations remains unmet; for example, document management still uses Google Drive, and civil service information systems are used to manage civil service activity data. | Unmet IS needs in work units |
| 13 | Some contract workers have access to system credentials. Oversight and protocols are needed to ensure credential security. | No official credential access arrangements for various IS |
| 14 | No user satisfaction evaluations are conducted as a foundation for ongoing information system development. | No master plan for information system development |
| 15 | There is no IS monitoring by management that displays strategic information in real time. | No master plan for information system development |
| 16 | Website security within the institution remains weak. | No mechanism for preventing cyber attacks. |

4.2.1. Identify Possible Cause

Based on the problem categories in Table 3, there are 11 types of problems: 1) lack of awareness and willingness to use the Information System, 2) lack of alumni data management mechanisms, 3) lack of IT and IS helpdesk services, 4) lack of a backup system mechanism, 5) lack of authentication and authorization mechanisms for application user registration, 6) data disintegration, 7) lack of a policy for sustainable application use, 8) unmet IS needs in work units, 9) lack of official credential access arrangements for various IS, 10) lack of an information system development master plan, 11) no mechanism for preventing cyber attacks.

At this stage, an initial analysis of possible causes of the problem, based on the rich picture, was conducted. Identification was carried out by brainstorming possible causes using a cause-and-effect diagram (CED) or fishbone diagram, also known as an Ishikawa diagram. The CED for the above problem categories is shown in Figures 5-7.

