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Knowledge Management Model for Smart Campus in Indonesia

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Abstract: The application of smart campuses (SC), especially at higher education institutions (HEI) in Indonesia, is very diverse, and does not yet have standards. As a result, SC practice is spread across various areas in an unstructured and uneven manner. KM is one of the critical components of SC. However, the use of KM to support SC is less clearly discussed. Most implementations and assumptions still consider the latest IT application as the SC component. As such, this study aims to identify the components of the KM model for SC. This study used a systematic literature review (SLR) technique with PRISMA procedures, an analytical hierarchy process, and expert interviews. SLR is used to identify the components of the conceptual model, and AHP is used for model priority component analysis. Interviews were used for validation and model development. The results show that KM, IoT, and big data have the highest trends. Governance, people, and smart education have the highest trends. IT is the highest priority component. The KM model for SC has five main layers grouped in phases of the system cycle. This cycle describes the organization's intellectual ability to adapt in achieving SC indicators. The knowledge cycle at HEIs focuses on education, research, and community service.

Keywords: knowledge management; model; smart campus; higher education institution (HEI); systematic literature review (SLR); preferred reporting items for systematic reviews and meta-analyses (PRISMA); analytic hierarchy process (AHP)

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1. Introduction

In Indonesia, smart universities or campuses (SC) do not have a conical meaning for mutual understanding. Various studies related to SCs provide definitions based on different approaches. If grouped, there are three approaches used in defining SC, namely: driven by technology, adoption of the smart city concept, and based on the development of an organization or business process [1]. This definition proves that organizational factors and business processes strongly influence SCs. One solution to manage these factors is KM. According to [2–5], KM is one of the critical components of SCs. SC technology components, especially in Indonesia, are diverse, and do not yet have a standard. This condition makes it difficult to determine the effect of components on the creation and success of SCs. As a result, SC practice is spread across various areas in an unstructured and uneven manner. Those areas are governance, people, mobility, environment, living, and economy [6]. The SC practice has not significantly affected the task of higher education institutions' (HEI) Tri Dharma, namely education, research, and community service. This challenge requires proof by mapping SC components and SC application areas based on previous research.

Based on research [5], one of the SC requirements is KMS. This feature requires a KMS to manage knowledge interactions. However, previous research is still small regarding the use of KMS to support SCs. This gap can be studied because it has a great chance of producing novelty.

According to [1,7], SC applications are strongly dominated by management systems, such as intelligent learning, library, and others. KMS is an essential component in the development of a management system. However, KMS has not been explicitly discussed in previous studies, whereas in practice, all these systems should require KM.

KM is a system that can help organizations process knowledge to support decision-making so that organizations can become smarter [8]. This advantage indicates that KM is an essential component of SCs. However, most researchers are not fully aware that KM is a significant component in SCs. The majority of implementations and community assumptions still consider SC components to be applications of the latest technology. This assumption impacts the existence and contribution of KM in developing KM. There is still very little research that discusses the implementation of KMS to support SCs. This condition raises the question of how KMS can support intelligent services. Based on this, an in-depth analysis and literature study are needed to determine the mapping of KMS that supports SCs.

According to [5], a smart campus has three conditions: complex interactions, full integration, and incentives for innovation and collaboration. Complex interactions and collaborations are features that require good resource management. Meanwhile, resource management can be optimal if KMS supports it.

The application of SC components and technology in Indonesia is still small and various [9]. This condition raises questions and problems as follows. First, does this condition raise questions about each SC component and technology's application trend based on previous research? Furthermore, the implementation of SCs is uneven and inconsistent in each HEI, which represents another challenge. These challenges drive solutions (SLR and KM models) for SC development at HEIs.

According to [4], the level of an SC can be measured based on the indicator "SmU smartness levels." All of these indicators have something in common, namely the application of technology components at HEIs. A knowledge management system (KMS) is one of the components of KM technology that affects SC indicators. However, the contribution of KMS for SCs has not been widely discussed, and has not been measured in previous studies.

The SC indicators provide challenges and research opportunities for KM models in analyzing and providing appropriate strategic recommendations. The KM model in this study aims to support the SC creation strategy. KMS strongly influences the KM model. The primary purpose of KMS in this research is to realize that SCs improve performance, research quality, and convenience by providing advanced information technology services that are dynamic and user-oriented. KMS, according to [10], consists of knowledge discovery systems, knowledge capture systems, knowledge sharing systems, and knowledge application systems. Meanwhile, according to research [11], KMS consists of acquisition, sharing, development, preservation, and application.

The urgency of the need for a KM model at HEIs is increasing when various problems arise in the pandemic that demand the creation of SCs. Meanwhile, previous research that comprehensively discusses the KM model for SCs is still very small. Therefore, this study contributes to filling these gaps. The KM model at HEIs, which will be developed through this study, is expected to provide a detailed framework to support the creation of SCs, especially in the pandemic era. The framework must significantly influence the SC indicators so that the SC can be said to be successful [4,12]. Based on these phenomena and challenges, further research is needed regarding the KM model. This study aims to develop a comprehensive KM model for SCs, especially in the pandemic era where previous research has not been done (still small). This objective also demonstrates that this study has a significant contribution and novelty to aspects of KM and SCs.

This paper is structured as follows. The first section provides background on the urgency of KM for SCs. Next, the narrative literature review (NLR) section discusses the components of the KM and SC models as the theoretical framework for this research. At the end of the NLR, we formulated four research questions (RQ) to fill the gap between background and NLR. The second section presents the methodology complemented by the research framework. The research framework consists of five main parts, namely: NLR, SLR, initial model development, quantitative approach with AHP, and validation by experts. Then, in the next section, we present the research results to answer the RQ. In the final section, we present a synthesis of the implications of the results for management theory and practice at HEIs. The conclusion section also discusses future research plans as a follow-up to the current study's limitations.

2. Smart Campus (SC)

SCs are the destination of most HEIs in Indonesia. In their development, HEIs in Indonesia have implemented many KM and ICT. HEIs that have implemented ICT use different terms, such as campus information systems, academic information systems (SIA), e-learning, digital campuses, and even smart universities or smart campuses. The difference between these terms is that there is no agreed standard or indicator. The further analysis and requirements of each HEI cause the absence of such standardization. Based on this, a standard is needed to build a model of using KM-based ICT to create an SC.

Relevant research related to this discussion is the research conducted by [4,5,12] that argued KM is the main component for creating an SC. According to Owoc and Marciniak (2013), an SC has four conditions: complex interaction, full integration, incentives for innovation, and collaboration operations. These requirements are strategies that must be carried out to create an SC. This strategy is expected to achieve the SC indicators and HEI's vision and mission/objectives.

An HEI's vision and mission can achieve the SC indicator. The vision and mission of HEIs in Indonesia are based on the concept of *Tridharma* [9]. According to Uskov et al. (2016), the SC indicator is an HEI which has an automatic capability in: (1) adaptation, (2) sensing (awareness), (3) inferring (logical reasoning), (4) self-learning, (5) anticipation, and (6) self-organization. The six indicators are the level of intelligence that an HEI must have to create an SC. However, according to Zakir, Defit, and Vitriani (2019), the SC indicator is based on the ICT PURA concept, which consists of: ICT Use, ICT readiness, ICT capability, and ICT impact. The indicator models (smartness level and ICT PURA) have different functions based on these two studies. Smartness level serves as an indicator of the maturity of SC implementation, whereas ICT PURA functions as an indicator of SC readiness. These indicators are concepts that are closely related to the implementation of various software. Implementation of software such as KMS has an essential role in fulfilling the SC indicators because it can manage knowledge automatically to perform the following capabilities: (1) modification of business functions; (2) identify, recognize, understand, and be aware of various events, processes, objects, and phenomena; (3) make logical conclusions based on raw data, processed information, observations, evidence, assumptions, rules, and logical reasoning; (4) acquire, modify, or formulate new knowledge, experience, or existing behavior to improve operations, business functions, performance, and effectiveness; (5) predict what will happen, how to handle the event, or what to do next; (6) change its internal structure (components), regenerate itself, and sustain itself in a directed (non-random) manner under suitable conditions, but without external agents/entities [4].

The automatic capability of an HEI can be carried out optimally in various implementation areas to achieve an SC. SC implementation areas vary widely depending on the needs and environmental conditions of the HEI. SCs consist of smart governance, smart people, smart mobility, smart environment, smart living, smart education, and smart economy [6,13]. HEIs in Indonesia have different SC implementation conditions from the previous research model. This condition requires the development of a model that considers the needs of HEIs in Indonesia.

Based on all research related to SCs, it is concluded that to create an SC in an HEI, a development model based on the scope is needed as follows: components and technology [4,5,12]; implementation areas [6,13]; SC indicators [4,14]; SC strategy [5,6,15]; and software [4]. However, a comprehensive study is needed to detail all the SC coverage and areas. Therefore, we formulate research questions as a result of developing these research gaps:

RQ1: What are the components and technologies of SCs?

RQ2: What are the trend areas on the SC research topic?

3. KM Model in HEI

The KM model at HEIs involves many pre-arranged KM enablers, such as organizational structure, technology, collaboration, and trust, so that knowledge management will be successful in higher education institutions. A KM enabler is a determining factor for the success of KM implementation in higher education institutions (HEIs) [16]. Previous research stated that KM processes and infrastructure (human resources and culture) influence university performance. These results support the hypothesis that IT moderates the relationship between KM practice and university performance [16]. IT has a positive impact on HEI performance. In particular, IT can support education and scientific research [17]. From these results, it can be concluded that the technology, in general, is the CSF model of KM in HEIs.

The KM model develops a virtual community of practice (VCoP) at HEIs. An effective VCoP can encourage members to participate to share and contribute knowledge, and can be based on many variables, such as: (1) leadership role in online communities; (2) content development, and quality of knowledge transfer; (3) shared goals of joining the community; (4) value of participation; (5) organizational culture of knowledge sharing and collaboration; (6) developed information technology infrastructure; and (7) integration of VCoP in organizational structure [18,19]. Other studies related to KM at HEIs show that organizational structure, the interaction between human resources, and organizational culture are the main contextual factors in the KM model [20]. From these three studies, it can be concluded that the KM model at HEIs is strongly influenced by KM infrastructure (information technology infrastructure, organizational structure, and culture), KM processes, especially knowledge sharing, and KM mechanisms in the form of VCoP.

This conclusion is also in line with the research results of Muqadas, Rehman, Aslam, et al. (2017), showing that KM infrastructure (leadership support, organizational culture, and incentives) is mandatory for the successful implementation of the KM process. HEIs' policymakers and academics must develop effective KM strategies to support KM processes and infrastructure. Examples of efforts are providing leadership that supports effective human resource management (HRM), creating a collaborative culture, and establishing an incentive or reward system. The KM strategy is essential in achieving organizational goals by encouraging, shaping, and maintaining the KM process among the civitas [21,22]. This KM strategy will be the key in implementing KM in various fields/implementation dimensions. KM strategies can be used as a tool to support a more competitive and ever-changing environments through an integrated service approach, drive for innovation, collaborative operations, intelligent learning communities, ICT sustainability, "green" concepts, governance, and visible campus reporting. Based on these challenges, the KM model at HEIs must have components of a KM strategy and dimensions/implementation areas. The KM strategy includes all approaches to support KM processes and infrastructure in adapting to a competitive and dynamic environment. At the same time, the dimensions/implementation areas contain all the scope of KM implementation in HEIs, such as education, environment, governance, and others.

The primary keys in model development are simplifying assumptions, identifying core and boundary conditions, and easing model implementation. Therefore, the KM model is used to describe the unity of several KM components to understand more deeply the concept of causality between these components. The KM model at HEIs is identical to the KM process and initiative to achieve an HEI's strategic goals. SC is one of HEIs' strategic goals to achieve an HEI's vision and mission (education, research, and community service). As such, the KM model at an HEI ideally is a holistic approach to KM implementation to create an SC that can improve the performance of education, research, and community service.

KM is the critical component and technology of an SC. KM is the most important and most common activity to create a knowledgeable civitas and campuses. For SC creation, the core of KM implementation is KM processes and systems, including planning, capturing, discovering, creating, and utilizing knowledge [23]. In addition, other studies have shown that the acquisition, sharing, and utilization of knowledge can increase intellectual capital, and encourage research innovation capabilities that lead to an increase in HEI performance [24]. Therefore, the ideal KM model for the creation of an SC is a model with a KM process and system component that is in line with the innovation needs of the institution. This conclusion is also drawn by the results of Papa et al. (2018), which shows that the knowledge acquisition process positively affects institutional innovation performance.

Innovation at an HEI is strongly influenced by the components of leadership, knowledge sharing, the ability to know academic expertise, acquiring knowledge of work culture, and the use of technology [25]. All of these components can be created by building KM capacity in the main areas of an HEI, because the capacity of KM (KM tools and techniques) will help create awareness of the importance of KM among the HEI civitas. Therefore, in developing a KM model to support the creation of SCs, it is necessary to have adequate technology, mechanism, and KMS components.

KMS, outcomes, and KM results have a very positive effect on HEI performance. This statement is supported by the research results of Naser, Al Shobaki, and Amuna (2016), who stated that the most critical factors that affect the high performance of institutions are KM processes, KM systems, leadership, people, outcomes, and KM results. In addition, the ideal KMS proposed to support institutional performance is to collaborate with the framework of social media functionality, e-learning elements, and KM components. Based on this research, it can be stated that the KM model for HEI performance must have components of people, KMS, outcomes, and KM results.

KMS with social media features plays an essential role in the success of KM at HEIs. Based on these necessities, KM and social media integration are absolute. As such, we need the main components to integrate KM and social media: technology, pedagogy, culture, evaluation, and leadership [26]. The KM technology component is a mandatory component in the implementation of KMS at HEIs. The KM technology can be educational data mining, enterprise architecture, and business intelligence to support knowledge discovery systems (KDS) [22]. In addition, examples of KM technology can be in the form of a knowledge web portal (learning, research, and vocational) to support a knowledge sharing system (KSS) [27]. Based on the analysis of the research results, the component of KM technology, especially in KDS and KSS, is a crucial component for developing a KM model in HEI.

KM has the task of managing knowledge comprehensively. The KM tasks are as follows: to mobilize hidden implicit/tacit knowledge, integrate knowledge from the organization and make it accessible to all, identify missing knowledge, create new knowledge, make knowledge more accessible and usable, create a knowledge-sharing culture for experimentation and learning, evaluate and reflect on the learning process, and the codification of new knowledge [28]. There is an additional need to capture and utilize knowledge based on these tasks. As such, by using a knowledge capture system (KCS) and a knowledge application system (KAS), these needs can be met. The analysis demands the development of a KM model in HEIs by including KCS and KAS as essential components.

The current development of the KM model research at HEIs combines the essential processes of KM with the essential processes of IS [29]. The IS process includes decentralized websites, dedicated portals, virtual libraries, electronic learning resources, and developed software and hardware. Successful implementation of the process can be achieved by meeting the following requirements: availability of software and hardware, adequate financial resources, robust IT infrastructure, dissemination of digital culture, and the existence of a dedicated center for KM and IS management. The scope of application is not only limited to students, but also includes teaching staff, academic leaders, student affairs staff, and external stakeholders. The application of this model has a positive impact on student performance, and the quality of faculty education outcomes. From the results of this study, it can be concluded that the KM model in HEI is strongly influenced by the components of the KM process, CSF and strategy, and outcome [29]. The KM process includes knowledge creation, storage, sharing, application, and evaluation. At the same time, the CSF component consists of people and organizations. The proposed strategy is an integrated portal and intelligent learning community. The last component of the results proposed by the research is the quality of education, research, and community service services. The second sub-component is the capability of the academic community to practice the knowledge process.

Based on the literature study, the KM model at HEIs that will be proposed must have a CSF layer, KM mechanisms, KM processes and systems, dimensions or implementation areas, strategies, results, outcomes, and goals. Each layer must have components and sub-components. For example, the CSF layer has a technology component. Therefore, to fully identify the layer components and models supporting SCs, a systematic literature review (SLR) and a mixed-method approach (qualitative and quantitative) are needed. The problems and the literature study deliver the research gaps, which were developed into research questions as follows:

RQ3: What are the key (critical) components of KM in HEIs?

RQ4: How does the KM model support the creation of SCs?

