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Facilitating Successful Smart Campus Transitions: A Systems Thinking-SWOT Analysis Approach

Bankole Awuzie [1,*], Alfred Beati Ngowi [2], Temitope Omotayo [3], Lovelin Obi [4] and Julius Akotia [5]

1 Centre for Sustainable Smart Cities, Central University of Technology, Bloemfontein 9301, South Africa
2 Research, Innovation and Engagement, Central University of Technology, Bloemfontein 9301, South Africa; angowi@cut.ac.za
3 School of Built Environment, Engineering and Computing, Leeds Beckett University, Leeds LS2 8AG, UK; t.s.omotayo@leedsbeckett.ac.uk
4 Department of Architecture and the Built Environment, University of Wolverhampton, Wolverhampton WV1 1LY, UK; L.Obi@wlv.ac.uk
5 School of Architecture, Computing and Engineering, University of East London, London E16 2RD, UK; j.k.akotia@uel.ac.uk
* Correspondence: bawuzie@cut.ac.za

Abstract: An identification of strengths, weakness, opportunities, and threats (SWOT) factors remains imperative for enabling a successful Smart Campus transition. The absence of a structured approach for analyzing the relationships between these SWOT factors and the influence thereof on Smart Campus transitions negate effective implementation. This study leverages a systems thinking approach to bridge this gap. Data were collected through a stakeholder workshop within a University of Technology case study and analyzed using qualitative content analysis (QCA). This resulted in the establishment of SWOT factors affecting Smart Campus transitions. Systems thinking was utilized to analyze the relationships between these SWOT factors resulting in a causal loop diagram (CLD) highlighting extant interrelationships. A panel of experts drawn from the United Kingdom, New Zealand, and South Africa validated the relationships between the SWOT factors as elucidated in the CLD. Subsequently, a Smart Campus transition framework predicated on the CLD archetypes was developed. The framework provided a holistic approach to understanding the interrelationships between various SWOT factors influencing Smart Campus transitions. This framework remains a valuable tool for facilitating optimal strategic planning and management approaches by policy makers, academics, and implementers within the global Higher Education Institution (HEI) landscape for managing successful Smart Campus transition at the South African University of Technology (SAUoT) and beyond.

Keywords: causal loop diagram; Smart Campus; systems thinking; universities

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1. Introduction

Smart City development and operation efforts have recorded varied performance, globally. However, similar attempts in Africa have been met with challenges attributed to contextual peculiarities [1–5]. For instance, there seems to be a palpable fear that the adoption of ICT technologies for Smart Cities will deepen the technology and poverty divide in these contexts [5]. Moreover, it is believed that these cities will promote exclusion and inequality instead of inclusion. Furthermore, it is feared that the expenditure towards Smart City development cannot be reasonably justified in the face of other societal challenges like hunger, strife, and outbreaks of different diseases [5,6]. Aside from elucidating communal perceptions which negate Smart City transitions in such climes, these perceptions render the consideration of contextual peculiarities during the planning, design, and development of Smart Cities imperative. Therefore, there is need to develop Smart Cities that support high levels of economic inclusivity and security in the developing world context [7]. Proponents of Smart Cities have advocated for its initiation at a micro level and scaling up upon acceptance by the populace based on increased appreciation and awareness concerning the modalities of such cities [8–11]. This line of thought has given a fillip to the Smart Campus initiative.

Universities have been described as living or real-world laboratories where innovative solutions are designed, developed, and tested for efficacy prior to eventual deployment at city-level [12–15]. These roles extend beyond the conventional boundaries of knowledge creation for Smart Cities. Society expects these institutions to, relying on multi-, inter-, and transdisciplinary (MIT) skill-sets available to them, serve as living laboratories for experimenting on Smart City components [15,16]. Accordingly, reverberations of the achievements recorded within Smart Campuses are expected to be felt across multiple scales within Smart Cities [17,18].

As part of the Smart Campus agenda, universities are transforming into Smart Communities imbued with Smart City attributes and vice versa [14,15,19–21]. Universities in South Africa are not left out as a cursory look at their websites and associated marketing paraphernalia reveals their aspirations to leverage digital technologies in transforming their operations, pedagogy, and research. These efforts are aimed at process optimization and efficiency savings and transforming learner-experiences [22].

Although these transitions are on-going, there is little evidence to show that the views of the users are being incorporated during the decision-making processes which govern its conceptualization, design, and implementation stages [23]. Scholars have observed the unidirectional nature of the Smart City implementation programs [24,25]. This is despite the need for Smart Campus projects to be mostly human-centered and user driven [26,27].