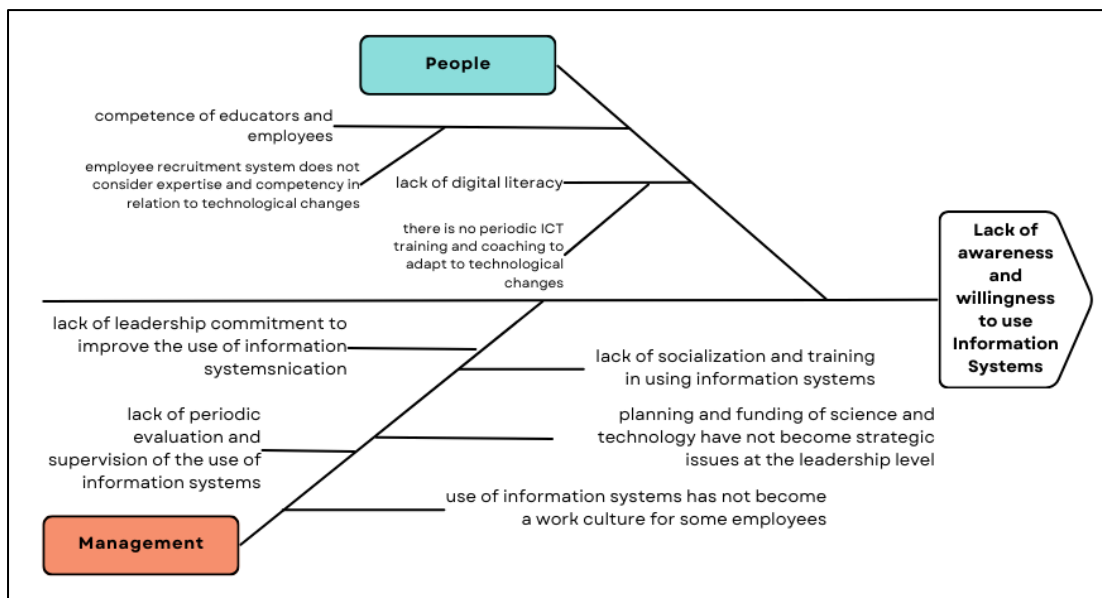


Figure 5 CED lack of awareness and willingness to use IS

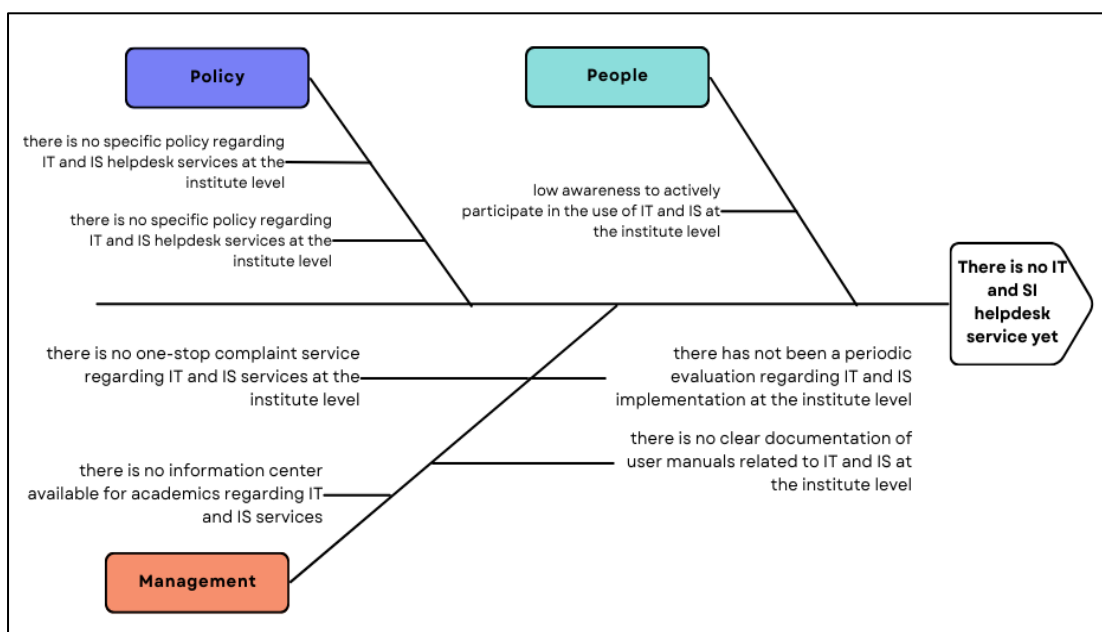


Figure 6 CED there is No IT and SI helpdesk service yet

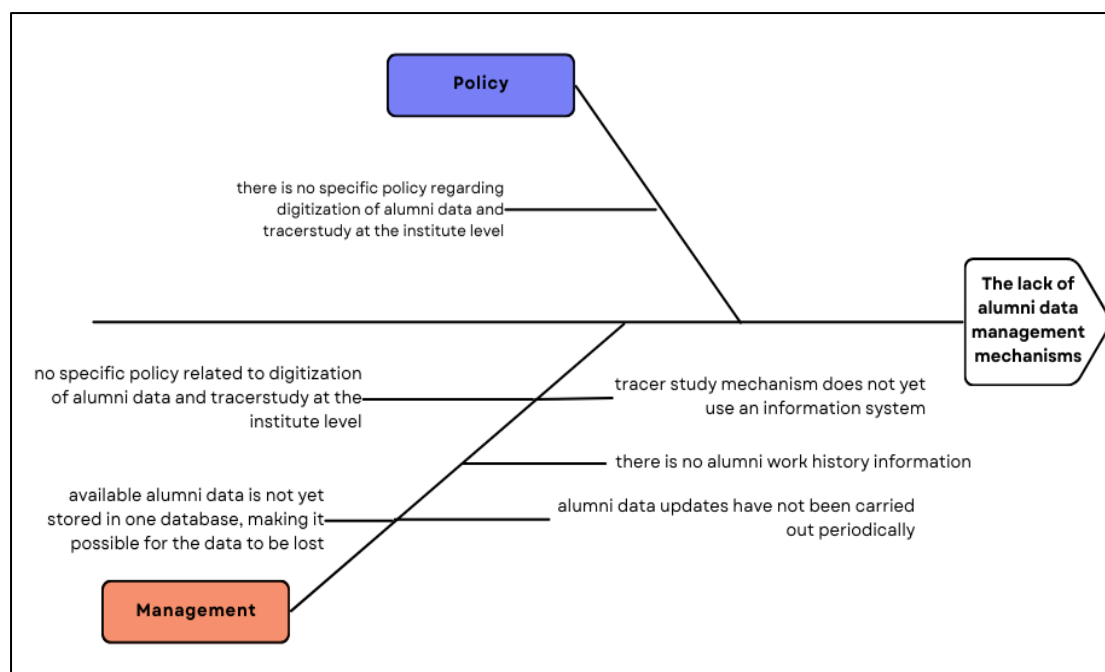


Figure 7 CED lack of alumni data management mechanisms

4.2.2. Collect And Analyze The Data

At this stage, information is collected, the problem's causes are explored, and root cause mapping is confirmed. Validation of the root cause mapping was conducted using triangulation techniques, ensuring and seeking respondents' approval of the interview instruments used with stakeholders in the faculty, study program, civil service and student affairs bureau, academic bureau, community services center, data and information systems center.