4. Materials and Methods

This study aims to build a KM model in HEIs. Therefore, this research can be categorized as developmental research. This research methodology has six main stages of developing a KM model based on these objectives. Figure 1 describes the steps of our framework in conducting comprehensive research. First, we identified strategic issues and previous studies. The second stage is developing a theoretical model based on a systematic literature review (SLR) and related research. Then, the third stage evaluates the theoretical model to verify the model. We conducted an evaluation based on several previous research models, namely: KM Solution & Foundation [30]; APO Framework KMP [31]; Smartness levels for smart university [4]; KM as foundation of smart university [5]; The characteristics and KPIs of the SC [13]; Smart campus areas [6]; Smart Learning Communities [15]; intelligent campus themes [6]; main distinctive sub-components of Smart university [4]; Indonesian Government KM Model [32]. The fourth stage is the initial modeling based on evaluation results of the theoretical model. Furthermore, in the fifth stage, researchers determine the priority of the theoretical model components quantitatively (a survey of 36 related experts) using the analytical hierarchy process (AHP). In the last stage, the researchers validated and developed the KM model to support the creation of an SC through interview techniques with KM and SC experts.

The purpose demands that this research uses a more comprehensive method than the previous research and literature. Therefore, this research method has great potential to provide significant newness and contribution to aspects of KM and SC. We claim it is comprehensive because it includes detailed steps with a mixed-method approach in developing the model compared to the previous research and literature. The method and scope of previous studies of the same kind have limitations. One of the limitations is that it only uses the SLR method or a quantitative approach [4,5,13], whereas this study uses a combination method for more precise results. Previous studies only studied the general condition of HEIs (not yet adaptive for the pandemic era) [16,20–22,24,25,29], whereas this study adopted the components needed for the pandemic era. This research method has a broader focus on identifying all components of the KM model that supports SCs, whereas previous studies only focused on technology components or specific other components [2–7,13–18,22–29,33–66]. The components of the model in this study are technological aspects and management aspects. Previous studies have only focused on individual KM topics in HEIs or SCs (few or no models combine these two topics) [4–6,12,13]. This study is very detailed in describing the research framework (from the beginning of the

SLR to model validation). At the same time, the previous literature does not clearly explain the research flow, or even minimal validation of each proposed method [5,16].

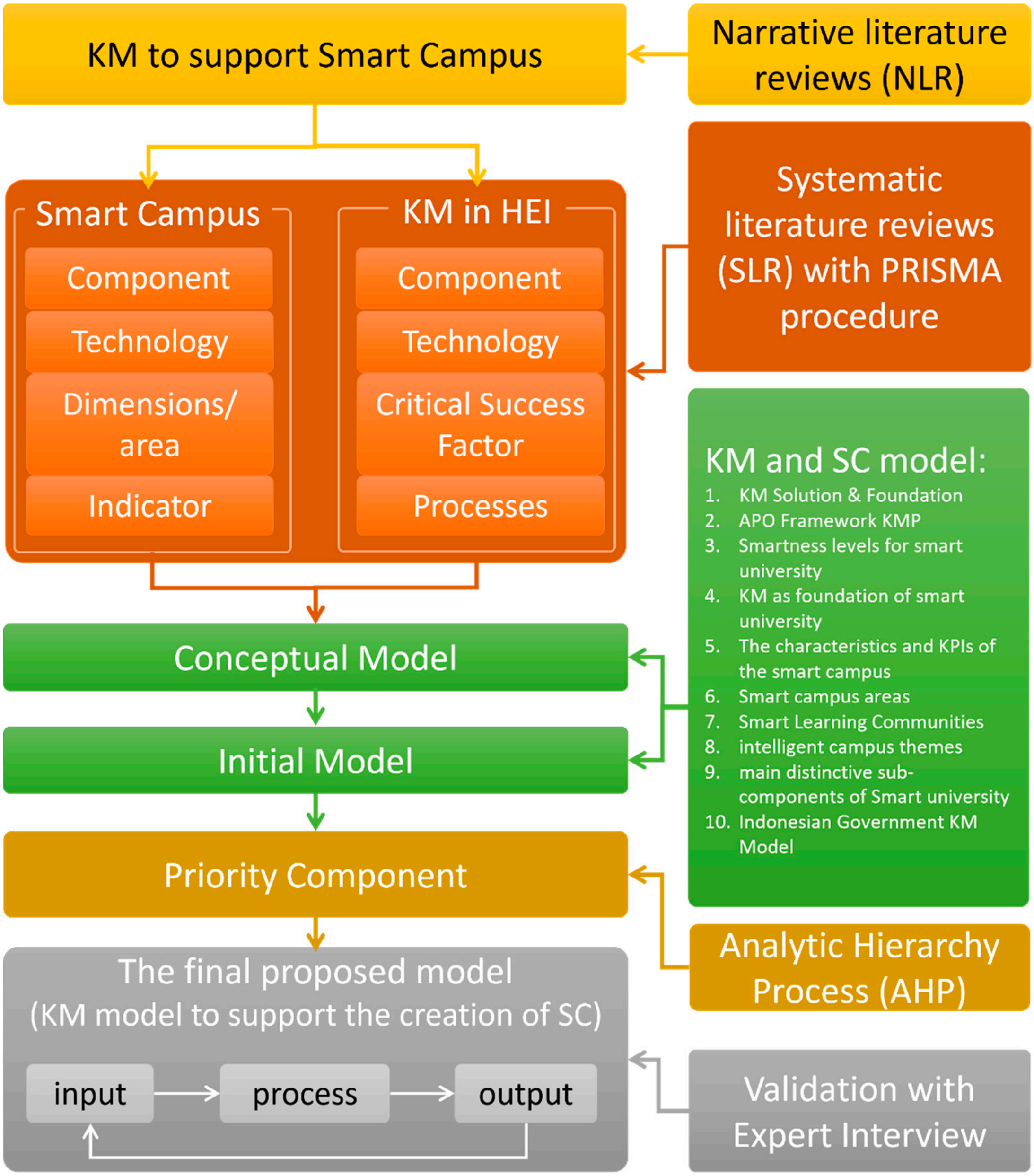

Figure 1. Research framework.

The necessity for SLRs in the SC and KM fields at HEIs is very high, based on the problems described in the introduction section. In addition, this SLR has not been done before, primarily related to KM and SC. The high number of previous studies related to SC and KM at HEIs has become an exciting challenge in developing KM models. Therefore, the need to perform SLR in this domain is essential, as all previous research supports it.

The SLR of this study used the PRISMA procedure from Liberati et al. (2009). The SLR will review the studies related to the domain, and then find deficiencies and their objectives, and then identify questions and answer them with evidence. The SLR process can be divided into several steps: a planning stage and a review stage. The planning stage consists of identifying SLR needs, and constructing research questions. Meanwhile, the review stage with PRISMA is as follows: (1) identification of eligibility criteria; (2) identification of sources of information; (3) study selection; (4) data collection; and (5) selection of data items [67]. Furthermore, Figure A1 shows a more detailed PRISMA procedure for selecting and assessing papers.

At the initial stage, we identified the criteria and sources of information. The criteria are based on Table A1. The information sources use nine electronic databases: Scopus, Science Direct, ACM Digital Library, IEEE Xplore, ProQuest, EBSCOhost, Springer, Emerald Insight, and IGI Global. We perform searches on these sources using advanced search features and queries. We also searched the reference list of articles that met the inclusion criteria to find other related studies relevant to this study.

We analyzed the differences in terms used for KM in HEIs and SCs. These different terms are structured in the form of a synthetic query that is formulated to provide the best search results. Search queries are structured based on the criteria in the previous section. The researcher searched using a Boolean search query: model OR framework OR components OR factor AND technology AND smart campus OR smart universities OR knowledge management OR academia OR academic institution OR higher education institution. The search query is based on the title, abstract, keyword of the article, and the 2007–2020 time period.

Based on Figure A1, the first step in selecting articles is to use exclusion criteria to filter out duplicate articles. The criteria are the results of the development of research questions. Then, we apply the criteria based on the article's language, domain, relevance, novelty, year, and accessibility. We first apply the article title, keyword, and abstract criteria, and then the full text of the article. The existence of components, technologies, and models related to SC and KM in HEIs in the article is also considered implicitly or explicitly.

Research questions and eligibility criteria are then developed into aspects that must be analyzed. These aspects are model, dimension, comparison, and context. The model in question is the KM model in general, and the KM model for HEIs. The dimensions that must be analyzed are the dimensions that affect KM and SCs. Comparative aspects can be used as comparisons, such as KM for research institutions and smart cities. The context that must be analyzed is the academic world, HEI, scholars, education, research, and community service. We classify this paper based on research questions to develop a KM model based on these aspects. The classification consists of SCs (components, technology, and trend areas) and KM in HEIs (dimensions, components, and models).

From this collection, research was conducted to filter it into two levels. The first level was screening articles. At this level, we explored and selected titles, abstracts, and keywords in articles obtained from search results based on eligibility criteria. The next level was to filter full text or partial articles according to the eligibility criteria. The reference list of each selected article was reviewed to find other relevant studies (through screening and full-text or partial stages).

Potentially relevant articles were collected and assessed by researchers. The researcher conducted an assessment based on a checklist using a five-point scale: "not at all" (0), "very little" (0.25), "a little" (0.5), "yes, but not enough" (0.75), and "enough" (1). The final score uses a value scale of 0–8 (Table A2). We chose to include articles with a score of more than 5 for further analysis.

The last SLR stage is the selection of data items as materials to answer research questions. The data items are presented in the figure. Then, the researcher extracts information from the selected articles into the table.

The SLR was conducted to find out the conceptual theory related to the components of the KM model in HEIs and SCs by using several analytical methods from several documents and scientific publications. Then, we evaluated the theoretical model by identifying the model (components, objectives, objects, strengths, weaknesses, and layers). Then the researchers used a hybrid and synthesis method based on the evaluation of the theoretical model. The synthesis stage aims to develop a KM model to support the creation of an SC.

The results of the previous synthesis stage in the form of KM components for SC can be used as research variables. Then, we arranged these components into variables in a questionnaire containing 99 questions. The questions use a five-point scale: strongly disagree, disagree, neither agree nor disagree, agree, and strongly agree. Researchers surveyed experts in fields related to KM and SCs. Experts consisted of 36 experts from various related institutions.

Furthermore, the researchers analyzed the data using descriptive methods with a quantitative research approach. This descriptive method aims to describe phenomena systematically, accurately related to facts, and the nature of the relationship between the phenomena being investigated. Data analysis used the AHP method to determine the most critical KM components in the formation of SCs.

In general, the stages of the AHP method in this study are as follows:

1. Determine the weight of each component and sub-component based on direct interviews with 36 experts.
2. Computation of the weight of each criterion by using pairwise comparisons.
3. Compute the consistency ratio value of each expert in answering questions.
4. Aggregating the results of the 36 experts to obtain a general pairwise comparisons matrix.
5. Determine the order of the criteria for computing the pairwise comparison based on the most significant value.

The results of the AHP analysis were then developed into a KM model design to support SCs in the form of diagrams. In the last stage, the researcher validated the model design through interviews with KM and SC experts. The validation process of the model design produces the final model. Interviews were conducted using open-ended questions to two KM and SC experts.

5. Results and Discussions

In this section, the researcher explains the data analysis, results, and discussion of the research. The discussion discusses the relationship and implications of the analysis results with previous theories and implementations of KM to support SCs. All explanations are arranged based on research questions. The explanation of the RQ 1 and RQ 2 sections uses SLR analysis techniques. The explanation of the RQ 3 section uses SLR and AHP analysis techniques.

In comparison, the explanation of the RQ 4 section uses hybrid analysis techniques and data synthesis from the previous results. Following, we analyze the interview data with open coding. The SLR technique analyzes literature data, and generates KM candidate components to support SCs. This SLR technique continues the data extraction results described in the previous section. SLR results are presented in this section in the form of a comprehensive and evidence-based explanation. The results of this section are structured to answer the research questions (RQ1, RQ2, and RQ3) with evidence. These results are also displayed and discussed in tables and figures for easy understanding.

Results of SLR with the PRISMA procedure (identification of eligibility criteria, identification of sources of information, study selection, and data collection) screened 68 papers. The last stage is selecting data items presented in three figures. Figure 2 shows SC components and technologies to answer RQ1. Figure 3 identifies the dimensions/areas of SC implementation to address RQ2. Lastly, Figure 4 shows the critical components of the KM model in HEIs to support answer RQ3.

AHP analyzes priority survey data for KM components to support SCs. Hybrid and synthesis techniques analyze the previous results data into an initial KM model. Furthermore, the open coding technique analyzes the data from expert interviews. This last technique aims to validate the initial model, and develop it into a final KM model.

5.1. Trend Areas on Smart Campus Research Topics (RQ2)

According to [6,13], the implementation areas of SC are smart governance, smart people, smart mobility, smart environment, smart living, smart education, and smart economy. All of these components have different contributions of each implementation and previous research. Previous studies that were selected from the previous stage were [2–7,13–15,17,18,22–29,33–66,68]. Figure 2 shows all these studies mapped in different colors according to their year of publication. Figure 2 shows that smart governance (SG), smart people (SP), and smart education (SEd) have the highest trends compared to other areas. The results of this SLR indicate that SG, SP, and SEd have a significant contribution in developing the KM model. SG, SP, and SEd are closely related to KM and the Tri Dharma concept research. This relationship is because KM is closely related to governance, human resources, and learning. These results indicate that KM is an essential component of SC practice. Smart living (SL) and smart environment (SEn) have the lowest references. SG has the highest trend in the 2020 pandemic era. These results show that, in 2020, the topic of SG has become a significant contribution to HEI governance to adapt to the pandemic era. However, in contrast to SP and SEd, the trend increased in 2019, and decreased in 2020. SP and SEd were widely studied in 2019 because they covered a broader aspect of education than in 2020. The SEd aspect in 2019 was broader in covering physical aspects, such as intelligent learning in general, intelligent learning technology, and face-to-face learning in the classroom. Meanwhile, the number of studies in 2020 decreased due to more specifically examining e-learning, mobile learning, blended learning, and ubiquitous learning.

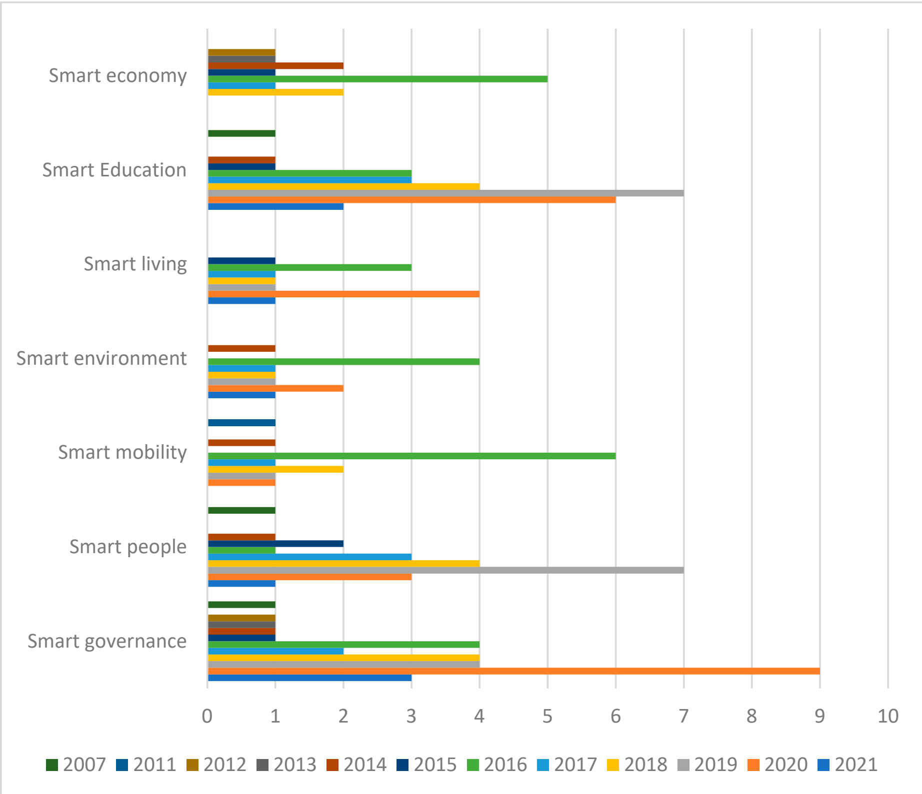

Figure 2. Smart campus implementation research trends.

However, this area is already included in the minimum SC implementation area because it has exceeded the minimum percentage (5%). The results of this SLR prove that the trend of the SC implementation area is more towards SG, SP, and SEd. However, SL, SEn, smart mobility (SM), and smart economy (SEc) may make significant contributions in their implementation in the field and further research. Therefore, a quantitative approach is needed in the next step (answer RQ3) to determine the priority level of each SC implementation area.

5.2. The Components and Technologies of Smart Campus (RQ1)

SC components and technologies are KM, big data, the internet of things, social network application, mobile and ubiquitous computing, cloud computing, and integration systems [4,5,12,23]. All of these components have different contributions to each implementation and previous research. Previous studies that were selected from the previous stage were [2–7,13–18,22–29,33–66]. Figure 3 shows all these studies mapped in different colors according to their year of publication. Most of these studies discuss KM as a component of SC implicitly. Therefore, we have to do SLR in all these studies with a contextual approach.