The South African University of Technology (SAUoT) is an institution where the systemic transition to a Smart Campus status is at an embryonic stage [28]. The desire to make a success of this initiative has necessitated the program proponents/designers to elicit the views of relevant stakeholder categories to foster effective decision-making and the prioritization of actionable ideas at this stage. The study on the transition process at SAUoT has been reported by the authors in previous studies [27,29]. In the study by Ngowi and Awuzie [27], the significant contribution of user-centric design to the development of a common ontology concerning various stakeholder categories was articulated. In a subsequent study [29], Ngowi and Awuzie collated the perceptions of relevant stakeholder categories concerning the potential strengths, weaknesses, opportunities, and threats associated with the on-going transformation into a Smart Campus status at SAUoT. However, the information drawn from the studies reported in these studies, particularly [29], have only provided a foundation for strategic planning of the institution's Smart Campus transition without considering the nature of interrelationships existing between these strengths, weakness, opportunities, and threats (SWOT) factors. Such an analysis will highlight how these relationships can be harnessed in planning for successful transitions in the SAUoT context where such transitions are still nascent and viewed with apprehension. In this study, the findings from the systems' thinking-enabled SWOT analysis will be used to a develop Smart Campus transition framework.

The contribution of SWOT analysis to the field of strategic management within the university context has been reported [30]. Srivastava et al. [31] reiterated its utility in eliciting community perception and participation in the development of a strategy for municipal solid waste management system in India. Furthermore, studies have highlighted the salient potential to be drawn from the juxtaposition of various multi-criteria-decision methods (MCDM) like analytic hierarchy process (AHP), analytic network process (ANP) [32–36], and fuzzy logic [37,38] for strategic planning and management. However, limited studies have shown the usefulness of systems thinking in fostering a comprehensive SWOT analysis.

Summarily, this study can be described as having two distinct yet interrelated objectives, namely: (a) to carry out a SWOT analysis of stakeholders' perceptions concerning the Smart Campus transition for the purposes of strategic planning and management using a systems-thinking methodology and an SAUoT exemplar, and (b) to propose a framework for effective Smart Campus transition based on the SWOT archetypes emerging from (a). It is expected that this paper will provide an insight into the utility of systems thinking in carrying out SWOT analysis.

The rest of the paper is structured as follows: a brief literature review of the Smart Campus agenda, a justification of the research design adopted, a presentation and discussion of the research findings, and the conclusion.

2. Literature Review

2.1. Defining the Smart Campus

The evolution of the Smart Campus initiative has been traced to the last two decades [21]. Yet, a widely accepted definition for the Smart Campus concept is lacking despite its increasingly topical nature. According to Muhammad et al. [39], extant Smart Campus definitions have been categorized into three, namely, as a technology-driven concept; a Smart City adoption concept; and/or, based on the development of an organizational or business process for enabling resource efficiency within such organizations. Furthermore, definitions under the technology-driven category posit the significance of the availability and the deployment of digital technologies towards the attainment of Smart Campus deliverables. However, definitions belonging to the Smart City adoption category appreciate the similarities existing between cities and campuses, especially as it pertains to production and consumption patterns. The Smart City dimensions are applicable to the Smart Campus albeit at a smaller scale and as such, similar measures can be deployed in enabling their occurrence and sustenance in either context [21].

Min-Allah and Alrashed [21] mapped the dominant themes of the Smart Cities against the Smart Campus themes to buttress the similarities therein. This mapping was based on five (5) dimensions; social, environmental, and economic sustainability, governance, and propagation. For more on this mapping, see Min-Allah and Alrashed [21]. Definitions in this category encapsulate the Smart Campus concept relying on the notion of the university serving as a microcosm of the city. Furthermore, such definitions attempt to elucidate the role of universities in facilitating the development of the right skillsets required by individuals to function optimally within the Smart City context was highlighted through the direct deployment of the right mix of information and communication technology (ICT) infrastructure in teaching and learning as well as research facets. These skills are deemed essential in developing smart citizens—a fundamental resource for the Smart City. Muhammad et al. [39] emphasized that definitions belonging to the last category focused on driving resource efficiencies within organizations using ICT infrastructure.

Corroborating the categorization by Muhammad et al. [39], Dong et al. [40] reiterated the need for Smart Campus definitions to be based on an articulation of the prime function of the university as an educational institution with emphasis on meeting the expectations of relevant stakeholders. They defined a Smart Campus as “an educational environment that is penetrated with enabling technologies for smart services to enhance educational performance while meeting stakeholders’ interests, with broad interactions with other interdisciplinary domains in the Smart City context” (p4). Similarly, Min-Allah and Alrashed [21] defined the Smart Campus as a campus “that utilises and integrates smart physical and digital spaces to establish responsive, intelligent, and improved services for creating productive, creative, and sustainable environment” (pp. 3–4). This study adopts both definitions. As such, a Smart Campus is presented as an efficient, safe, sustainable, responsive, and enjoyable place to learn and work, underpinned and enhanced by the availability of digital/internet-based technologies [41]. Its evolution has been linked to the need to foster a new paradigm in higher education due to the overt reliance on the information and communication technologies [25]. To Zhang et al. [26], the Smart Campus provides a smart environment for training citizens to become more productive within an evolving Smart City framework.