4.2.3. Find The Root Cause

At this stage, an analysis is carried out to identify the main root cause, which leads to the problem's identification. This is done by evaluating the results of the cause-and-effect diagram (CED) using the five whys technique, also known as the Why-why diagram. This technique is used to obtain a more detailed identification of the causes of the problem that were previously analysed. The why-why diagram is a tool used in quality management to identify the root cause of a problem without stopping until the real cause is found, usually achieved by asking 'why' five times to the problem [16][17]

The possible causes of the problem resulting from the brainstorming session are the first "why" results, and will be identified until the root cause is identified according to the brainstorming categories in the CED. The interview questions in Table III were used to explore the root causes of the problem in the CED diagram. The "why-why" diagram is structured based on the categories that influence cause and effect in the CED: people, management, and policy. Each CED contains two to three "why-why" diagrams. Out of 10 CEDs, 24 "why-why" diagrams were generated. Two of these are shown in Figures 8 and 9.

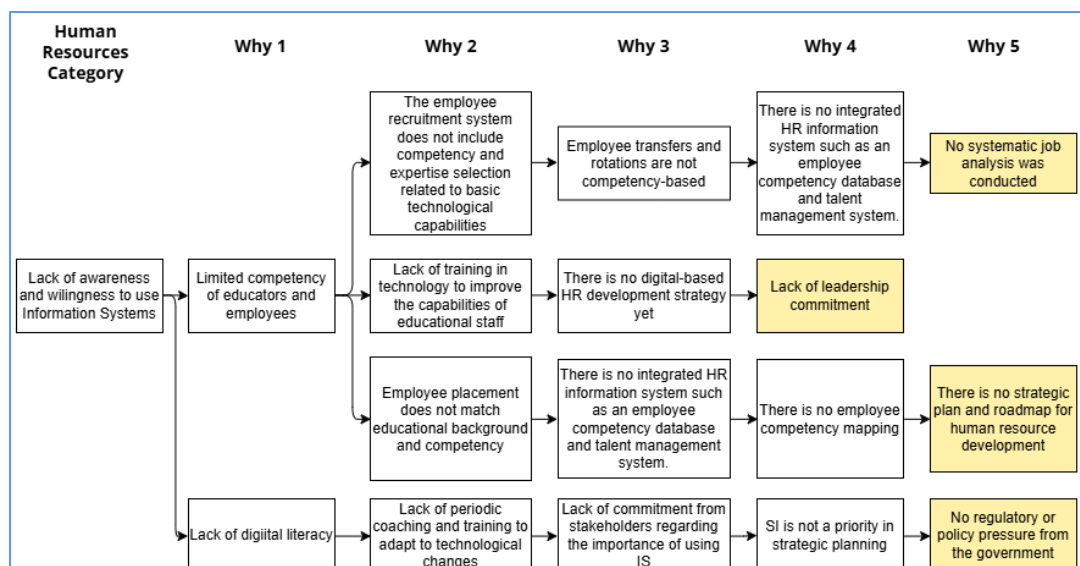


Figure 8 Why-why diagram human resource category from lack of awareness and willingness to use IS