Figure 3 shows the components and technologies of SC extracted and assessed. Figure 3 shows that KM, IoT, and big data have the highest trend compared to other technology components. KM had the highest trend in 2019. This trend shows the time before the pandemic. Then, the trend decreased during the 2020 pandemic. The movement for big data was most increased in 2018, but it fell in 2020.

In contrast is IoT, which has the highest trend in 2020. This trend shows that IoT is being developed more than other technology components to support health protocols. Whereas KM is more increased than big data in 2020, this trend indicates that KM can profoundly impact human resource learning in a pandemic. The impact of KM is very significant, for example, in the following: individual adaptability in an emergency; providing accurate and real-time information to prevent the spread of viruses; making sure the right people have the accurate information at the right time [69].

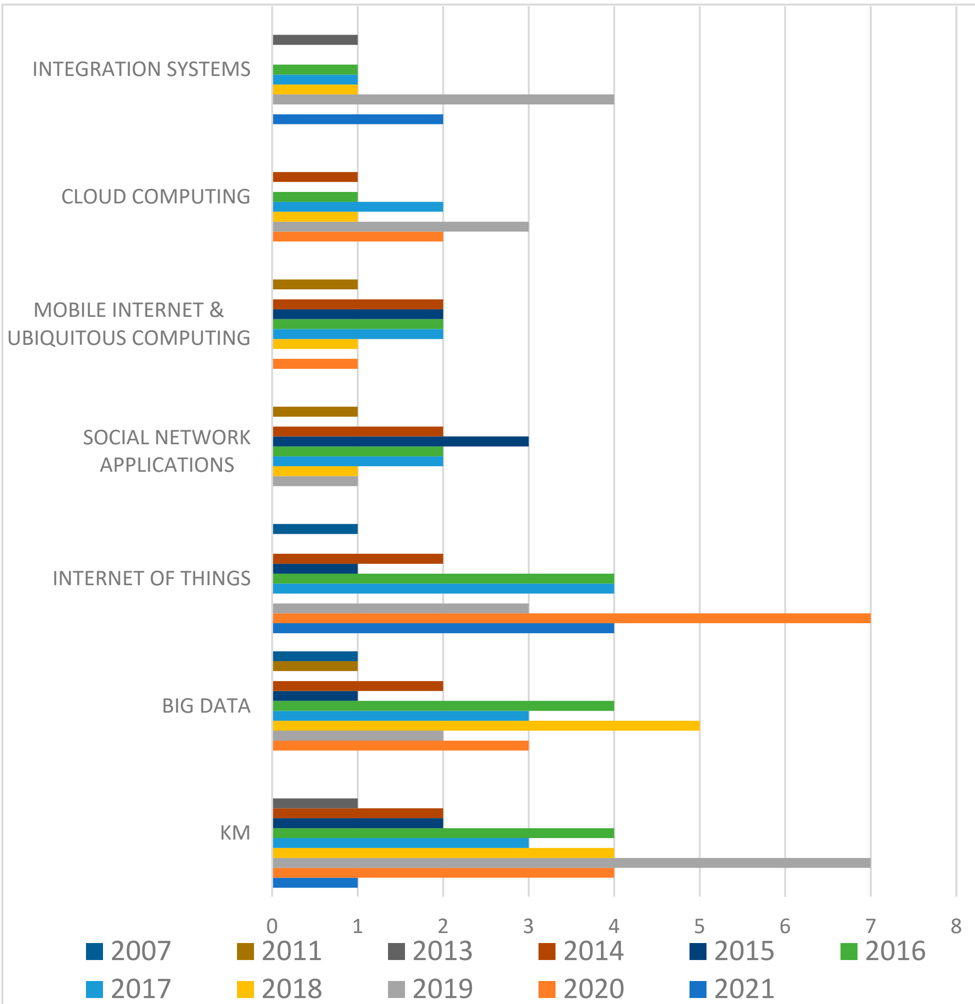

Figure 3. Components and technologies of smart campuses.

These results indicate that KM is an essential component of SC practice. Social network applications (SNA) is a component that is included in the category of medium implementation because it has a total of 12 references. In addition, this number proves that SNA requires the implementation of other components and technologies, such as KM, big data, and cloud computing. SNA based on KM, big data, and cloud computing can find out someone's expertise in HEIs.

Cloud computing and integration systems have the lowest number of references, 20% of the total. However, this low number does not mean that these two components are less critical, because an analysis with a quantitative approach is still needed. This SLR result is an exciting finding because it is in stark contrast to the current pandemic, because during and after this pandemic, services at HEIs need an integrated system and cloud computing. The integration system at HEIs in Indonesia are an essential service during this pandemic. Ideally, this integrated system service can provide education, research, community service, and support administrative services in an integrated manner. This condition is a challenge for HEIs, as they need to pay attention to the urgency of their needs and resources.

These results prove that all SC components and technologies have different levels of contribution depending on the needs of each institution. Therefore, a priority level for each of these components is needed to facilitate implementation by institutions in general. The priority level will be determined using a quantitative approach in the results section of RQ3.

5.3. The Key Components of KM in HEI

This section presents an analysis of the key components of the KM model in HEIs to support SCs. Based on the previous NLR process, the components of the KM model to support SCs are as follows: (1) outcomes; (2) strategy; (3) dimensions/areas; (4) knowledge discovery systems; (5) knowledge capture systems; (6) knowledge sharing systems; (7) knowledge application systems; (8) KM mechanism; (9) CSF KM (human); (10) CSF KM (organization); (11) CSF KM (technology); (12) results/goals. In order to prove the component's contributions in previous studies, the next step is that these components are arranged in Figure 4. Previous studies related to the critical components of KM in HEIs that resulted from SLR selection from the previous stage are [2,4–7,9,13–51,68,70–75]. The selection results are mapped into 12 categories, and displayed in different colors according to their year of publication.

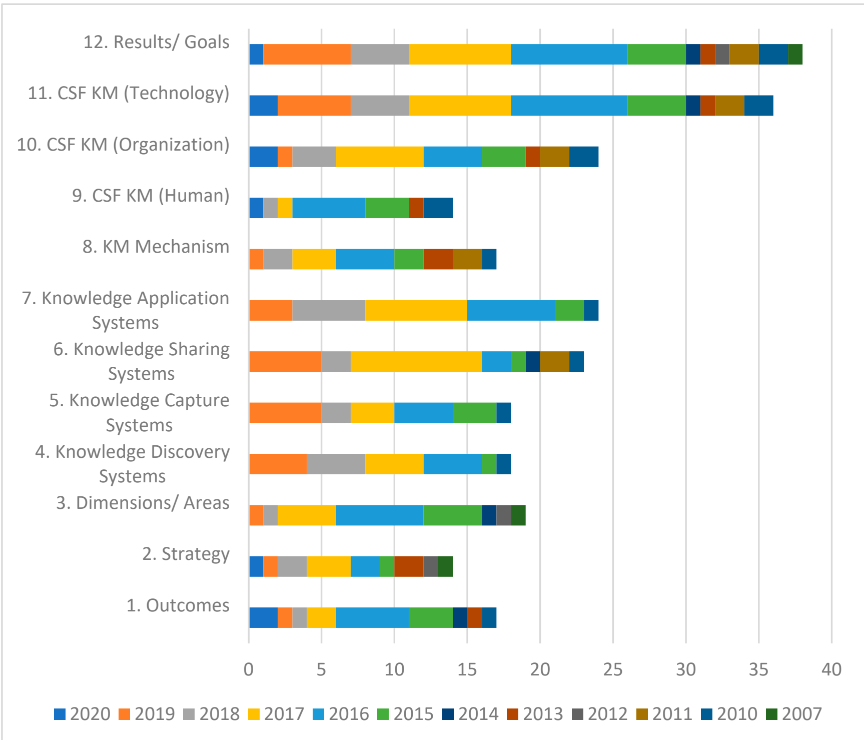

Figure 4. Key components of KM in HEI.

Figure 4 shows the component categories that are most studied are the results/goals of KM. This component was most widely distributed in 2016, and was consistently reviewed across all publishing years in the figure. This trend shows that results/goals are essential to supporting the organization's performance, vision, and mission. The second most abundant component is technology. The technology in question is KM technology. These results prove that technology is the primary factor of the CSF KM model. Figure 4 also shows that each component contributes at least 25% in supporting the SC. The component with the highest number is the result component, whereas the component with the lowest number is the strategy component.

5.3.1. Initial Model

The analysis results illustrate that the main problem in SC development is the availability of technology, organization, people, processes, and KM systems. Other additional problems are improving KM strategies, dimensions of SC implementation, and KM mechanisms. Based on some of the problems above, the development of the KMSC model aims to solve these problems.

These results indicate that the KM model is an essential component of SC practice. At the same time, the KM model has layers/components and sub-components to support SCs. Researchers need key components to develop a suitable model according to their needs in developing the KM model. In other words, determining this essential component is the initial design stage of the KM model. The key components of the model were determined using a hybrid method. This method describes the 12 components of previous research.

Furthermore, the researchers carried out a hybrid and synthesis process to compile a holistic KM conceptual model, as shown in Table A3. The synthesis selected several main models that would be used to develop a KM model to support SCs. Table A3 shows the selected main models that can support SCs, along with justifications. Each selected model is then designed as a layer with sub-components, as shown in Table A3.

The results of this synthesis prove that all components affect SCs. These results have provided an overview of the critical components and sub-components of the KM model for SCs. However, these results do not provide a detailed and valid priority level for each component and sub-component. Therefore, this result raises the challenge of how significant each component's priority level is to support SCs. This challenge is increasingly complex because each component has different sub-components, as shown in Table A4. As such, an additional question will arise, namely, what is the significance/priority level of each component and sub-component to support SC? Compiling the critical components of the KM model requires calculating the priority level of each component and sub-component of the KM model. Therefore, in the next section, researchers will analyze with a quantitative approach to determine the priority level of each component and sub-component of the KM model.

5.3.2. Data Analysis with AHP

At this stage, the researchers took a quantitative approach with the AHP technique to determine the priority of KM components and sub-components in the formation of SCs. This AHP analysis section is divided into two main parts: the analysis of the priority weights of layers/components, and the analysis of the priority weights of the sub-components. Based on the components/layers selected, the researcher performs calculations using a comparison matrix. At the same time, the weighting uses the pairwise comparison method or comparison scale in pairs.

Layer/Component Priority Weight Analysis to Support Smart Campus

Figure A2 shows a graph of the relationship between the priority weights of the components. The weight comes from the tendency of respondents (as many as 36 experts) to the value of their importance. Figure 1 shows that the IT CSF component is the most prioritized compared to other SC formation components. The level of consistency/consistency ratio

(CR) of each expert in answering is still below 0.1. The CR value shows that the results of the weighting of interests are still included in the category of consistent component values.

Figure A2 shows a graph of the relationship between the priority weights of the components. The weight comes from the tendency of respondents (as many as 36 experts) to the value of their importance. The CSF-IT component is the most prioritized compared to other SC formation components. The level of consistency/consistency ratio (CR) of each expert in answering is still below 0.1. The CR value shows that the results of the weighting of interests are still included in the category of consistent component values.

Table A5 shows the aggregate value of the importance of each component of the proposed SC from 36 related experts. An interesting result is that the IT component is the only component with the highest priority of 27%. In contrast, the other eleven SC components are spread out by 5–8% of the weight of importance. This value provides information that in the formation of the SC, the main component that must be repaired and prepared correctly is the IT component. In other words, this component is considered the most crucial to forming the SC. At the same time, the layer with the lowest priority level is strategy. KMS components/layers are spread over several priority levels. KMS with KAS type has the highest priority, and KCS has the lowest priority.

Sub-Component Priority Weight Analysis to support Smart Campus

At this stage, the researcher will calculate the priority of all sub-components in each component/model layer by using a comparison matrix.

1. Information Technology

IT consists of sub-components: infrastructure, big data, IOT, social network applications, cloud computing, integration systems, and cyber security. The weighting of all sub-components uses the pairwise comparison method, or a comparison scale in pairs. The results of the weighting to get the priority value are as follows:

Figure A3 shows the box-plot distribution of each sub-component of IT concerning its importance. These results indicate that the experts answered with good consistency because of $CR < 0.01$. The cyber security and integration system sub-components are considered more important than the other five sub-components. These results are because the cyber security and integration system sub-components have an importance weight of 19% and 16%, respectively, as shown in the table. In addition, the value of these two sub-components has a higher aggregate interest than the other five sub-components.

Meanwhile, the other five sub-components generally have the same relative importance weight (12–13%). Table A6 shows that big data has the lowest priority value. This value means the need for big data has not become a top priority to support SCs.

2. KM Mechanism

The KM mechanism consists of sub-components: collaborative creation, meetings, conferences, cooperative projects, organizational policies, on-the-job training, presentations, support centers, and best practices. The weighting of all sub-components uses the pairwise comparison method, or a comparison scale in pairs. The results of the weighting to get the priority value are as follows:

Figure A4 and Table A7 show that, basically, the nine sub-components of the KM mechanism have relatively the exact weight of importance. However, the top priority is collaboration creation. The table shows that priorities are divided into four levels. The first level: the collaboration and meeting creation. The second level: the conference and cooperative projects. The third level: the sub-components of organizational policies, on-the-job training, presentations, and support centers. The fourth level is the best practices.

3. Organization

The organization consists of sub-components: change management, opportunity, leadership, cost, organization structure, network, stakeholders, HR process, monitoring and evaluation, and common knowledge. The weighting of all sub-components uses the pairwise comparison method, or a comparison scale in pairs. The results of the weighting to get the priority value are as follows:

Figure A5 and Table A8 show that, basically, the ten sub-components of this organization's CSF have relatively the exact weight of importance. However, the top priority is the change management sub-component. The table shows that priorities are divided into four levels. Change management is the first level. The second level is the opportunity sub-component. The third level: leadership, cost, and organization structure. The fourth level: the network, stakeholder, and HR process sub-components. Lastly, the fifth level: monitoring, evaluation, and common knowledge.

4. Knowledge Application System (KAS)

The KAS consists of sub-components: enterprise resource planning, management information systems, case-based reasoning systems, awareness systems, monitoring systems, decision support systems, troubleshooting systems, and system support for the capture transfer of experts' knowledge. The weighting of all sub-components uses the pairwise comparison method, or a comparison scale in pairs. The results of the weighting to get the priority value are as follows:

Figure A6 shows the box-plot distribution of each sub-component of CSF-IT concerning its importance. These results indicate that the experts answered with sufficient consistency because of CR < 0.1. Table A9 shows that the four sub-components of KAS, namely enterprise resource planning, management information systems, case-based reasoning systems, and awareness systems, have a relatively more critical level of importance (17%, 16%, 15%, and 14%) compared to other sub-components. In comparison, the other four components have an average level of importance of 9–10%. These results provide an overview of recommendations for policymakers that the four sub-components of KAS (enterprise resource planning, management information system, case-based reasoning systems, and awareness systems) are essential to be developed first.

5. Knowledge Sharing System (KSS)

The KSS consists of sub-components: lessons learned systems, learning and teaching analytics, databases and repositories, electronic discussion groups, expertise locator systems, and team collaboration tools. The weighting of all sub-components uses the pairwise comparison method, or a comparison scale in pairs. The results of the weighting to get the priority value are as follows:

Figure A7 shows the box-plot distribution of each KSS sub-component concerning its importance. These results indicate that the experts answered with sufficient consistency because of the value of CR < 0.1. Table A10 shows that the four KSS sub-components, namely lessons learned systems, learning and teaching analytics, databases, and repositories, have a more critical importance level (22%, 21%, 19%, and 14%) compared to other sub-components. At the same time, the other three components have an average level of importance of 11–12%. These results provide an overview of recommendations for policymakers that the four sub-components of KSS (lessons learned systems, learning and teaching analytics, databases, and repositories) are essential to be developed first.

6. Dimensions/areas of smart campus implementation

Dimensions/areas consist of sub-components: smart economy, smart living, smart environment, smart education, smart governance, smart mobility, and smart people. The weighting of all sub-components uses the pairwise comparison method, or a comparison scale in pairs. The results of the weighting to get the priority value are as follows:

Figure A8 and Table A11 show that the four sub-components, namely smart economy, smart living, smart environment, and smart education, have higher importance than the other three sub-components. These results indicate that the most critical dimension implemented to support SC is the smart economy. Table A11 shows that priorities are divided into five levels. The first level is the smart economy sub-component. Subsequently, the second level is smart living, smart environment, and smart education. The third level is the sub-component of smart governance. Last, the fourth level is the smart mobility sub-component.