2.2. Characteristics of a Smart Campus

Certain characteristics are expected to be present in a campus before it can be described as a Smart Campus. As with the definition of the Smart Campus concept, there is a lack of a uniform framework for identifying these characteristics.

For instance, Davies [42] identified three elements which need to be present before a campus can be labelled as a Smart Campus. These elements include the concept of the university as a collection of people, amenities, and assets which respond to and are shaped by the values, expectations, and shifting demands of its "citizens". The availability of a robust connectivity between the operational and transactional capabilities associated with such campuses was identified as the second element. Such capabilities include sensor-based smart parking facilities and interactive learning spaces, more accessible and safer facilities through the deployment of digital lighting, and the use of relevant technologies to enhance spaces for brokering new and more nuanced relationships between students and staff, alumni, business, and community partners. These capabilities are comprised of skills required to build and sustain more complex co-design and co-production relationships across the campus or multiple campuses and beyond the campus with business, government, and start-up or innovation hubs.

According to Davies [42], the third element involves significant investment in infrastructure and services upon which the other elements are premised. Reiterating the significance of the third element, Dong et al. [40] maintained that aside from the stakeholder, a Smart Campus was mainly underpinned by the infrastructure, technology, and service layers, respectively. Any attempt at the design of a Smart Campus must consider the interplay between these layers and the influence thereof on the ability of the Smart Campus to meet stakeholder expectations. The presence of relevant technologies and infrastructure remains critical to Smart Campus transitions. Although there is a plethora of technologies available to universities for this purpose, there seems to be a consensus among scholars on the criticality of the following technologies: Cloud computing, sensor networks, Internet-of-things (IoTs), augmented and virtual reality, and artificial intelligence in Smart Campus development [21,39,40].

Similarly, Muhammad et al. [39] identify a set of Smart Campus characteristics, namely the ability to rapidly adapt and respond to changes in a manner that allows for meeting stakeholders' expectations leveraging on the intelligence embedded in the plethora of supporting systems. Furthermore, Muhammad et al. [39] assert that aside from providing an intelligent learning environment, a Smart Campus should be supportive of the customization of services based on user roles and attributes. For Dong et al. [40], a Smart Campus should be context-aware, data-driven, imbued with forecasting capabilities, immersive, collaborative, and ubiquitous. To achieve these features within the Smart Campus context, the authors highlight the salience of certain considerations during the design and implementation phase. They posit that successful Smart Campuses must be human-centered, learning-oriented, and with appropriate structures to support interdisciplinarity [40].

Therefore, a Smart Campus can be described as a campus which enables an alignment of "university as city or collective" aspirations and stronger connections across and outside the campus with the necessary investments in requisite technology assets and capabilities to bring about value creation and capture for its stakeholders. This will involve a combination of the physical and digital assets, services, and platforms to improve the total university experience across the following facets: iLearning, iGovernance, iGreen, iHealth, iSocial, and iManagement [39]. However, Zhang et al. [26] opine that the iLearning facet was most critical considering the fundamental role of universities as purveyors of knowledge.

Based on the foregoing, the rationale behind the increasing financial commitment by universities [43] towards Smart Campus transitions can be discerned. Scholars opine that such investments are predicated on the potential of the Smart Campus to transform the higher education sector through the institution of effectiveness in service delivery to relevant stakeholders [21,40,43]. Moreover, the potential of universities with Smart Campuses to fare better in terms of cost and time savings, protection of the environment, effective monitoring of attendance of staff and students as well as effective space planning and utilization efforts has been reiterated by these studies. The implementation of Smart Campus projects in universities enables the collection of critical data about operational facets for optimal decision-making.

The absence of a generic model for Smart Campus design and implementation has been highlighted [21]. This has made the appraisal of Smart Campus performance in a whole-of-campus manner by stakeholders challenging. In fact, scholars have attributed the lack of comprehensive Smart Campus projects to the absence of a generic design and implementation model [21,40]. This has led to the determination of relevant key performance indicators (KPIs) for measuring Smart Campus performance [44]. Usually, the Smart Campus is implemented according to six different work streams, namely, smart micro grid, smart utility, resource management, improved services, people management, and educational services [21]. In addition, most attempts at developing KPIs for Smart Campus are dependent on the indicators for each of these work-streams [44,45]. This is evident in the Smart Campus project reportage in extant literature. Examples of such projects include the development of an anytime-anywhere learning within a Smart Campus environment [46], Smart parking [11,47,48], frameworks for modeling movements on a Smart Campus [49], development of platforms for energy management and optimization on campuses [50–52], dynamic timetabling systems [53], the use of apps for location directions and information dissemination purposes [54], real-time space utilization measurement [55], development of a context-aware Smart classroom [56–59], and the use of digital platforms for IoT-based disaster management [60].