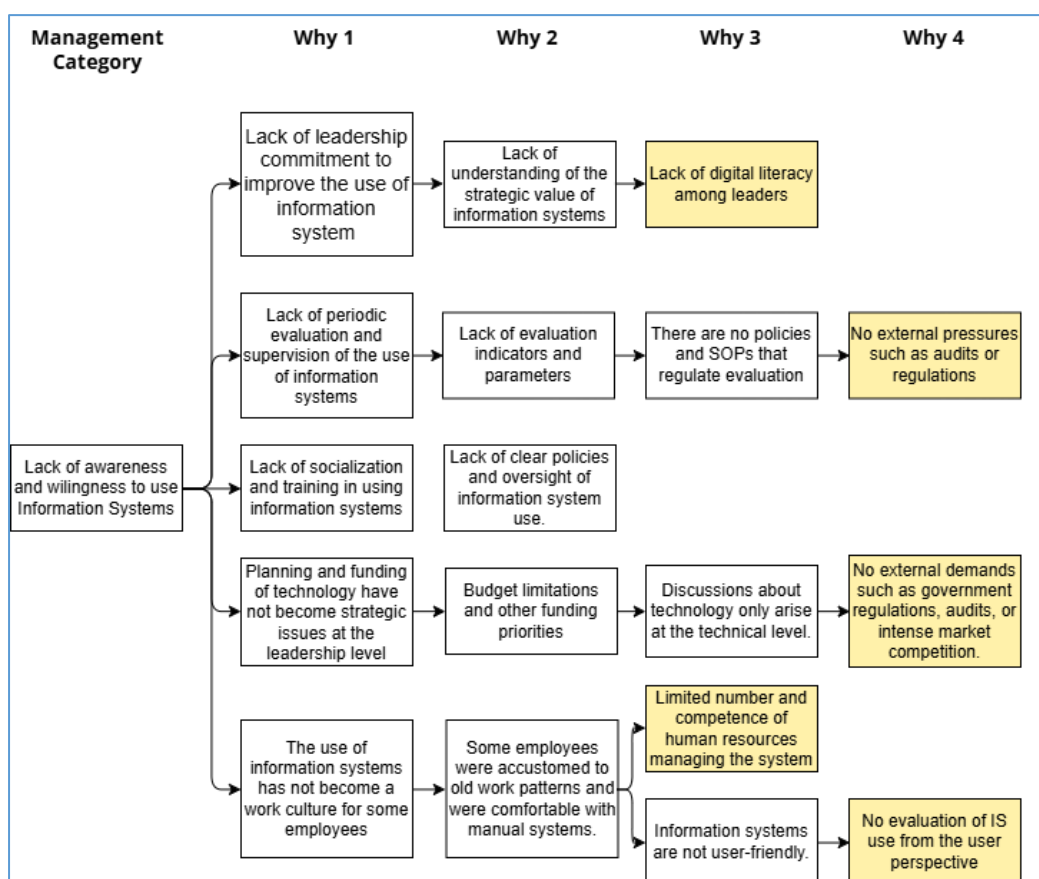


Figure 9 Why-why diagram management category from lack of awareness and willingness to use IS

Based on the results of the Why-Why diagram analysis, various root causes of the problem were identified. Overall, several root causes were found to be the same, although the analysis results came from different cause categories. The problem was divided into three categories based on root cause type: human resources, management, and policy. The results of the identification of possible solutions in this study are shown in Table 7.

Table 7 List of root causes

| No. | Category | Problem's Root Causes |
|-----|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1 | Human Resources | <p>Organizational leadership demonstrates limited commitment to adopting and using information systems (IS).</p> <p>Comprehensive strategic planning and the development of a human resource roadmap are urgently required</p> <p>Digital literacy among organizational leaders remains critically insufficient.</p> <p>A limited sense of ownership and minimal active participation in information technology (IT) and information systems (IS) persist across organizational units.</p> <p>The absence of information and communication technology (ICT) expertise in leadership roles is unsustainable.</p> <p>Most work units experience an acute shortage of reliable human resources possessing ICT competencies.</p> <p>Regulatory and policy barriers significantly impede the recruitment and transfer of personnel with ICT competencies.</p> <p>The pool of workers with adequate ICT knowledge available for inter-unit transfer remains limited.</p> |
| 2 | Management | <p>Organizational governance remains conventional and has not yet adopted AGILE Government practices.</p> <p>Communication regarding the curriculum between the campus and alumni is infrequent, both within the institution and with external agencies or organizations.</p> <p>There is a limited understanding of the significance of IT implementation across organizational components.</p> <p>Low understanding of the importance of IT implementation for various components.</p> <p>Budgets and infrastructure do not yet support implementing IS/IT help desks, backup systems, and other requirements.</p> <p>Planning efforts are primarily concentrated on IS/IT development.</p> <p>Masterplan studies remain incomplete and lack a comprehensive scope.</p> <p>Budget allocations prioritize sectors other than ICT.</p> <p>No comprehensive study has been conducted to assess digital maturity and IS/IT requirements.</p> <p>Digital literacy training/ seminars and other initiatives have not been a management focus.</p> <p>There has never been an evaluation of IS usage from a user perspective.</p> <p>Cybersecurity considerations have not yet been incorporated into the institution's strategic agenda.</p> |
| 3 | Policy | <p>Standard operating procedures for IT and information systems implementation and operations are currently absent.</p> <p>Employee placement is determined by evolving leadership policies.</p> <p>Leadership policies do not mandate or support regular updates of information systems data.</p> <p>Institutional policies impose constraints that hinder the fulfillment of IT and information systems requirements.</p> <p>No external government regulations or policies currently mandate the use of information systems.</p> <p>An information security policy has not been established.</p> <p>Standard operating procedures for vulnerability management are not in place.</p> |