7. Human

Human resources have the following sub-components: personal knowledge, motivation, goodwill and integrity, commitment, and human capital. The weighting of all sub-components uses the pairwise comparison method, or a comparison scale in pairs. The results of the weighting to get the priority value are as follows:

Figure A9 shows the box-plot distribution of each sub-component of the HR CSF concerning its importance. These results indicate that the experts answered with sufficient consistency because of CR < 0.1.

Table A12 shows that the personal knowledge sub-component has the highest level of importance (21.50%) compared to other sub-components. Meanwhile, the sub-component with the lowest importance is human capital. These results provide an overview of recommendations for policymakers that the personal knowledge sub-component must first be developed.

8. Knowledge Discovery System (KDS)

The KDS consists of the following sub-components: recommender system, enrollment management system, web portal, videoconferencing, data mining, academics analytics system, risk management system, and repositories of information. The weighting of all sub-components uses the pairwise comparison method, or a comparison scale in pairs. The results of the weighting to get the priority value are as follows:

Figure A10 and Table A13 indicate that the recommendation system sub-component has a higher level of importance (17%) than the other sub-components. Meanwhile, the human capital sub-component has the lowest level of importance (14.14%). These results provide an overview of policymakers' recommendations that the recommendation system's sub-components are the most important to be developed first.

9. Outcome

The outcome has the following sub-components: growth productivity, development, social capacity, quality, capability, and performance. The weighting of all sub-components uses the pairwise comparison method, or a comparison scale in pairs. The results of the weighting to get the priority value are as follows:

Figure A11 and Table A14 show that the *growth* sub-component has a higher level of importance (19.06%) than the other sub-components. At the same time, the performance sub-component has the lowest level of importance (11.25%). These results provide an overview of recommendations for policymakers that the *growth* sub-component is the most important to be developed first.

10. Goal

The goal component consists of sub-components: inferring, adaptation, anticipation, self-organization, sensing goal, and self-learning. The weighting of all sub-components uses the pairwise comparison method, or a comparison scale in pairs. The results of the weighting to get the priority value are as follows:

Figure A12 shows a box-plot distribution graph of each goal sub-component concerning its importance. These results indicate that the experts answered with sufficient consistency because of CR < 0.1. Table A15 shows that the inferring sub-component has a higher level of importance (18.80%) than the other sub-components. Meanwhile, the self-learning sub-component has the lowest level of importance (15.48%). These results provide an overview of recommendations for policymakers that the inferring sub-component is the most important to first become a goal.

11. Strategy

The strategy component has the following sub-components: green and ICT sustainability, collaborative operation, comprehensive contact, encouragement, visible campus government and reporting, smart learning communities, and fully-integrated. The weighting of all sub-components uses the pairwise comparison method, or a comparison scale in pairs. The results of the weighting to get the priority value are as follows:

Figure A13 shows a box-plot distribution chart of each strategy sub-component concerning its importance. These results indicate that the experts answered with sufficient consistency because of CR < 0.1. Table A16 shows that the sub-components of the strategy, green and ICT sustainability, and collaborative operation, have relatively more critical importance (18.15% and 15.21%) than other sub-components. In contrast, the other components have an average level of importance of 13.33%. These results provide an overview of recommendations for policymakers that the green and ICT sustainability sub-component is essential to be developed first.

12. Knowledge Capture System (KCS)

The KCS component has the following sub-components: web-lecturing systems, activities recording systems, computer-based simulations, computer-based communication, and feedback systems. The weighting of all sub-components uses the pairwise comparison method, or a comparison scale in pairs. The results of the weighting to get the priority value are as follows:

Figure A14 and Table A17 show that the web-lecturing systems sub-component has the most importance (30.14%) compared to the other sub-components. This value is striking because the difference is very high with the second priority. The other sub-components have an average level of importance that is significantly different from the priority, 17.46%. These results provide an overview of recommendations for policymakers that this sub-component of web-lecturing systems must first be developed.

5.4. KM Model to Support the Creation of the Smart Campus

This stage plays a role in finalizing the model by synthesizing and analyzing interview data. This interview technique serves to validate the initial model. The synthesis stage aims to develop a KM model to support the creation of an SC, together known as KMSC. The results of the interview analysis are divided into two parts. The first is to validate the order of layers/components and sub-components. The second is the validation of the KMSC model diagram and flow.

Based on the results of the AHP analysis, the table shows that the weight of interest of components/layers of the KMSC model is slightly different from the theory of previous research. The results of the AHP analysis show the following order of priorities: IT CSF, KM mechanism, organizational CSF, KAS, KSS, implementation area, human resources CSF, KDS, outcome, output/goal, KCS, and strategy. Meanwhile, based on research [55], the KM model as a KM solution is arranged in the following order: KM infrastructure, KM mechanisms, KMS, and KM processes. In addition, according to Talisayon (2013) and Sensuse et al. (2016), the KM model has eight layers, with a sequence of visions, CSFs, KM mechanisms and technology, KM systems, KM cycles, outputs, and outcomes. The difference between the results of the AHP analysis and previous research requires a synthesis to develop an appropriate model according to the theory and empirical facts. Experts provide recommendations as synthesis by grouping several components/layers, as shown in the figure. The grouping is as follows: the first layer is CSF (IT CSF, organizational CSF, human resources CSF); the second layer is the KM mechanism; the third layer is the KM system and process (KAS, KSS, KDS, and KCS); the fourth is the implementation area; and the fifth is vision/goals (outcome, output, and strategy). This synthesis indicates that the priority level of the results of the AHP analysis is still applied while taking into account the theory of previous studies.

Furthermore, the second part to answer RQ4 is to validate the KMSC model diagram and flow. The results of the expert interview analysis provide recommendations that the model layer diagrams can be grouped based on the components/layers contained in theory. Furthermore, the model layer is grouped into several system phases. In addition, experts provide recommendations on paths that can support intelligent principles. The plot should have an intelligent or non-linear character. Based on these recommendations, the model can be described by a linkage line between the yield layer and the KMS component (red line in the figure). This line shows that this model can learn in choosing the right strategy to achieve SC indicators and outputs.

Figure 5 shows a KM model to support a complete SC consisting of five main components/layers. Each layer is grouped based on the phase of the system, namely input, process, and output/goal/vision. The first layer is grouped in the input category because this layer includes the resources used. The second, third, and fourth layers are grouped in the process category because this layer includes processing resources, namely: KM mechanisms, KM processes, KM systems, and dimensions/implementation areas. The last fifth layer is grouped in the category of outputs/goals because this layer includes the results achieved. The grouping of these three categories describes relationships and cycles that start with input, then process, go to goals, and return to input. This cycle illustrates the existence of automatic or intelligent learning to use the right inputs and processes when the outputs/goals do not match the target needs. This cycle has intelligent capabilities to improve the ability of this KM model to adapt to achieve SC indicators.

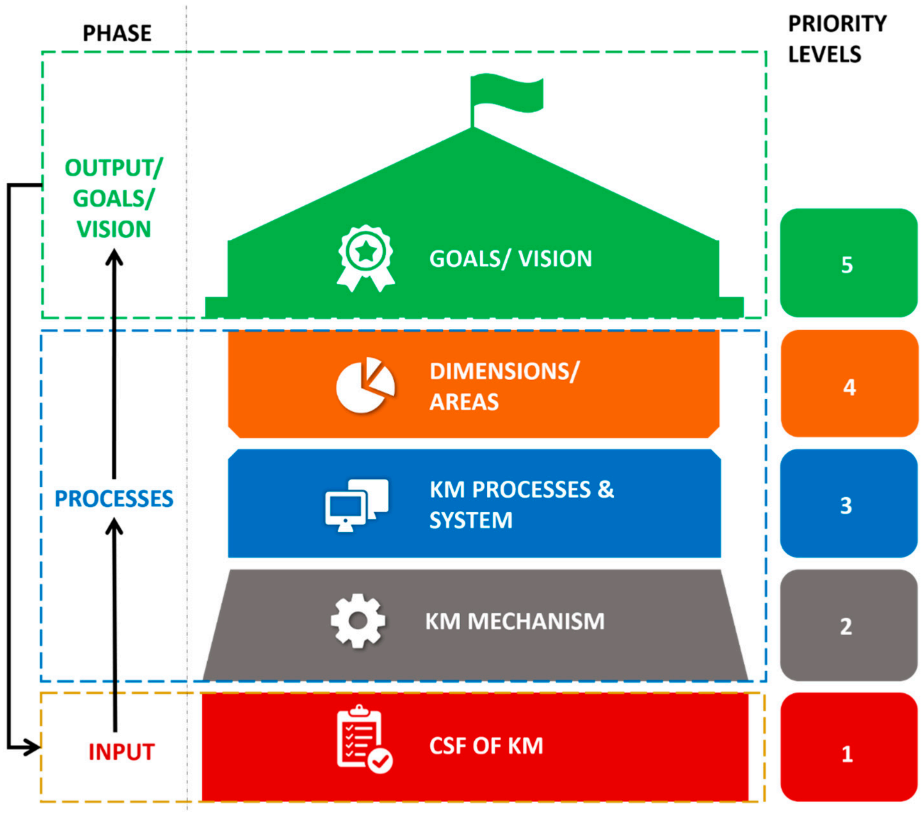

Figure 5. The proposed KM model to support SCs with a priority level.

The results of grouping several components into one layer cause the priority level to be different from the results of the AHP analysis. This difference is quite interesting because there is a change in the order of the components as a whole. However, these differences do not cause significant changes in the priority level of each layer because each layer still uses the priority level order of the AHP analysis results. In addition, several components are not grouped in a layer category. These components are KM mechanisms, and implementation areas or dimensions.

Figure 6 shows that the first layer is composed of three essential components. The justification for grouping these three components is based on the theory [10] that the foundation of KM consists of three essential aspects: people, organization, and IT. IT occupies the highest priority level. This result is quite challenging because the priority level is different from several previous studies, which stated that human resources are the main priority compared to technology. However, in this model, information technology becomes the priority. These results prove that this model layer is a model to manage knowledge, and support SCs. This result aligns with previous research, which states that technological innovation barriers are highly prioritized among others [75].

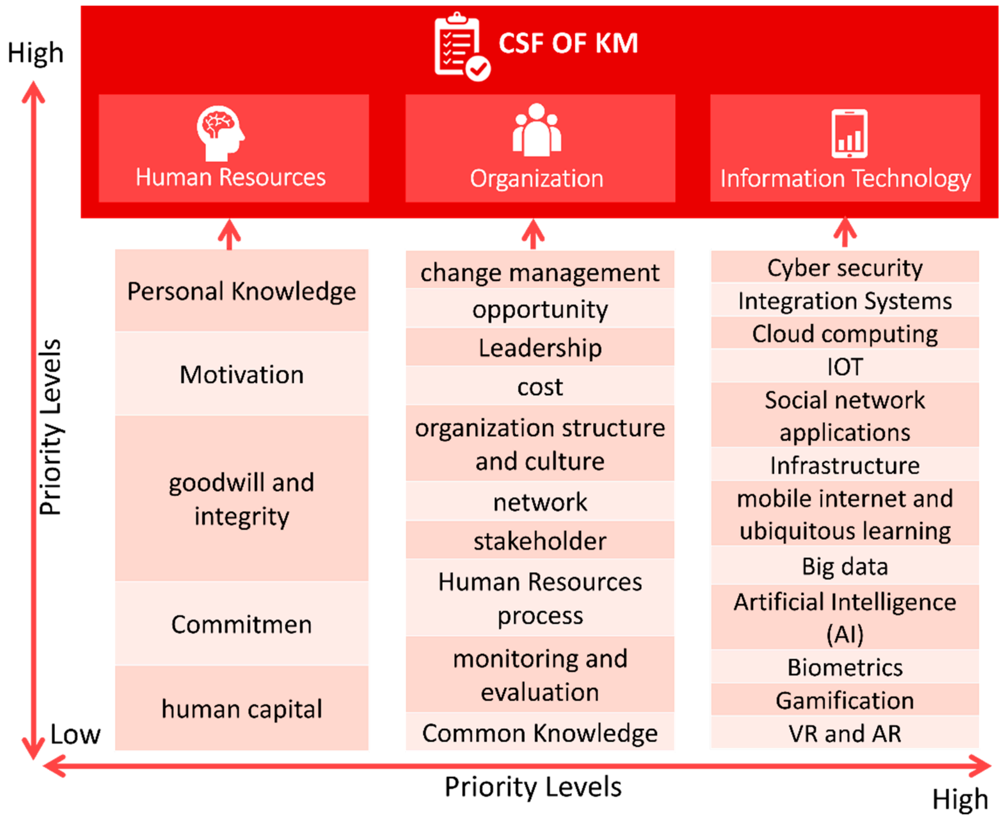

Figure 6. Component/first layer (CSF of KM) of model KM to support SCs.

Information technology has the highest priority level because it is needed to design and build technology to drive organizational performance and human resources. Information technology is considered the main requirement for an HEI's operational activities. This condition is proven by the current pandemic, which demands distance learning facilities. Cyber security is the highest priority sub-component because it is related to the security of information and communication transactions. As such, ideally, before implementing other information technologies, HEIs should implement cyber security first.

In order to create post-pandemic adaptive education, experts provide recommendations for the addition of IT sub-components. These sub-components are artificial intelligence (AI), biometrics, gamification, virtual reality (VR), augmented reality (AR), mobile internet, and ubiquitous learning (MIUL). Figure 6 shows the priority level of some of these sub-components. The priority levels are as follows: mobile internet and ubiquitous learning ranked 7th; AI ranked 9th; biometrics ranked 10th; gamification ranked 11th; and VR and AR ranked 12th. MIUL's justification for ranking seventh is because this sub-component requires cloud computing and infrastructure to develop learning management systems (LMS) and massive open online courses (MOOCs). At the same time, the justification for the sub-components of AI and biometrics is because they require the provision of high-performance computing (HPC) infrastructure, and the development of big data for academics first.

Furthermore, after big data from academics and related stakeholders, gamification can be developed to support an interactive learning platform more personalized and more in line with user preferences. The last priority is VR and AR. The justification is that this sub-component will be more optimal if gamification has been developed first. Gamification will manage interactivity features, challenges, and user feedback on immersive 2D/3D environment-based learning materials, whereas VR and AR function to create digital elements and immersive 2D and 3D environments.

The infrastructure sub-component is in the second-lowest position. This position is quite questionable. IT infrastructure is considered a low priority because building and developing IT infrastructure requires a priority program design first. The design can then be used as consideration for building IT infrastructure. However, interestingly, big data is in a lower position. This position proves that big data requires IT infrastructure first. This condition is caused because big data is a development of database systems in general. The difference lies in the processing speed, volume, and types of data available, which are more numerous and varied than the DBMS (database management system) in general.

The organizational component places the change management sub-component at the highest priority. This result is because change management plays a role in managing the dynamics of change in other sub-components (opportunities, leadership, costs, organizational structure, networks, stakeholders, HR processes, monitoring, and evaluation). In addition, change management is the first process that must be carried out during and after the evolution of information technology (previous components). Furthermore, the general knowledge sub-component is placed in the lowest position because it results from the previous sub-components' accumulation. In other words, the general knowledge sub-component can be formed based on combining the previous sub-components.

The HR component has fundamental differences from the organizational component. The HR component places the personal knowledge sub-component at the highest priority. This result is because the HR component continues the previous sub-component, namely general knowledge. Experts provide recommendations to distinguish between the sub-components of the HRS process and the HR component. The recommendation is to give a different name between the sub-components of the HRS process and the HR component. The HR process sub-component is more identical with organizational procedures in HR management, whereas the HR component is related to the competencies and attitudes of each individual. The HR process sub-component was changed to talent management based on these recommendations. Talent management is limited to processes and an integrated strategy to manage the HEI community's capabilities, competencies, and strengths. The concept of talent management is not limited to recruiting the right candidate at the right time, but also extends to exploring hidden and unusual qualities.

Furthermore, this concept aims to develop and maintain the academic community and employees, and obtain the desired results. HEIs have a dynamic community and human resources, including students, lecturers, and administrative personnel. Based on these conditions, talent management is needed at HEIs as a sub-component of the organization.

In the organizational and HR components, it is proven that knowledge is the principal capital in the input stage. The organizational component has general knowledge, whereas the HR component has personal knowledge. General knowledge includes academic, organizational, and external knowledge, whereas personal knowledge, for example, includes technical knowledge of research, and experience of scientific publications. This result aligns with previous research that stated that the KM model's input in HEIs must have academic, organizational, technical, and external knowledge [76].

The second layer is the KM mechanism, with the highest priority being the creation of collaboration (Figure 7). With the creation of collaboration as the sub-component with the highest priority, it will improve the performance of human resources in carrying out other mechanism actions. This increase is because human resources contribute to a collaborative culture requiring optimal interactions. The collaboration will positively impact the attitude of the academic community because they consider all civitas to have competence in their respective fields. In contrast, the best practice is placed at the lowest position. From these results, it is easier to design and develop best practices after carrying out several actions and procedures.