Although various studies have sought to explore the utility of stakeholder perspectives during the design and implementation of Smart Cities [61–68], limited studies have attempted to explore and incorporate these views in designing for successful Smart Campus transitions [29]. Obviously, eliciting such perspectives will enable better articulation of the potential challenges and enablers of such successful transitions. Obviously, such elicitation leads to the establishment of the SWOT factors and subsequent understanding of the relationship between these factors through a SWOT analysis. The accruing information from both processes will facilitate the development of a framework for managing Smart Campus transitions in a holistic and comprehensive manner. This is the contribution which this study seeks to make, leveraging multi-stakeholder perspectives within SAUoT and a panel of experts.

3. Materials and Methods

A case study research design was adopted for this study due to its provenance in enabling an in-depth investigation into a phenomenon in its natural context [69]. SAUoT was used as the case study for this research, as the background data for the systems thinking-led SWOT analysis were derived from the perceptions of various stakeholders in the university.

3.1. Description of Case Study Context (SAUoT)

SAUoT is a University of Technology which is situated in the central region of South Africa. It operates from two distinct yet interlinked campuses across two locations. SAUoT has been in operation for nearly four decades, transforming from a Technikon into a full-fledged University of Technology in 2004. Going by SAUoT's vision 2030, which declares its aspiration to be "a leading African University of Technology, shaping the future through innovation" [28], the drive for improved productivity through enabling resource efficiency during the delivery of its core mandate and the provision of a digital experience for its students and staff remains critical to this vision. Beyond this immediate focus, SAUoT has always relayed its intention to provide relevant knowledge and competencies to the region within which it is domiciled.

The SAUoT's host city, Bloemfontein, has been involved in Smart City transitions for the past decade. This aspiration has been reported in several studies [70–72]. However, limited progress has been made in this direction due to challenges identified by Das [5].

SAUoT's campus potential to serve as an ideal living, real-world laboratory to develop and evaluate a range of Smart Campus and potentially Smart City concepts have been reported by Ngowi and Awuzie [29]. Accordingly, SAUoT in articulating an institutional Smart Campus strategy is seeking to leverage this potential to provide Smart City solutions to the city of Bloemfontein. However, such contribution will be predicated on the institution's ability to successfully transition into a Smart Campus in itself. To do this, the institution needs to manage the complexities associated with such transitions in manner that is "people" oriented rather than solely "hardware-centered" [27]. This managerial approach will culminate in the avoidance of simply finding uses for new technologies and data, rather than focusing on the actual needs of those that use and service the city and campus [27,73].

This study draws on this imperative to build upon the perspectives of various stakeholders within SAUoT concerning the SWOT factors influencing the institution's Smart Campus transition with adequate consideration of relevant contextual peculiarities as reported by Ngowi and Awuzie [29]. It investigates the nature of the causal relationships existing between these SWOT factors. Furthermore, it proposes a framework, which details the nature of these interrelationships, which can be relied upon by university administrators for planning and managing Smart Campus transitions at a strategic level.

3.2. Data Collection

The collection and analysis of data for this study occurred in two phases. The first phase comprised of a brainstorming workshop whereas the second phase concerned the validation of the archetypes depicting the nature of the relationships existing between the SWOT factors identified during the brainstorming session by a panel of experts.

The brainstorming workshop session was convened and facilitated by the first and second author to elicit viewpoints from various stakeholder categories within SAUoT concerning the design and implementation of the Smart Campus initiative. An effort was made to identify and recruit discussants purposively from the different stakeholder groups present on campus [74]. The import of this selection was premised on the need to provide these groups with the opportunity to participate in the development of a protocol for SAUoT's Smart Campus transition. In total, 19 participants were recruited aside from the authors who acted as facilitators. Stakeholder groups from which these participants were drawn included: non-academic personnel from the Registry, Finance/Accounts, Procurement, Facilities, and Information and Communication Technology (ICT) departments. Members of academic staff representing different disciplines and a select number of students from the Student Representative Council (SRC) participated in the workshop. The distribution of the discussants is provided for in Table 1.

In summary, the workshop featured a truly representative audience comprising of the internal stakeholders of the university community.

The facilitators had requested for researchers in the audience to make presentations on the utility and application of the Smart ideology according to their different specialisms. These presentations lasted for 10 minutes each on average. PowerPoint presentations on themes such as Smart Buildings, Smart Energy, Smart Water, Smart Mobility, and the Internet of things (IoT) was carried out. In the aftermath of these presentations, questions around salient issues were posed by the facilitators to achieve the objective of the workshop—the development of a common ontology among different stakeholder categories concerning a Smart Campus and identification of priority areas where the incorporation of smart features were deemed imminent.

Table 1. Demographics of experts.

No.	Sector	Discussant Code	Number of Discussants per Category
1.	Registry	R1-2	2
2.	Finance/Accounts	F/A1	1
3.	Procurement	P1-2	2
4.	Estates and Infrastructure (Facilities)	FA1-2	2
5.	Information and Communication Technology (ICT)	ICT1-2	2
6.	Student Representatives	SR1-4	4
7.	Academic staff	AS1-6	6
	Total		19

Source: Compilation from author's fieldwork (2018).