4.3. Mapping Root Causes Into Smart Campus Dimension

Mapping the root causes of problems within the smart campus dimension was conducted at the end of the study to explore the actual problems occurring in the field, which were perceived as still far from the implementation of the four smart campus dimensions. The mapping results are shown in Table 8.

Table 8 Mapping root causes into smart campus dimension

| No. | Smart Campus Dimension | Sub Dimension | Root Cause Code | Problem's Root Causes |
|------|------------------------------------------------------------------------------------------------------------------|----------------------|-------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1. | Smart Economy | Business services | RC1 | Budgets and infrastructure do not yet support implementing IS/IT help desks, backup systems, and other requirements. |
| | | | RC2 | Budget allocations prioritize sectors other than ICT. |
| 2. | Smart Society | Community engagement | RC3 | A limited sense of ownership and minimal active participation in information technology (IT) and information systems (IS) persist across organizational units. |
| | | | RC4 | Digital literacy among organizational leaders remains critically insufficient. |
| | | | RC5 | Most work units experience an acute shortage of reliable human resources possessing ICT competencies. |
| | | | RC6 | The pool of workers with adequate ICT knowledge available for inter-unit transfer remains limited. |
| | | RC7 | Organizational leadership demonstrates limited commitment to adopting and using information systems (IS). | |
| | | RC8 | Comprehensive strategic planning and the development of a human resource roadmap are urgently required. | |
| | | RC9 | There is a limited understanding of the significance of IT implementation across organizational components. | |
| 3. | Smart Environment | - | - | - |
| 4. | Smart Governance | Cybersecurity | RC10 | Cybersecurity considerations have not yet been incorporated into the institution's strategic agenda. |
| | | | RC11 | Standard operating procedures for vulnerability management are not in place. |
| | | Data governance | RC12 | An information security policy has not been established. |
| | | | RC13 | Leadership policies do not mandate or support regular updates of information systems data. |
| RC14 | Standard operating procedures for IT and information systems implementation and operations are currently absent. | | | |

Based on the mapping results in Table 8, there are 14 root causes of problems under the smart campus dimension, namely the smart economy, smart society and smart governance dimensions. The mapping results do not identify the root causes of problems related to the dimensions and sub-dimensions of the smart environment, particularly in the management of the natural environment and the sustainability of the institution's resources.

To validate the results of the root cause mapping of problems using the smart campus dimension, triangulation was conducted with informants I1, I2, and I3. Informants were selected based on their competency and position. The validity testing instrument is shown in Table 9. All informants stated that

the root cause mapping of problems related to the smart campus dimension aligns with the findings; thus, the triangulation results are valid.

Table 9 Triangulation of root cause mapping of problems and smart campus dimension

| Root Cause Code | Relevance of Smart Campus Dimensions and Sub-Dimensions | | Informant Confirmation | | | Validity |
|-----------------|---------------------------------------------------------|---------------------|------------------------|-----------|-----------|----------|
| | | | I1 | I2 | I3 | |
| RC1 | Smart Business | Economy – Smart | Confirmed | Confirmed | Confirmed | Valid |
| RC2 | Smart Business | Economy – Smart | Confirmed | Confirmed | Confirmed | Valid |
| RC3 | Smart Engagement | Society – Community | Confirmed | Confirmed | Confirmed | Valid |
| RC4 | Smart Engagement | Society – Community | Confirmed | Confirmed | Confirmed | Valid |
| RC5 | Smart Responsibility | Society – Social | Confirmed | Confirmed | Confirmed | Valid |
| RC6 | Smart Responsibility | Society – Social | Confirmed | Confirmed | Confirmed | Valid |
| RC7 | Smart Responsibility | Society – Social | Confirmed | Confirmed | Confirmed | Valid |
| RC8 | Smart Responsibility | Society – Social | Confirmed | Confirmed | Confirmed | Valid |
| RC9 | Smart Responsibility | Society – Social | Confirmed | Confirmed | Confirmed | Valid |
| RC10 | Smart Cybersecurity | Governance - | Confirmed | Confirmed | Confirmed | Valid |
| RC11 | Smart Cybersecurity | Governance - | Confirmed | Confirmed | Confirmed | Valid |
| RC12 | Smart Governance | Governance – Data | Confirmed | Confirmed | Confirmed | Valid |
| RC13 | Smart Governance | Governance – Data | Confirmed | Confirmed | Confirmed | Valid |
| RC14 | Smart Governance | Governance – Data | Confirmed | Confirmed | Confirmed | Valid |