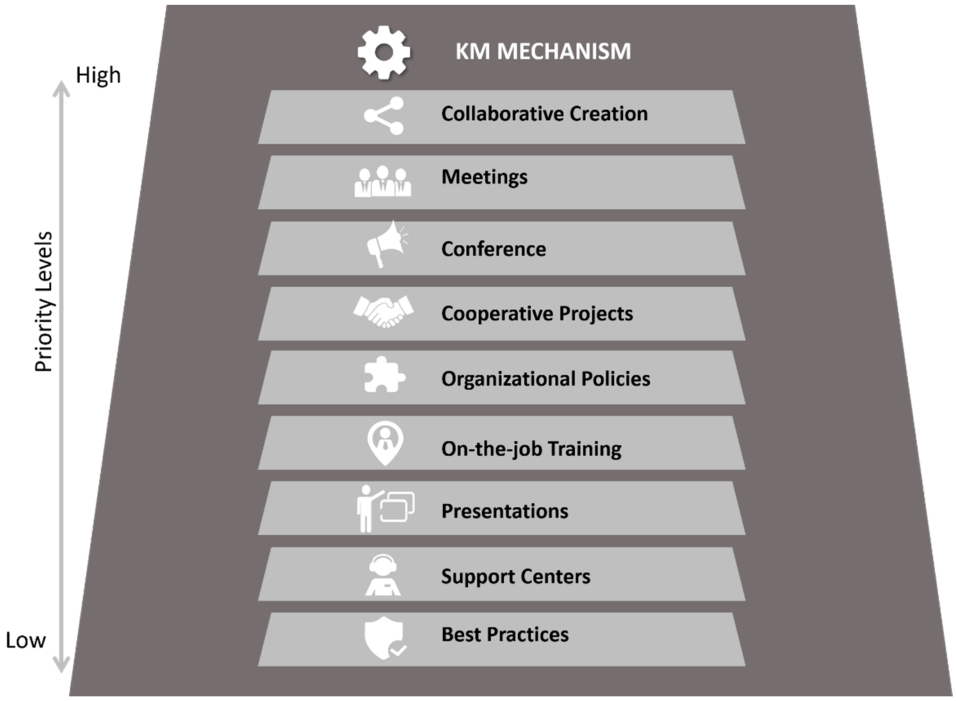

Figure 7. Component/second layer (KM mechanism) of model KM to support SCs.

The KM system and processes at the third layer are the most critical system components for creating an SC. The reason is that this layer includes all knowledge-based systems that the academic community will use. In addition, KMS plays a role in designing quality KM applications to facilitate organizations in overcoming business process integration problems [77]. The application will interact directly with the user. An appropriate plan is needed to build an interactive system based on this. This statement is in line with the results of the AHP analysis, which places KAS at the highest priority level. This result is evident because KAS places the enterprise resource planning (ERP) sub-component at the highest priority (Figure 8). ERP in the early stages will make it easier to design and develop other systems. KSS is placed on the second priority because it is considered the component that has the most decisive influence on KAS. For example, with the DSS sub-component related to scientific publications, it will be easy to develop into an ELS of expertise for the academic community.

Furthermore, Figure 8 shows that SBC significantly influences KSS because KDS mainly aims to find new knowledge based on data, information, and knowledge from KSS. Meanwhile, KCS has the lowest priority level because it continues and impacts KSS. KSS is considered a higher priority than KCS because to get knowledge from users, institutions should share it first. This effort is made to create a culture of sharing in the organization. Based on the causal relationship, the experts recommend adding relationships between systems by providing arrows, as in research [10].

In the fourth layer (area or SC dimension), the experts agree with the priority level of the AHP analysis results. Experts provide recommendations regarding the justification and explanation of the priority level of area layers or SC dimensions. The smart economy (SEcon) is ranked the highest priority because it has the right strategy to implement the SC (Figure 9). The strategy is to create an HEI economic ecosystem that can quickly adapt to the challenges of the era of disruption. The era of economic disruption is when users shift economic activities originally carried out in the real world into the virtual world. Having this strategy at the beginning will make it easier to design other SC areas. What about the justification for the smart education dimension (SEdu), which is placed at the third priority level? Whereas education is the primary goal of HEIs, SEdu is HEIs’ ability to use smart solutions to improve student learning and researcher performance. Smart solutions are implemented in new ICT ideas, facilities, environments, and infrastructure. Based on the needs of these solutions, creating SEdu requires the dimensions of SEcon, smart living (SL), and smart environment (SEnv) first. SEcon serves as a resource and strategy for building ICT facilities and infrastructure. SL plays a role in developing accommodation facilities and security. Meanwhile, SEnv provides intelligent service systems related to environmental interactions, such as energy, conservation, water, waste, and others.

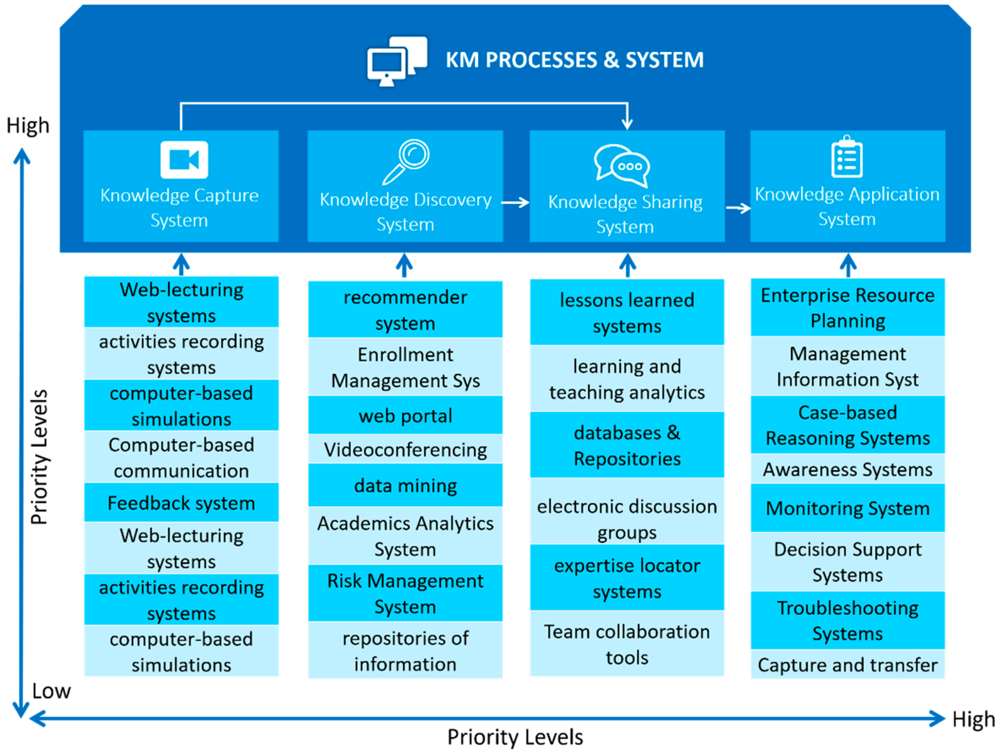

Figure 8. Components/third layer (KM processes and systems) of model KM to support SCs.

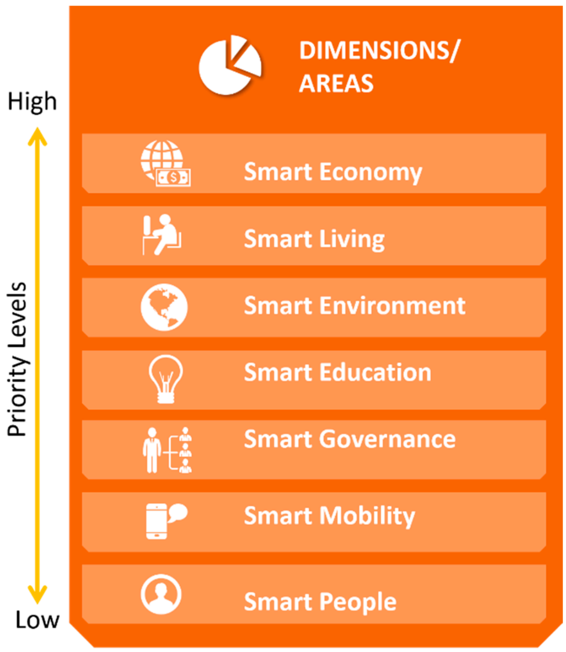

Figure 9. Fourth component/layer (SC dimension or area) of model KM to support SCs.

The model has three sub-components at the top layer (goal and vision) (Figure 10). The outcome has the highest priority compared to other sub-components (outputs and strategies). However, it is different from the validation from experts. The recommendation from the experts is to place the strategy on the top priority compared to outputs and outcomes. The recommendation has a justification that the outcome cannot be achieved without a prior strategy and output design. Based on these recommendations, the fifth layer image is changed into strategy, output, and outcome in order of priority level. The order of each sub-component does not change. Therefore, the experts provide recommendations to align with the direction from strategy to output, output to the outcome, and outcome to strategy. The flow line is described as a life cycle. The meaning of this cycle is that when it produces an outcome that is less than or not by the needs, the strategy will adjust to produce the correct output/system and outcome according to the needs.

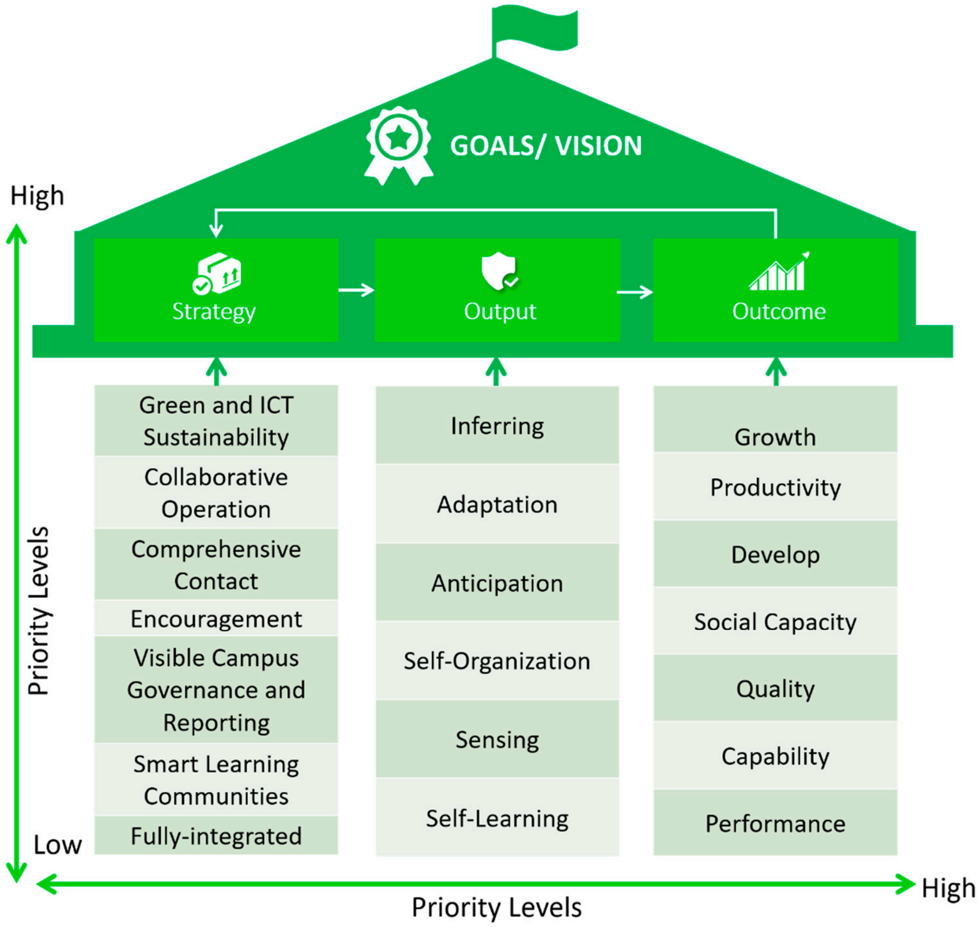

Figure 10. Components/fifth layer (goals/vision) of model KM to support SCs.

The green and ICT sustainability sub-component (GICTS) is placed at the highest priority because it has programs related to planning, infrastructure, and security for ICT sustainability. In addition, the program focuses on the "green" concept, namely the process of being environmentally responsible and saving resources throughout its life cycle.

The collaboration operation sub-component is very precisely placed in the second position because collaboration between the academic and administrative community will improve the performance of the HEI program. With this performance, it will be easier to carry out the realization of the plans that have been designed in the previous sub-components. The collaboration operation sub-component is a continuation strategy from the previous sub-component because this sub-component will use intelligent infrastructure and security system testing through collaboration between users.

The next step that must be performed is the intelligent management of resources, equipment, and utilities, making it possible to determine the location of objects in real-time using ICT infrastructure. These efforts can be carried out through a comprehensive contact sub-component program. The ultimate goal of all these sub-components is to create a fully integrated program. Fully integrated services are placed at the last position because this sub-component has specific requirements created in the previous sub-component. These requirements are the basic schema of the system infrastructure that can support heterogeneous HEI data; system service security; use and saving of resources; collaboration between civitas and stakeholders; resource management; support for innovation; structured administrative governance; and intelligent learning communities.

The output component covers the features or level of intelligence that an HEI must possess to achieve an SC. The inferring sub-component has the highest priority. This result is because, in the initial step, an HEI requires features that can find out the phenomena and problems by processing raw data into knowledge for leadership decision-making. This need can be met with the capabilities possessed by the inferring sub-component. The ability is to develop systems with automated features to make logical conclusions based on raw data, processed information, observations, evidence, assumptions, rules, and logical reasoning.

Furthermore, the output needed by an HEI is the ability to operate and carry out its primary business functions better. Based on this, the most appropriate sub-component to be implemented is adaptation. Adaptation has programs to support system development to automatically change educational strategies, research procedures, community service programs, and administrative governance.

After adapting, an HEI should ideally have the ability to anticipate. Therefore, the output that must be achieved is anticipation. *Anticipation* is the output that has the feature of automatically reasoning to predict what will happen, how to handle that event, or what to do next. As an example, suppose the prediction results will harm the HEI. Therefore, internal changes will be needed to overcome these impacts. Internal changes could be made through a self-organization approach. The strategy is as follows: build an automated system to change the structure of internal components, self-regenerate, and self-defense in a directed manner under suitable conditions, but without external entities.

When internal changes have been made, it will be easier for an HEI to find out the character and identity of its components. Then, the following output that must be prioritized is sensing (awareness). Output sensing has the intuitive ability to use various sensors to identify, recognize, and understand various events, processes, objects, phenomena, and impacts (positive or negative) on the main components of the HEI. After the five outputs are achieved, the HEI will be more effective in practicing KM by using the program at the output of *self-learning. Self-learning* is an output that can automatically acquire, formulate, and modify new knowledge, experience, or existing behavior to improve operations, business functions, performance, and effectiveness.

The outcome component begins with growth. *Growth* is a result that must be obtained at the beginning because it will shape the mindset of the HEI community. This growth mindset will always believe that one's talents and competencies can develop continuously. This mindset will facilitate the learning process, and encourage innovation to create productivity. The productivity in question is related to the results of education graduates, research results, and community service programs. In order to increase productivity, development is needed. Development sub-components can change productivity outcomes through positive changes or additions to physical, economic, environmental, and social components. Development has characteristics that can be felt, and that are valuable and not necessarily immediate, including aspects of change and conditions to continue these changes.

Furthermore, changes in these conditions will affect the formation of social capacity. Social capacity is an ability to cooperate in managing public relations. Social capacity will encourage individuals, groups, and organizations to act positively and exhibit cooperative behavior, inclusiveness, openness, and equality.

Social capacity has programs to create quality. The programs are education, training, cultural development, and socialization. Meanwhile, social capacity can organize people in several programs to achieve capability. The programs are as follows: allocating and controlling power, determining access to resources, resolving conflicts, steering society, and compiling competitive and collaborative processes. As such, all efforts to organize these people can empower their resources appropriately to improve performance, and achieve goals.

Each problem has several causes. The causes are as follows: human capital gap ratio, knowledge gap, organizational culture, leadership, monitoring and evaluation, commitment, lack of knowledge and experts, lack of IT infrastructure, KM process has not been implemented properly, learning and development, and regulations related to KM implementation.

6. Conclusions

This study aims to explore SCs supporting KM comprehensively. This study comprehensively covers SC inputs, processes, and outputs/goals. The results of this study are divided into four main parts, namely SC components/technology, SC area trends, key KM components in HEIs, and KM models to support SCs. SC components and technologies vary across HEIs. Based on SLR results, KM, IoT, and big data components have the highest trend compared to other technology components.