Questions posed to the audience during the deliberations were centered on the following thematic areas:

- A context-specific definition of the Smart Campus;
- Stakeholders' expectations of a Smart Campus environment;
- An appraisal of the state-of-art Smart infrastructure at SAUoT; and
- A SWOT analysis concerning the transition towards a Smart Campus environment.

However, for this study, the focus will be on the analysis of the causal relationships existing between the SWOT factors emanating from the last objective of the brainstorming session. Findings from these objectives have been reported elsewhere [27,29].

Discussants were requested to write down their answers on a notepad once a question was posed. A round of discussion ensued upon receipt of the notepads and the facilitator tried to achieve a consensus among participants on key issues concerning that question. This process lasted for three hours with breaks in between. The facilitators thematically analyzed the texts provided by the participants during the workshop. A comprehensive document outlining the details of the workshop was compiled by the authors and subsequently shared with the participants later. At this point, these participants were availed with a one-week window to either express their reservations on the information provided or make clarifications where necessary concerning the emerging implementation objectives included in the document. At the end of this period, all participants agreed that the content of the compilation as it pertained to the SWOT factors was a valid reflection of their contributions.

Subsequently, the systems thinking methodology was applied to establish the interrelationships between these factors using causal loop diagrams (CLD). The emergent CLD representation of the interrelationships between these factors, see Figure 1, was shared with five experts for validation.

3.3. Validation of SWOT Causal Loop Diagram

In validating the initial SWOT causal loop diagram in Figure 1, structured interview questions as stated below were sent to five different experts in three continents and five countries. The interview questions covered the content, structure, practicability, and acceptability of the SWOT causal loop diagram in Figure 1. Thus, the interview questions were:

(1) Are there any missing variables from the list?
(2) Please can you briefly indicate any variable that should be linked to each other?
(3) Considering the structure of the causal loop diagram, do you think this diagram represents a SWOT for a Smart Campus implementation?
(4) Do you think the causal loop diagram is simple enough?
(5) Are there any ambiguities in the causal loop diagram above?

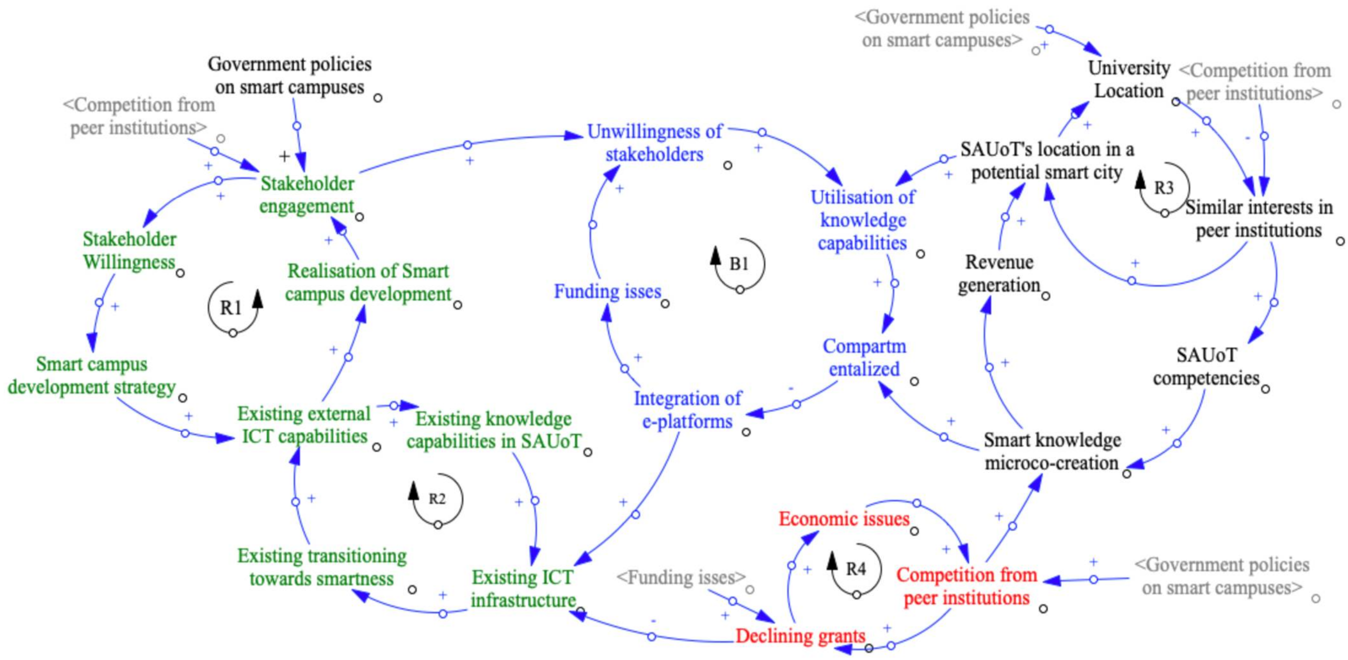

Figure 1. Initial SWOT causal loop diagram (green—strengths; black—opportunities; blue—weaknesses; red—threats) Source: Authors' construct (2020).