4.4. Discussion

Based on the rich picture in Figure 4, 11 problem categories related to IS use on campus were identified. Analysis using 11 CEDs yielded 24 why-why diagrams that explored 27 root causes across three categories: Human Resources, Management, and Policy. The root cause exploration in the why-why diagrams was conducted based on semi-structured interviews with stakeholders.

The application of SSM with RCA in this study proved effective in analyzing problem situations and gaining a broader perspective than offered by a holistic overview and various stakeholder opinions in the field. Thirteen root causes of the problems were identified related to the smart campus dimensions: two in the business services sub-dimension, two in community engagement, five in social responsibility, two in cybersecurity, and two in the data governance sub-dimension. The remaining 14 root causes in the management and policy category were not included or were not relevant to any smart campus dimension. This was due to inconsistencies between the root causes and the smart campus sub-dimensions, which emphasize the use of technology.

The smart economy dimension relates to campus entrepreneurship and the provision of technology-based services. However, several narratives in [3] suggest that this dimension can include economic issues such as finance, services, and management. Therefore, we include the root causes of problems related to technology-based financial services in the business services sub-dimension. Meanwhile, in

the smart society dimension, the most common root causes are related to social issues and the quality of life of academics associated with the use of technology. [3] These issues fall within the domain of management and human resources.

The smart environment dimension focuses on environmental management and resource sustainability, including: 1) integrating technology to assist environmental management efforts, such as using sensors to reduce noise pollution or paper waste; 2) connecting to green energy sources such as solar power to minimize carbon emissions and power consumption; 3) using the campus as a laboratory to meet the SDGs; and 4) developing a waste management system to eliminate waste and increase recycling. Based on interviews to further explore the root causes of problems, the smart environment dimension did not address the root causes of problems related to learning and teaching activities. The issues identified, uncovered, and investigated for their root causes were not related to environmental management or to the use of technology, such as smart environmental coverage. This indicates that the institution has not implemented environmental management related to resource sustainability in teaching and learning.

After conducting further investigation, specifically into the website-based information system and the status of the institution's website, issues emerged regarding frequent cyberattacks on various scientific journal websites that altered their appearance or displayed online gambling advertisements, as well as the frequent unavailability of study programs and faculty websites. After analyzing the root causes of the problems, they were identified as falling within the sub-dimensions of cybersecurity and data governance.

The root cause analysis in this study was not directly conducted using the smart campus dimension, as it was based on emerging issues within the university environment related to IS use and information flow. These issues are frequently raised by the academic community and form the basis for the utilisation of technology in institutions. Therefore, this research focuses on exploring the underlying issues and developing a more structured approach to identify the root causes for further action.

The identified root causes indicate that improvements are needed in these sub-dimensions to help institutions build a smart campus. However, the development aspect is not limited to these 13 root causes; it encompasses all dimensions, sub-dimensions, and indicators within the smart campus framework. A smart environment lacking root causes does not necessarily mean that improvements and development in that sector are unnecessary. Dimensions and sub-dimensions that lack relevance to root causes indicate that these aspects have not been developed, thus requiring further efforts to initiate them.