However, other technologies (social network applications, mobile internet, and ubiquitous computing, cloud computing, and integration systems) contributed less frequently to HEIs. The implication is that HEIs must prepare SC components and technologies tailored to their needs. The necessities of concern are related to the central functions of business (education, research, community service) and supporting functions (administration, strategy during a pandemic). For example, an HEI needs an integrated system and cloud computing during the pandemic and post-pandemic, whereas for Education, an HEI requires more KM. Research and community service will require more social network applications, mobile internet, ubiquitous computing, IoT, and big data.

The trend in the SC area shows that smart governance (SG), smart people (SP), and smart education (SEd) have the highest trends compared to other areas. The results of the SLR show that KM is an essential component of SC practice. The area or dimensions of SL, SEn, smart mobility (SM), and smart economy (SEc) have a lower trend. Meanwhile, based on AHP analysis and expert validation, the SC area with the highest priority trend is the smart economy. The next priority is the area of smart living, smart environment, smart education, smart governance, smart mobility, and smart people. The priority level of the SC area impacts the application of information technology at HEIs. HEIs should ideally implement IT in the economic sector to support other SC programs. Then, the second stage is smart living, smart environment, and smart education. The smart governance sub-component fills the third stage. Smart mobility is in the fourth stage. The fifth stage contains smart people. These results can be recommended to HEIs who want to create a comprehensive and effective SC.

The results of RQ1 and RQ2 indicate that KM is an essential component for SCs. Based on these results, this study outlines the critical components of KM to create a successful SC program, especially during the pandemic and post-pandemic. The key components of KM forming SCs consist of KM topics, SC artificial intelligence, and information systems. The results of the AHP analysis and expert validation prove that the critical components of KM forming the SC consist of 12 components covering the topic. Based on expert recommendations, the 12 components are ordered from high to low priority level, namely as follows: IT, organizations, human resources, KM mechanisms, knowledge application systems, knowledge sharing systems, knowledge discovery systems, knowledge capture systems, areas implementation, strategy, and outcome. Each component has a sub-component resulting from the study of the literature.

The KM model to support the creation of SCs has the characteristics of a knowledge life cycle at HEIs related to education, research, community service, and supporting the administration. The life cycle consists of inputs, processes, and goals. Based on the results of expert validation, it is evident that the SC creator KM model consists of five layers that cover the life cycle. Each layer is grouped based on the phase of the system, namely input, process, and output/goal/vision. The first layer is grouped in the input category because this layer includes the resources and knowledge used. General knowledge has academic, organizational, and external expertise, whereas personal knowledge, for example, includes technical knowledge of research, and experience of scientific publications. The first layer is CSF KM, which covers IT, organization, human resources. The second, third, and fourth layers are grouped in the process category. This layer protects the way of processing resources and knowledge, namely: KM mechanisms, KM processes, KM systems, and dimensions/implementation areas. At the same time, the last fifth layer is grouped in the category of goals because this layer includes the results achieved. The fifth layer covers strategy, outputs, and outcomes.

Based on this explanation, this KM model can be a reference and guide for HEIs when implementing KM in HEIs as a form of SC: the implementation of KM in general and, specifically, during the pandemic and post-pandemic periods. With this effort, HEIs will find it easier to choose the most crucial components to be designed and developed first. This model can provide recommendations to HEI leaders to create KM strategies to support SCs. The explanation also proves that the study results support the conclusion because the explanation can conclude the results, and answer the RQ systematically.

This study has limitations in analyzing the causal relationship between components and sub-components. Based on these limitations, future research will explore the causal relationship between components and sub-components of KM, and develop a KM model to create a more comprehensive SC. Further research can use other methods, such as interpretive structural modeling (ISM) and structural equation modeling (SEM).

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Conflicts of Interest: The authors declare no conflict of interest.

Appendix A. SLR Diagram

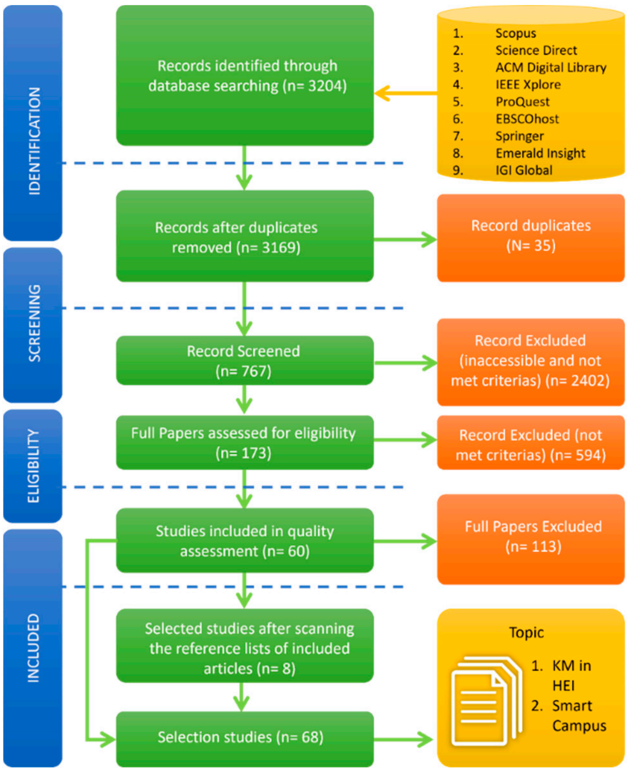

Figure A1. PRISMA procedure diagram.

Appendix B. SLR Criteria and Assessment

Table A1. Article inclusion and exclusion criteria.

Inclusion Criteria	• Original research and peer-review • The paper discusses and identifies smart campus/smart universities (components, technology, and research trend areas). • The paper discusses and identifies the KM component in HEIs. • Relevant with the search keywords • Written in English • Published between 2007–2021 • Should include KM for academia, KM in academic institution, KM in higher education institution, smart campus domain • Should include model, components, technology, dimension • Should be accessible
Exclusion Criteria	• Articles that have no relevance with the search keywords • Articles that are not written in English • Articles that are published before 2013 • Articles that do not include KM for academia, KM in academic institution, KM in higher education institution, smart campus domain • Articles that are not accessible • Duplicate articles

Table A2. Article quality assessment checklist.

Checklist	Checklist Question
C1	Does the article clearly describe the research objectives?
C2	Does the article write a literature review, research background, and context?
C3	Does the article display related work from previous research to show the main contribution of the research?
C4	Does the article describe novelty and validation techniques in the methodology or proposed model used?
C5	Does the article clearly describe the model, components, technology, and dimension (KM in HEIs and SCs)?
C6	Does the article have well-discussed research experiments, results, and comparisons?
C7	Does the article provide conclusions that are relevant to the research objectives/concerns?
C8	Does the article discuss limitations and recommend future work or improvements in the future?

Appendix C. Initial Model

Table A3. Selected KM model (previous studies) for SCs.

Model	Justification
KM Solution and Foundation [30]	KM solution is a way to facilitate HEIs in the KM process and system activities. KM foundation serves as a fundamental aspect of KM related to infrastructure, technology, and mechanisms to support SC applications.
APO Framework KMP [31]	The APO KM framework serves as the basis for reference and benchmark results to improve KM performance at HEIs in achieving SCs.
SmU smartness levels [4]	SmU smartness levels serve as objectives and maturity levels of KM-based SC implementation.
KM as foundation of smart university [5]	This model provides a KM-based SC implementation strategy at HEI, which includes interaction, integration, innovation, and collaboration.
The characteristics and KPIs of the smart campus [13]	This model is tasked with classifying the main characteristics and indicators in the immediate implementation of SCs in HEIs (people, education, mobility, living, economy, and environment).
Smart campus areas [6]	This model is tasked with classifying the dimensions of SC implementation in general (people, governance, mobility, living, economy, and environment).
Smart Learning Communities [15]	This model has the task of providing a KM-based SC implementation strategy for HEIs that includes practical, connectable, accessible, ubiquitous, sociable, sharable, and visible/augmented aspects.
intelligent campus (i-campus) themes [6]	This model has the task of providing a KM-based SC implementation strategy for HEIs related to the concepts of green and ICT sustainability, visible campus governance, and reporting.
SmU main distinctive sub-components [4]	This model has the role of providing a KMS-based software system for HEI.
Indonesian Government KM Model [32]	This model has a significant role as a KM driver and enabler to accelerate SC initiatives and implementation at HEIs.

Table A4. Selected KM model (previous studies) for SCs.

Layer	Component
GOALS	The center for superior and competitive science, technology, and culture, based on the concept of Tri Dharma, which has the abilities: (1) adaptation, (2) sensing (awareness), (3) inferring (logical reasoning), (4) self-learning, (5) anticipation, and (6) self-organization
OUTCOMES	Quality, development, performance, capability, social capacity, productivity, growth
STRATEGY	Comprehensive contact, fully-integrated, encouragement for innovation, collaborative operation, smart learning communities, green and ICT sustainability, visible campus governance and reporting
DIMENSIONS/ AREAS	Smart governance, smart people, smart mobility, smart environment, smart living, smart education, smart economy
KM SYSTEM	Knowledge discovery systems: (1) data mining, (2) repositories of information, (3) web portals, (4) videoconferencing, (5) expert systems, (6) enrollment management system, (7) risk management system, (8) academic analytics system, (9) recommender system. Knowledge capture systems: (1) chat groups, (2) best practices databases, (3) computer-based communication, (4) AI-based knowledge acquisition, (5) computer-based simulations, (6) web-lecturing systems, (7) activities recording systems, (8) feedback system. Knowledge sharing systems: (1) team collaboration tools, (2) databases and repositories of digital learning content, (3) lessons learned systems, (4) expertise locator systems, (5) learning and teaching analytics systems, (6) online (web) resources, (7) learning portals, (8) electronic discussion groups, (9) web-based access to data. Knowledge application systems: (1) capture and transfer of experts' knowledge, (2) troubleshooting systems, (3) case-based reasoning systems, (4) decision support systems, (5) enterprise resource planning systems, (6) management information systems, (7) monitoring systems, (8) awareness systems, (9) early warning systems.
KM MECHANISM	Support centers; organizational policies; meetings; conferences; on-the-job training; best practices; presentations; cooperative projects; collaborative creation of documents.
CSF OF KM	HUMAN (motivation, human capital, commitment, and creation, goodwill and integrity, personal knowledge); ORGANIZATION (common knowledge, HR process, regulation, leadership, organization structure and culture, teamwork, environment, monitoring and evaluation, stakeholder, network, opportunity, cost, change management); TECHNOLOGY (IT infrastructure, big data, internet of things, social network applications, mobile internet and ubiquitous computing, cloud computing, integration systems, cyber security).

Appendix D. Data Analysis with AHP (Figures)

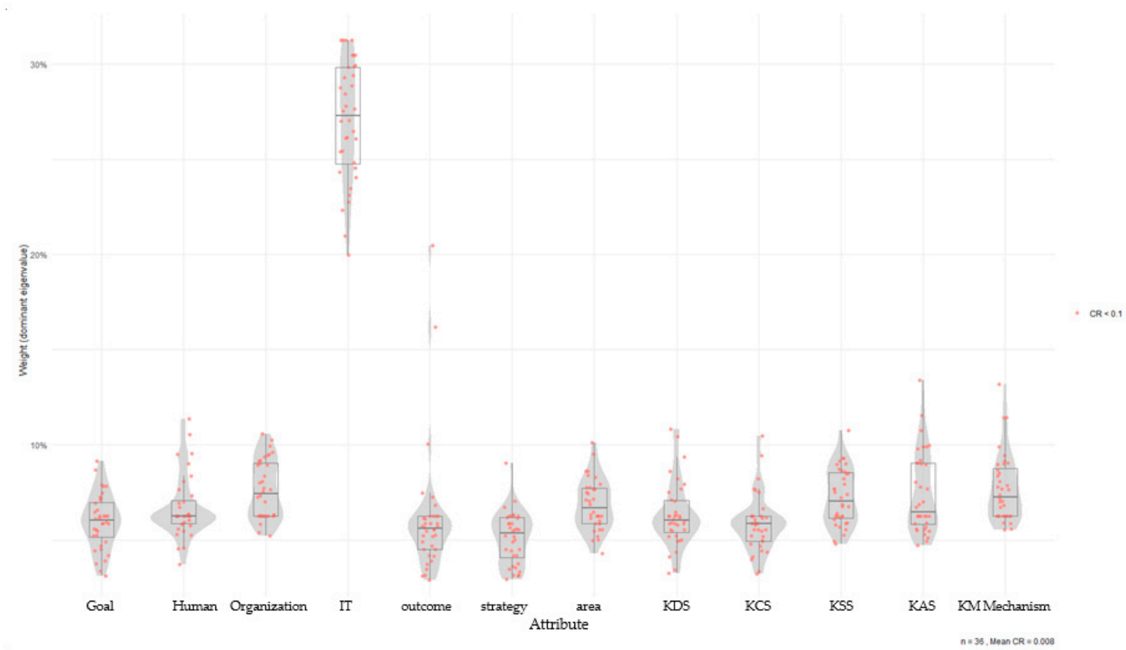

Figure A2. Priority weighting (box-plot distribution) for each component/layer of the KM model to support SCs.

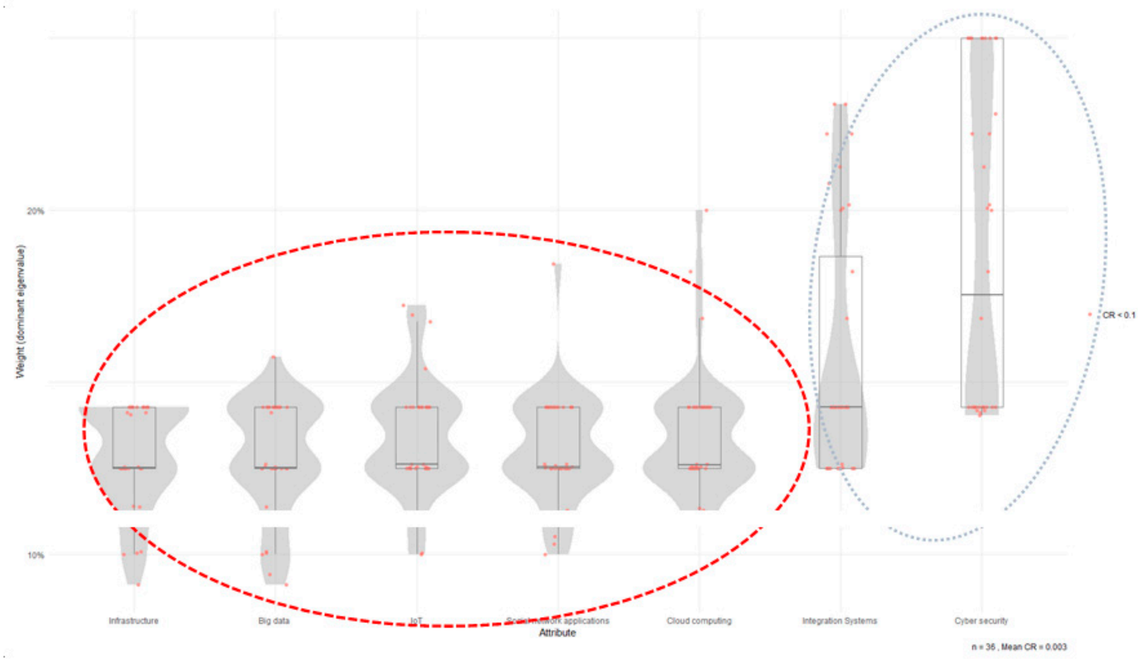

Figure A3. Priority weighting (box-plot distribution) for each sub-component of IT.