The experts contacted for the purpose of validation of the SWOT causal loop diagram were mainly academics in built environment schools in South Africa, the United Kingdom, and New Zealand with an interest in Smart Cities, Smart Campus, and systems thinking research. The feedback from these experts who are situated in Africa, Europe, and Oceania provided a multi-dimensional overview of how Smart Campuses are perceived in other regions of the world. The experts' demographics are provided in Table 2.

Table 2. Features of expert involved in the validation phase.

Experts	Country of Residence	Profession
EXP1	South Africa	Professor of Construction project management
EXP2	South Africa	Senior researcher in built environment
EXP3	United Kingdom	Senior Lecturer in Quantity Surveying
EXP4	United Kingdom	Lecturer in Quantity Surveying
EXP5	New Zealand	Post-doctoral fellow in construction project management

4. Results

4.1. A SWOT Analysis Concerning the Transition Towards a Smart Campus Environment

Table 3 provides a summary of the responses of the stakeholders, categorized according to SWOT of SAUoT's Smart Campus transition as elicited from the workshop session at the institution.

Table 3. A strengths, weakness, opportunities, and threats (SWOT) analysis of the South Africa University of Technology (SAUoT)'s Smart Campus transition.

Strengths	**Weaknesses**
1. The realization of the need to develop a Smart Campus; 2. The apparent willingness on the part of a sizeable number of stakeholders to be a part of the initiative; 3. The presence of an already existing ICT infrastructure at the university, hosting several platforms like the e-learning platform; 4. The presence of knowledge capabilities within the institution; and 5. Some faculties are already experiencing a transition towards Smartness (starting from going paperless).	1. Poor integration of extant e-platforms on the Information Technology Support (ITS); 2. Unwillingness on the part of relevant stakeholders to embrace the Smart Campus initiative; 3. Poor and inadequate funding issues; 4. Compartmentalized nature of the various pockets of knowledge; and 5. Inability to effectively utilize the knowledge capabilities present on campus.
Opportunities	Threats
1. Advantages conferred on the University by virtue of its location; 2. The location of SAUoT (within a city desirous of attaining a Smart City status) is considered an opportunity. SAUoT can provide the competencies required, if it becomes smart. This can provide opportunities for the co-production/co-creation of smart knowledge assets which can in turn bring about improved revenue for the institution. 3. Presence of similar interests in peer institutions, regionally, nationally, and internationally for benchmarking purposes.	1. Competition from peer institutions 2. Declining grants from external sources (Department of Higher Education and Training (DHET), Department of Science and Innovation (DSI) etc.)

Source: Ngowi and Awuzie [29].

4.2. Systems Thinking: SWOT Causal Loop Diagram

Systems thinking enables an articulation of causes and effect, action, and impact of cybernetic decisions [75–78]. It contains loops which result in archetypes of causalities derived from prevailing attributes of a system [79,80]. Thus, systems thinking aims to understand why and how one attribute influences another [79,81]. In the application of systems thinking in organizational studies and management, the causal loop diagrams reveal other attributes of the systems during their development [81]. In a loop with all positive influences of the attributes on each other, there will be a reinforcing loop. Each arrow in a loop indicates the direction of the relationship. The positive (+) and (-) signs on the arrows reveal the nature of the impact of one attribute on another. When there is an odd number of negative loops in the system, a balancing loop will be noted. Within a system, there will be reinforcing and balancing loops.

The SWOT causal loop diagram in Figure 1 applied the SWOT analysis in Table 3 to present an understanding of how campuses can transit into a Smart community within a city. The attributes with green, black, blue, and red, all represent strengths, opportunities, weaknesses, and threats, respectively. The initial causal loop diagram produces reinforcing loops R1, R2, R3, R4, and balancing loop B1. Some variables emerged during the development of the initial SWOT causal loop diagram. These are government policies on Smart Campuses (S); funding issues (W); economic issues (T); Smart Campus development strategy (S); and revenue generation (O). In order to develop a realistic SWOT causal loop diagram for Smart Campuses, the initial SWOT causal loop diagram in Figure 1 was validated through the expert interviews.

Table 4 highlights a summary of the feedback obtained from the expert panel based on the questions posed. These responses were instrumental to the restructuring of the SWOT causal loop diagram and the SWOT archetypes.

Table 4. Summary of findings from experts' opinions.