A smart campus can be viewed as a system for building a more advanced academic culture. Smart campuses can effectively process campus data, thereby predicting student learning outcomes and supporting decision-making [18]. Smart campus development in higher education is quite diverse, with some efforts carried out by [4], [19], [16], [20], [21], [22], [23], [24]. Research by [4] initiated smart campus development by developing a system design based on academic culture, which encompasses the scope of system development, including infrastructure, campus services, applications, and business and customer management within the campus environment. The research continued by developing a smart campus roadmap to implement the system design development. Similar research, which developed a further smart campus development plan, was conducted by [16], with a strategic plan for the development of 27 required information systems and a five-year development roadmap. Smart campus development, initiated by Strategic Information Systems Planning (SISP), was also conducted by [20] using the Ward and Peppard framework. The main results of the study were the identification of seven types of IS that needed to be developed, along with a portfolio of integration and facility-addition priorities for existing IS.

Another approach to smart campus development was taken by [21], utilising the TOGAF ADM to build an Enterprise Architecture (EA) that serves as a blueprint for IS development, encompassing business architecture, data architecture, application architecture, and technology architecture. The study's results included a list of activities to develop a smart campus, the various obstacles encountered, and a complete computer network structure at the university.

[22] took a different approach, conducting a literature review and qualitative analysis of the implementation of Artificial Intelligence (AI) technology for smart campus development. The results presented practical strategies for developing a smart campus ecosystem. A qualitative analysis of smart campus development readiness using questionnaires and interviews was also conducted by [23], which aimed to evaluate schools' readiness to build a smart campus. The research results show that the school

<http://sistemasi.ftik.unisi.ac.id>

management is committed to development, as demonstrated by the construction of several supporting infrastructures that have provided a modern and effective educational experience. Furthermore, the research results also indicate that the school has provided guidance to improve digital literacy for teachers and students. However, the implementation of data governance has not fully met the requirements for broad smart campus development.

Meanwhile, the initiation of smart campus development through the development of an information system was carried out by [19] and [24]. [19] Developing a smart campus involves rebuilding the existing academic information system due to numerous shortcomings, including the inability to handle a large number of users. The redevelopment was undertaken because the academic information system is the primary information system for supporting business processes in higher education. Meanwhile, [24] developed a web-based data integration platform as an initiative for smart campus development, utilising APIs for data integration and the K-means algorithm to analyse and process large-scale data.

This study presents a different approach to smart campus development initiatives, including structured problem analysis and identifying the root causes of issues related to IS and information flow. A qualitative approach using the SSM method for preliminary studies of smart campus development is still limited and represents a novelty in this research. This study has limitations in its methodology, namely, the use of only stages 1 through 2 of the SSM, integrated with RCA. This study has not yet reached the stage of formulate the root definition od relevant systems or purposeful activity (Stage 3), building a conceptual model (Stage 4), comparing the model with the real world (Stage 5), or formulating and taking action for change (Stages 6 and 7). Furthermore, the exploratory analysis in this study is limited to the fundamental aspects of technology use, specifically the flow of data and information (Information Systems), rather than the technical development of Information Technology (IT) infrastructure more broadly. The issues studied are more inclined towards IS governance as a preliminary step before implementing other cutting-edge smart campus technologies. Likewise, the determination of the problem's root cause is based on current issues developing within the institute's environment regarding IS use, so it does not cover all indicators or ideal parameters of a smart campus framework as a whole.

5 Conclusion

The analysis of information management and system use in smart campus activities using SSM revealed 12 main problems: 1) lack of awareness and willingness to use the Information System, 2) no alumni data management mechanism, 3) no IT and IS helpdesk, 4) no backup system, 5) no user authentication and authorization, 6) data disintegration, 7) no policy for sustainable application use, 8) unmet IS needs in work units, 9) no official access regulations for IS, 10) no master plan for information system development, and 11) no mechanism for preventing cyber attacks.

After brainstorming using a cause-and-effect diagram and identifying root causes using a why-why diagram, 27 root causes were identified: 8 human resource problems, 12 management problems, and 7 policy problems. The results of mapping the root causes of the problems into the smart campus dimension revealed 13 root causes relevant to the smart economy, smart society, and smart governance dimensions. Meanwhile, the other 14 root causes of the problem are not relevant to the smart campus dimension because they are not related to the application of technology.

The current research has only reached the problem identification and root cause stage (stages 1-2 of SSM). Further research can proceed to stages 3 to 7, namely building a conceptual model, comparing the model with the real world, formulating feasible systemic changes, and taking concrete actions to improve the situation. In addition, given that one of the root problems is the lack of an IS master plan and an HR development roadmap, further research can develop a five-year strategic roadmap for implementing a comprehensive smart campus, similar to what other researchers have done, such as [15].

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