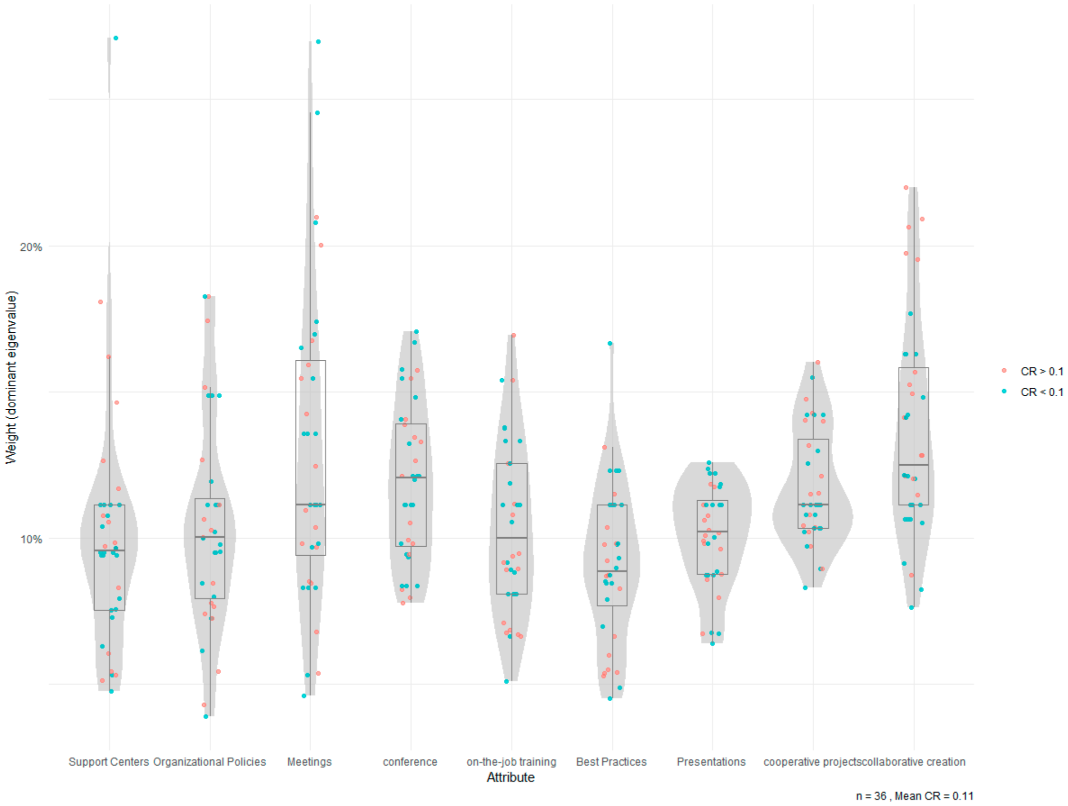

Figure A4. Priority weighting (box-plot distribution) for each sub-component of the KM mechanism.

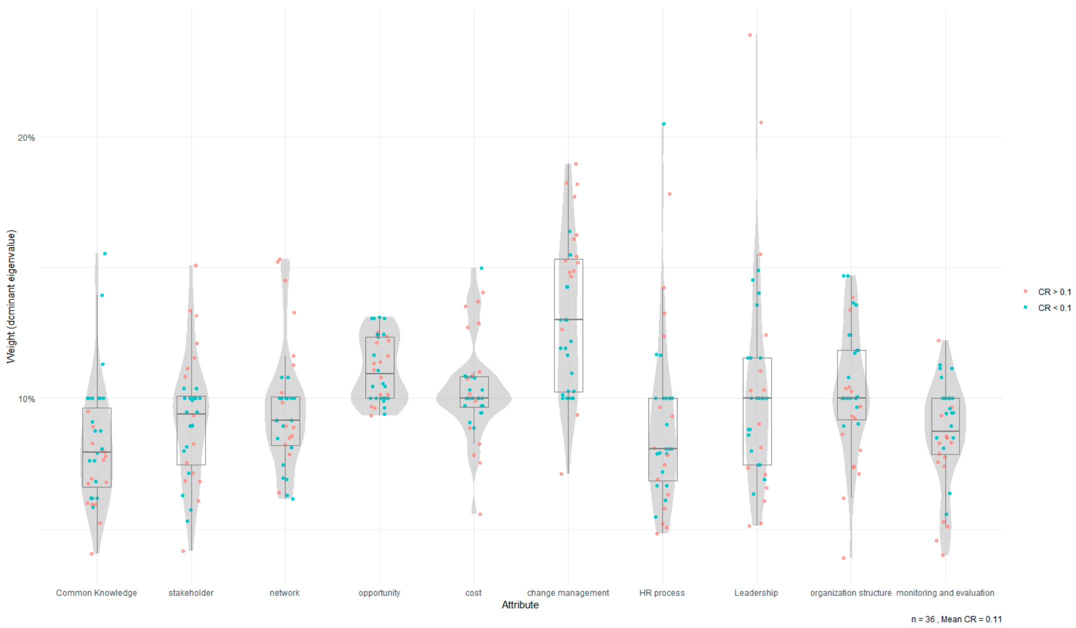

Figure A5. Priority weighting (box-plot distribution) for each sub-component of organization.

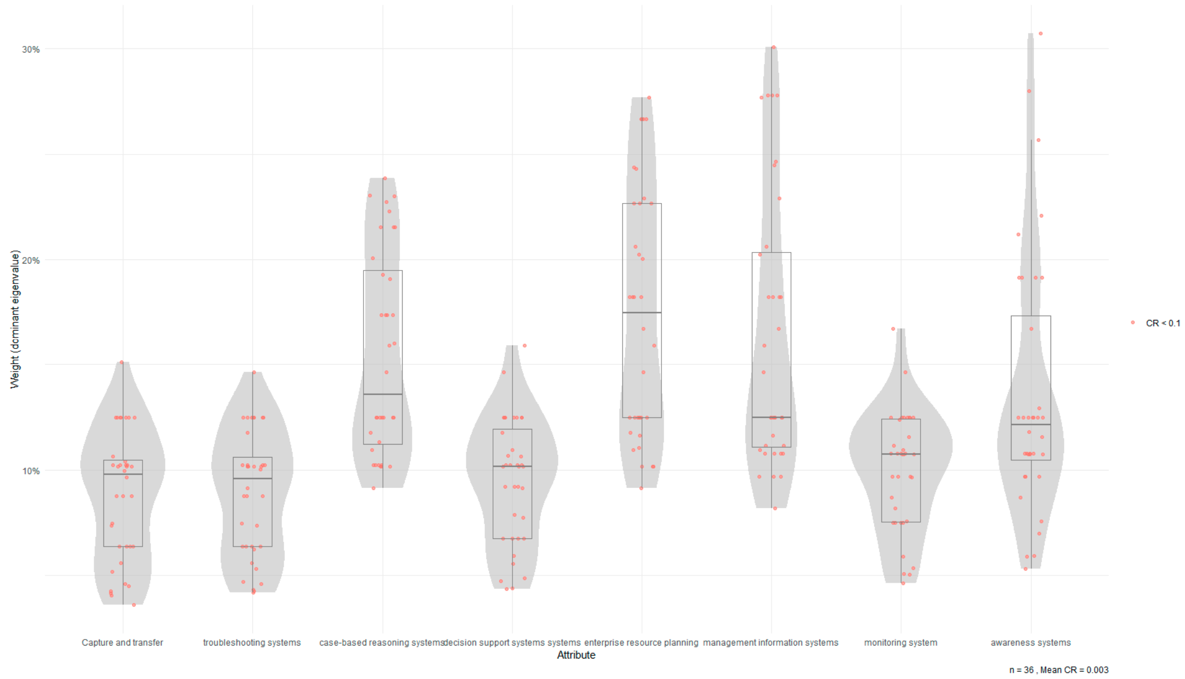

Figure A6. Priority weighting (box-plot distribution) for each sub-component of KAS.

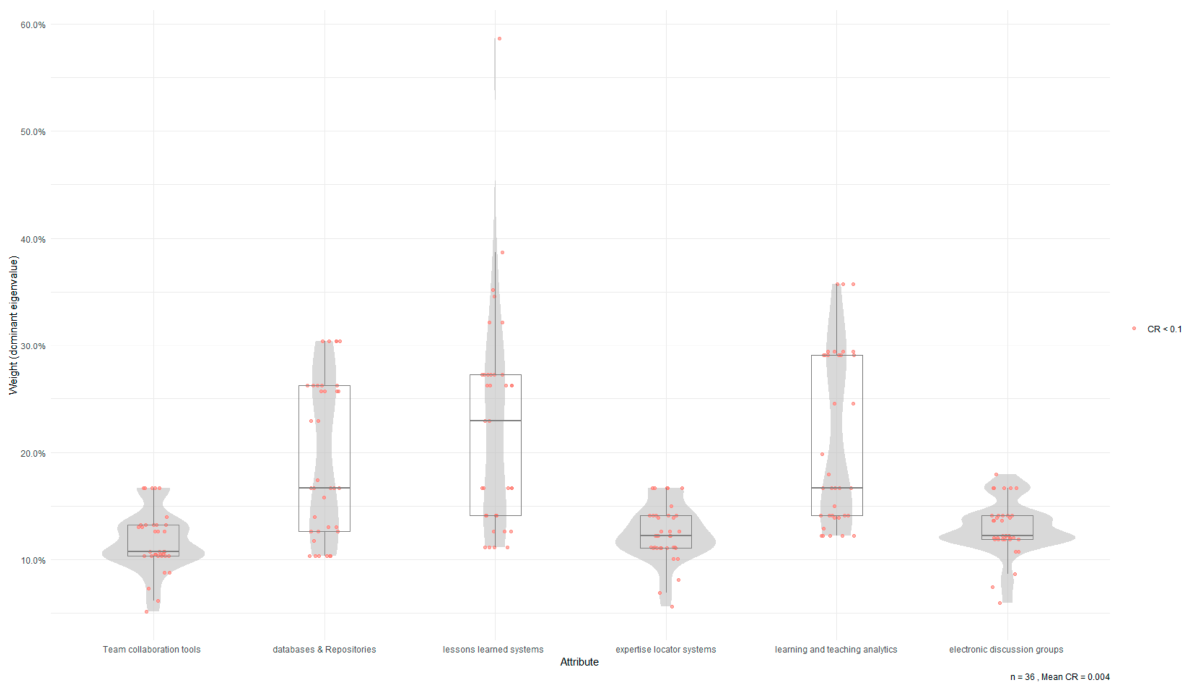

Figure A7. Priority weighting (box-plot distribution) for each sub-component of KSS.

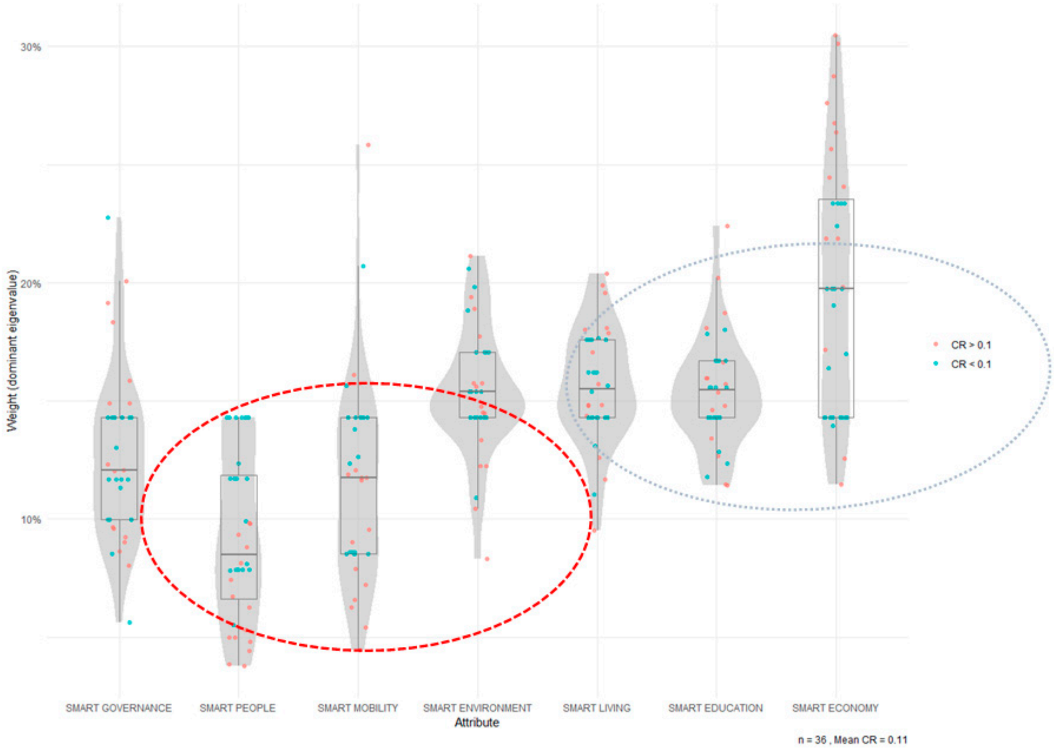

Figure A8. Priority weighting (box-plot distribution) for each sub-component of SC areas.

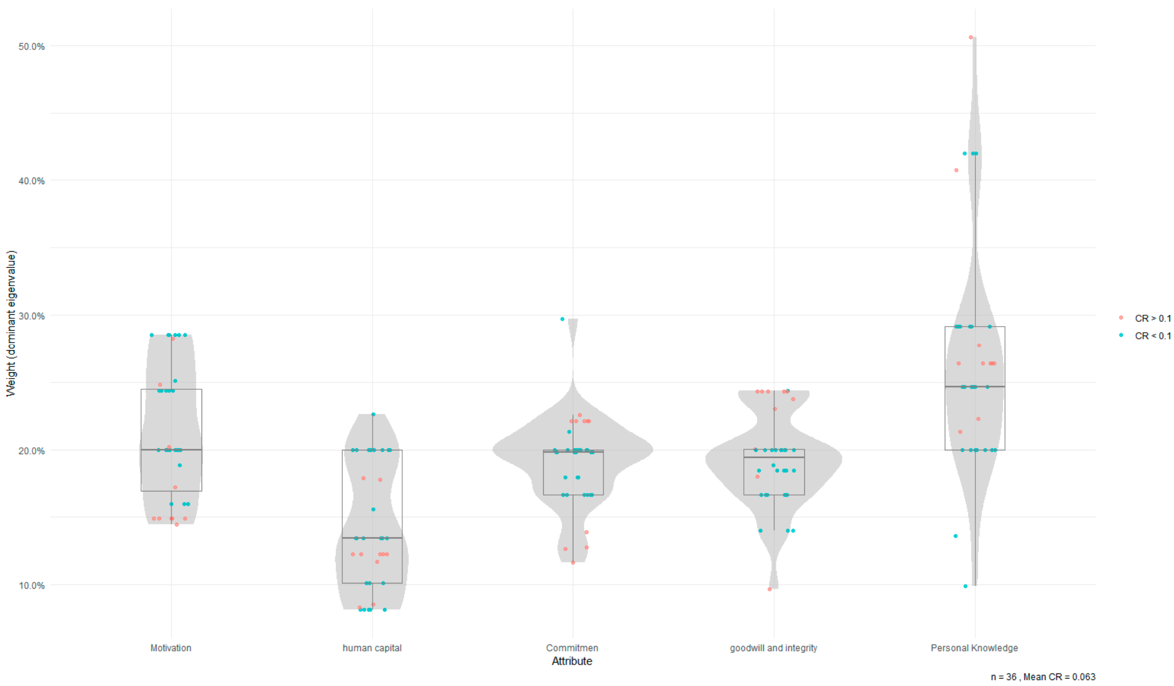

Figure A9. Priority weighting (box-plot distribution) for each sub-component of human.

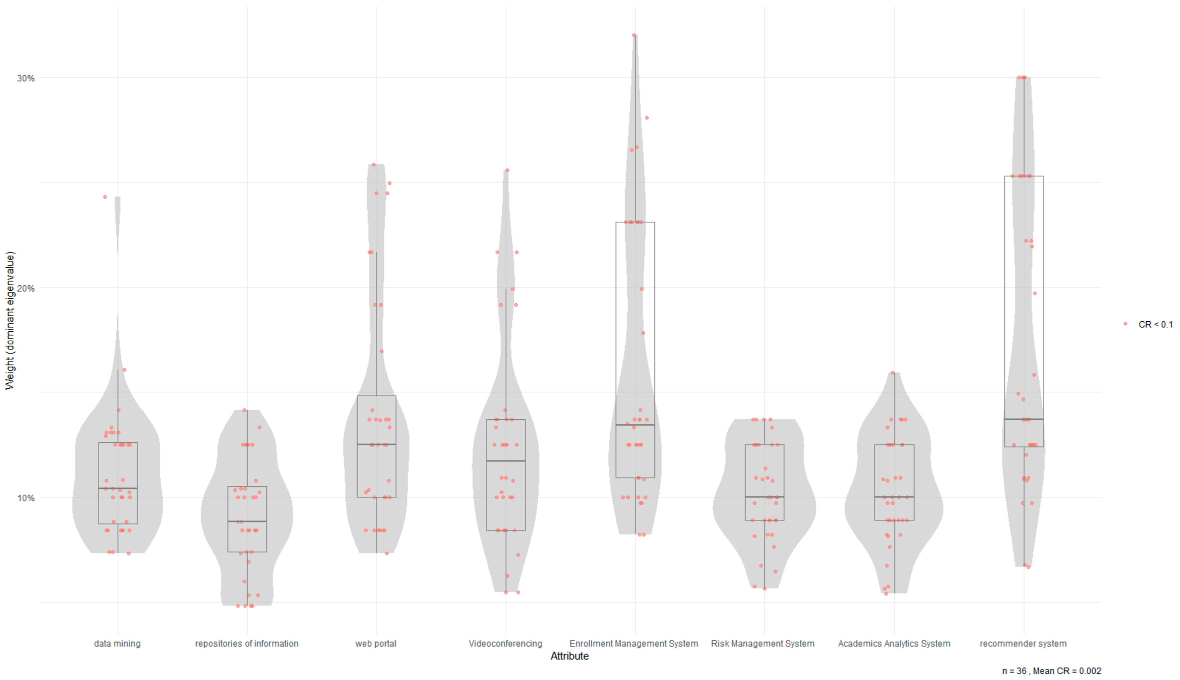

Figure A10. Priority weighting (box-plot distribution) for each sub-component of KDS.