Expert Opinion Codes	Experts' Comments	Changes Effected
SA-EXP1	Inclusion of new SWOT variables: Strength International incentive. Engagement of campus end users. Weakness Absence of local examples. Opportunities Location of campus SAUoT-city aligned values. Presence of similar interests for benchmarking purposes. Similar international guidelines. Platform for implementing sustainable campus objective. International grants. Enhancement of university curriculum. Threat Executive management's interest.	Strength International incentive. Campus user's engagement. Weakness Local examples. Opportunities SAUoT's location in a potentially Smart City was stated. Existing interests for benchmarking. Similar international guidelines. Platform for implementing sustainable campus objective. University curriculum. Threat Executive management.
SA-EXP2	Suggestions stated: Separation of CLDs The CLDs or conceptual models for each aspect may be made separately by considering the most influential parameters and their one way or two-way causalities. Structure Think in terms of "information- decision-action-impact" on the system (environment) (information leading to a decision based on which actions are taken and the actions have an impact on the system), then the action will come back as the information as feedback. Polarities Polarities only influence two consecutive variables and succeeding or preceding to the two concerned consecutive variables are not impacted by the polarities assigned to the two variables. For example, IF there are four variables linked in a feedback loop A-B-C-D, then A influences the polarity of B but does not influence the polarity of C. Balancing loops Even number of negatives becomes positive and adds to become a reinforcing loop and odd number negative becomes negative and generates a balancing loop (ll balancing loops are not bad—they are needed to stabilize the system).	The different models were separated according to the reinforcing loops and SWOT. The structure of the model was revised according to "information- decision-action- impact". The polarities have been revised accordingly. This is evident in R1, R2, R3, and R4. The change in structure and variables have led to new balancing loops.
UK-EXP1	Suggestion stated: Description The model is concise, and it described the issues associated with the transition to Smart Campus within the tertiary educational sector.	The positive feedback was used to enhance the structure and polarities.

Table 4. *Cont.*

Expert Opinion Codes	Experts' Comments	Changes Effected
UK-EXP2	Suggestion stated: Clarity The model is not very simple to understand in some respects as it is not clear to understand the connections in a few places. For example, it is not clear how stakeholders' engagement leads to unwillingness of stakeholders as a weakness. Also, how can unwillingness of stakeholders, result in utilization of knowledge capabilities or do you mean underutilization? Not clear how Smart knowledge micro co creation is an opportunity for compartmentalization? Where possible the links can be better described for clarity.	More neutral words were used to describe the variables. "Unwillingness of stakeholders" has been renamed as "stakeholder willingness". The connections of knowledge capabilities were revised.
NZ-EXP1	Suggestions stated: Summary and further explanation The reinforcing and balancing feedback loops are clearly indicated to enable experts understand the system. However, R1-R4; B1 needs to be summarized to increase clarity, especially for higher education stakeholders who do not have the knowledge of system dynamics. Clarity on "government policy" Government policy is linked to R1; R3; and R4. Any significance considering it is not one of the SWOT variables in Table 1? Same thing applicable to "economic issues" linked to R4!	Archetypes were produced in addition to the new structure. The archetypes will be explained individually. There are new variables, reworded variables, and connections in the CLD has changed and there are new reinforcing and balancing loops which will be explained in a separate section.

Source: Authors' compilation (2020)

Considerable changes were made to the initial SWOT causal loop diagram. The summary of SA-EXP1 view's elucidated new SWOT sets for the causal loop diagram. These included international incentive (S); campus user engagement (S); local examples (W); SAUoT's location in a potentially Smart City was stated (O); existing interests for benchmarking (O); similar international guidelines (O); platform for implementing sustainable campus objective (O); University curriculum (O); and executive management (T). SA-EXP2 provided suggestions on the polarities, structures, separation, and balancing loop. He observed an error in balancing loop B1 as B1 was observed to be another reinforcing loop. The polarities of the loops were reconsidered.

Other suggestions from UK-EXP1, UK-EXP2, and NZ-EXP1 were incorporated into the validated SWOT causal loop diagram in Figure 2.

The archetypes extracted from Figure 2 expunged the required reinforcing and balancing loops for the attainment of a successful Smart Campus transition. The experts' feedback was used to create a non-regional SWOT causal loop system as illustrated in Figure 2. Consequently, the outcome of each archetype described in the subsection below can be transferred to many campuses in developing countries where holistic Smart Campus transitions are at embryonic phases due to lack of awareness and knowledge. This challenge is further exacerbated by the lack of relevant literature detailing the evidence of successful holistic Smart Campus transitions and/or guidelines for achieving same, globally [23]. This is a gap where this study seeks to make a salient contribution towards bridging. An improved knowledge base concerning the procedure for eliciting and applying stakeholder perspectives through a systems-led SWOT analysis will assist university administrators, particularly in developing countries, to embark on such transitions.