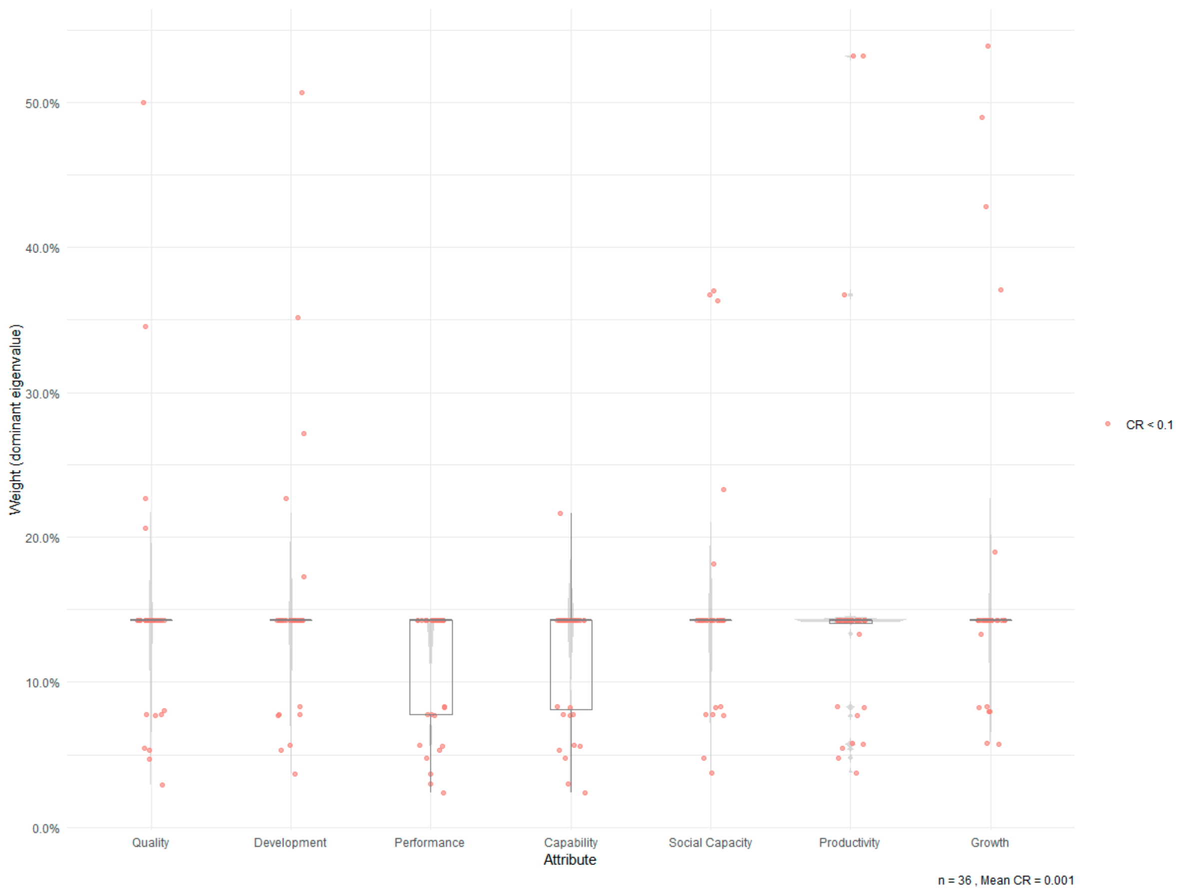

Figure A11. Priority weighting (box-plot distribution) for each sub-component of outcome.

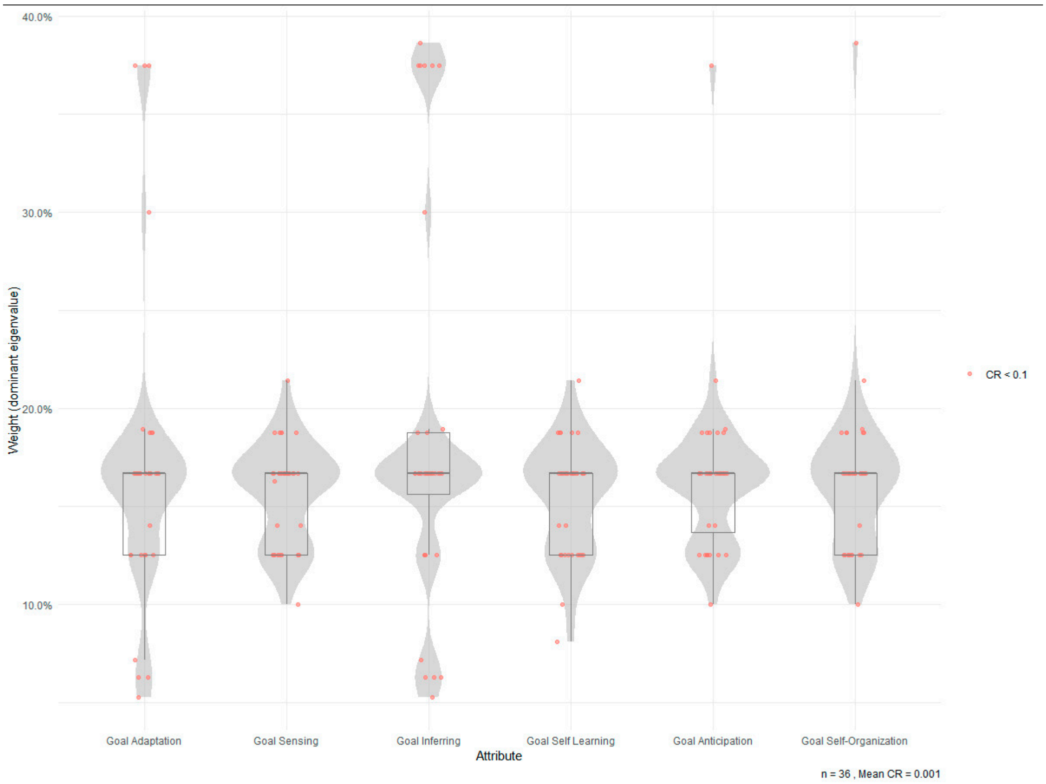

Figure A12. Priority weighting (box-plot distribution) for each sub-component of goal.

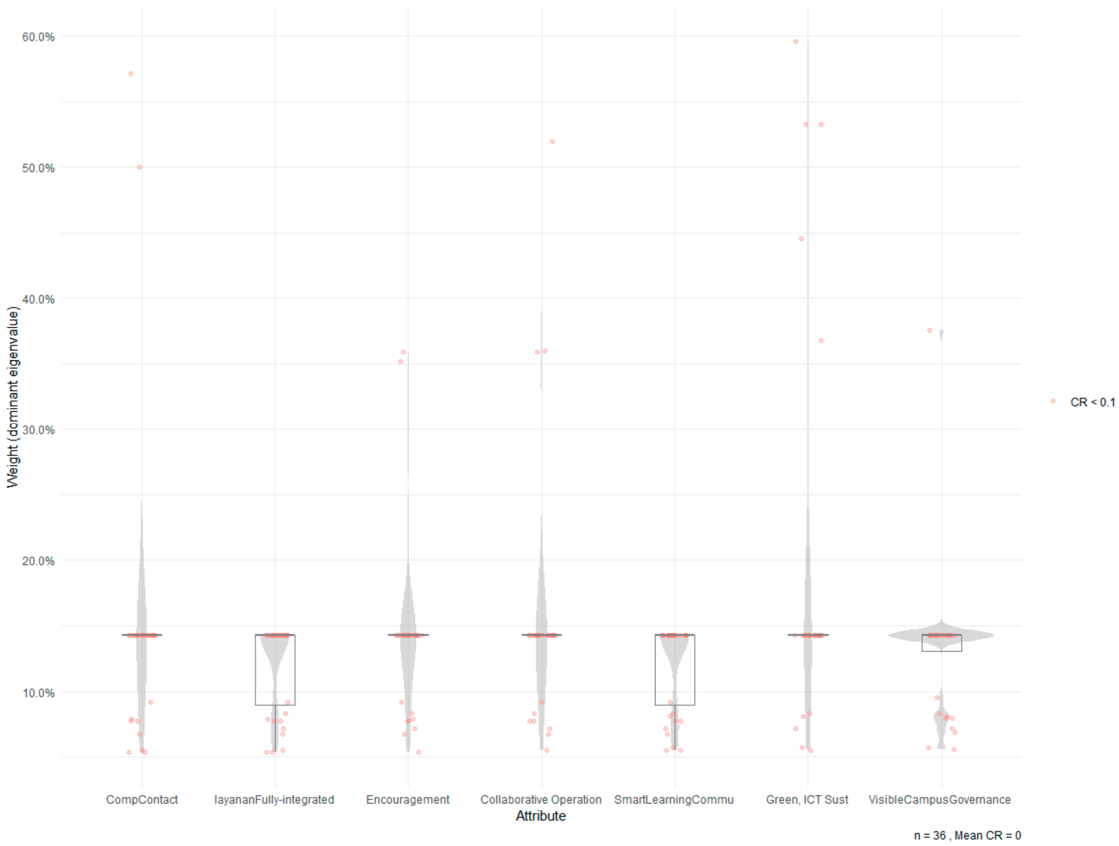

Figure A13. Priority weighting (box-plot distribution) for each sub-component of strategy.

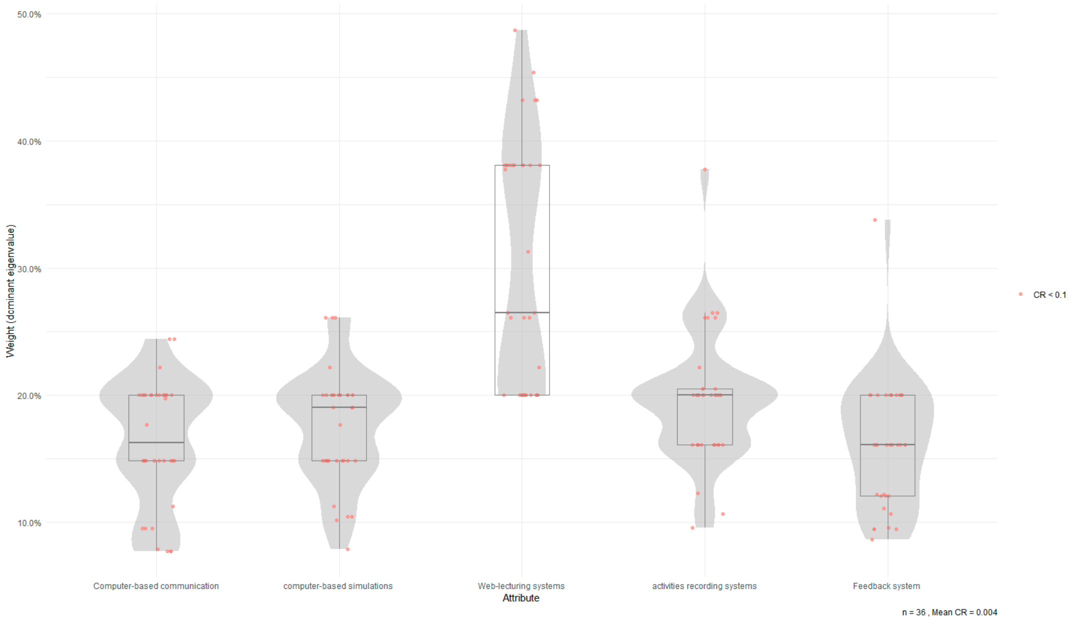

Figure A14. Priority weighting (box-plot distribution) for each sub-component of KCS.

Appendix E. Data Analysis with AHP (Tables)

Table A5. Priority weighting (percentage) for each component/layer of the KM model to support SCs.

Components	Weight	Priority
IT	26.99%	1
KM mechanism	7.71%	2
Organization	7.62%	3
KAS	7.45%	4
KSS	7.26%	5
Implementation Area	6.87%	6
Human	6.69%	7
KDS	6.32%	8
Outcome	6.11%	9
Output/Goal	5.98%	10
KCS	5.89%	11
Strategy	5.13%	12

Table A6. Priority weighting (percentage) for each sub-component of IT.

Sub-Components	Weight	Priority
Cyber security	18.77%	1
Integration Systems	15.66%	2
Cloud computing	13.50%	3
IOT	13.40%	4
Social network applications	13.03%	5
Infrastructure	12.84%	6
Big data	12.79%	7

Table A7. Priority weighting (percentage) for each sub-component of the KM mechanism.

Sub-Components	Weight	Priority
Collaborative creation	13.49	1
Meetings	12.79	2
Conference	11.93	3
Cooperative projects	11.71	4
Organizational Policies	10.47%	5
On-the-job training	10.35%	6
Presentations	10.12%	7
Support Centers	9.97%	8
Best Practices	9.17%	9

Table A8. Priority weighting (percentage) for each sub-component of organization.

Sub-Components	Weight	Priority
Change management	13.04%	1
Opportunity	11.22%	2
Leadership	10.40%	3
Cost	10.34%	4
Organization structure and culture	10.31%	5
Network	9.61%	6
Stakeholder	9.14%	7
HR process	9.00%	8
Monitoring and evaluation	8.68%	9
Common knowledge	8.26%	10

Table A9. Priority weighting (percentage) for each sub-component of KAS.

Sub-Components	Weight	Priority
Enterprise resource planning	17.41%	1
Management information systems	16.29%	2
Case-based reasoning systems	15.44%	3
Awareness systems	13.60%	4
Monitoring system	9.99%	5
Decision support systems	9.53%	6
Troubleshooting systems	8.91%	7
System for capture and transfer of experts' knowledge	8.82%	8

Table A10. Priority weighting (percentage) for each sub-component of KSS.

Sub-Components	Weight	Priority
Lessons learned systems	22.40%	1
Learning and teaching analytics	21.03%	2
Databases and repositories	19.44%	3
Electronic discussion groups	12.93%	4
Expertise locator systems	12.46%	5
Team collaboration tools	11.74%	6

Table A11. Priority weighting (percentage) for each sub-component of SC areas.

Sub-Components	Weight	Priority
Smart economy	19.4%	1
Smart living	15.9%	2
Smart environment	15.6%	3
Smart education	15.4%	4
Smart governance	12.9%	5
Smart mobility	11.6%	6
Smart people	9.3%	7

Table A12. Priority weighting (percentage) for each sub-component of human.

Sub-Components	Weight	Priority
Personal knowledge	25.82%	1
Motivation	21.50%	2
Goodwill and integrity	19.41%	3
Commitment	19.12%	4
Human capital	14.14%	5

Table A13. Priority weighting (percentage) for each sub-component of KDS.

Sub-Components	Weight	Priority
Recommender system	17%	1
Enrollment management system	16%	2
Web portal	14%	3
Videoconferencing	12%	4
Data mining	11%	5
Academics analytics system	10%	6
Risk management system	10%	7
Repositories of information	9%	8

Table A14. Priority weighting (percentage) for each sub-component of outcome.

Sub-Components	Weight	Priority
Growth	19.06%	1
Productivity	17.09%	2
Development	15.34%	3
Social Capacity	13.37%	4
Quality	12.44%	5
Capability	11.46%	6
Performance	11.25%	7

Table A15. Priority weighting (percentage) for each sub-component of goal.

Sub-Components	Weight	Priority
Goal Inferring	18.80%	1
Goal Adaptation	17.08%	2
Goal Anticipation	16.47%	3
Goal Self-Organization	16.46%	4
Goal Sensing	15.71%	5
Goal Self-Learning	15.48%	6

Table A16. Priority weighting (percentage) for each sub-component of strategy.

Sub-Components	Weight	Priority
Green and ICT Sustainability	18.15%	1
Collaborative Operation	15.21%	2
Comprehensive Contact	14.84%	3
Encouragement	13.97%	4
Visible Campus Gov and Reporting	13.23%	5
Smart Learning Communities	12.31%	6
Fully-integrated	12.29%	7

Table A17. Priority weighting (percentage) for each sub-component of KCS.

Sub-Components	Weight	Priority
Web-lecturing systems	30.14%	1
Activity-recording systems	19.63%	2
Computer-based simulations	17.63%	3
Computer-based communication	16.35%	4
Feedback system	16.24%	5

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