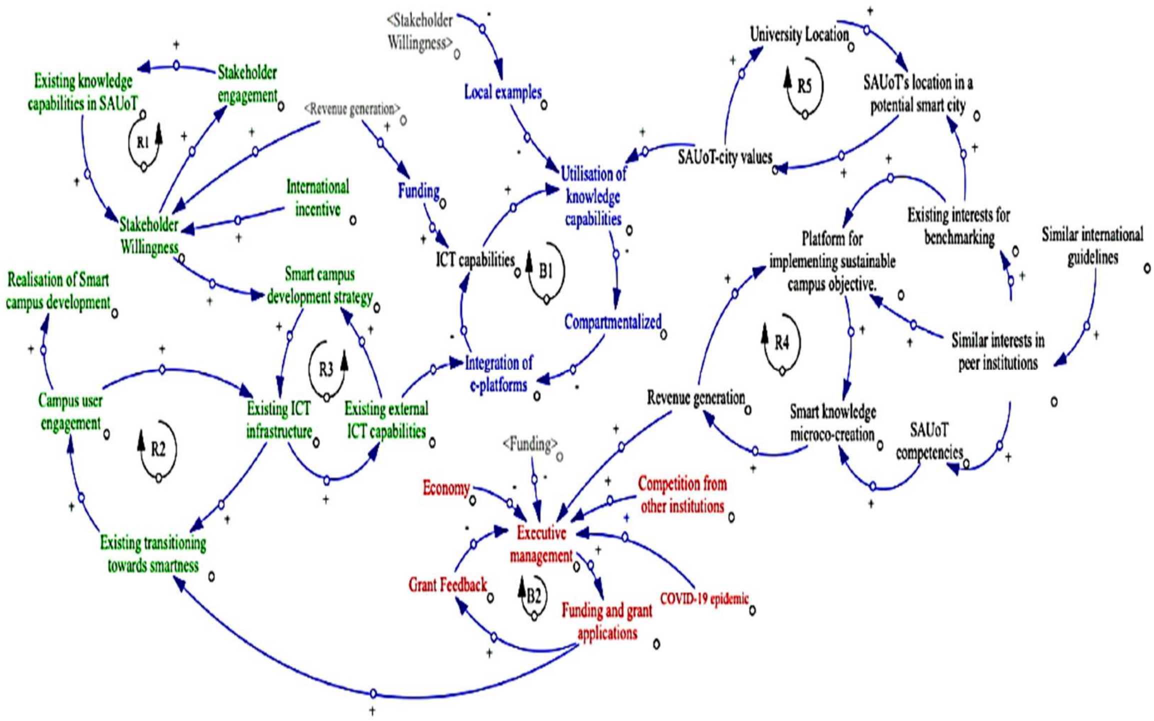

Figure 2. Validated SWOT causal loop diagram.

5. Discussion

5.1. Archetypes for Smart Campus Transitioning

Reinforcing loop R1 emerged from the "strength" category of the SWOT causal loop diagram in Figure 3. In R1, stakeholders' willingness to create a Smart Campus depends on revenue generated and international incentives. If the stakeholders managing the campus have enough revenue to create a Smart Campus, coupled with international incentives, stakeholder engagements will utilize existing knowledge capabilities at SAUoT to understand the requirements for a Smart Campus. Hence, reinforcing loop R1 leads to a Smart Campus strategy in Figure 3. Several meetings and consultations must be held with relevant stakeholders such as the University's governing council, information technology experts, and funding agencies. The realization of a Smart Campus development is linked to reinforcing loop R2.

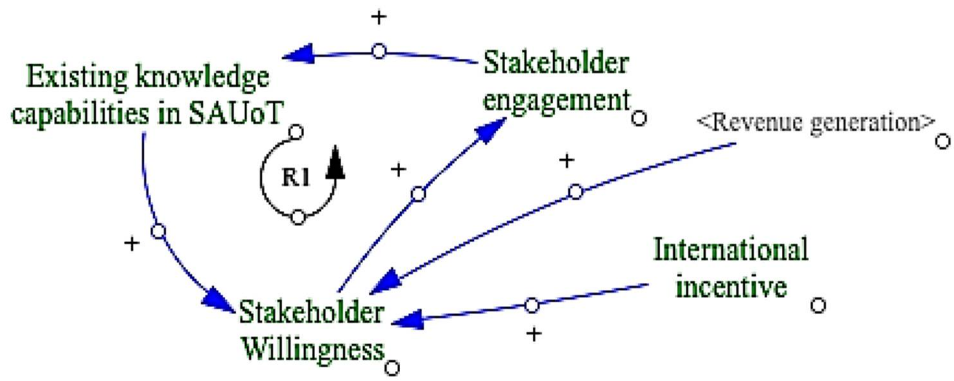

Figure 3. Reinforcing loop R1.

The reinforcing loop R2, in Figure 4, engaged more with the strengths associated with the development of a Smart Campus. With a capable ICT infrastructure on campus, it will be very easy to transition into a Smart Campus with the inclusion of the campus end-users. The campus end-users, in this case, are the students and staff of the university.

By harnessing data from all end-users, an understanding of what is required for a Smart Campus can be created. The existing ICT infrastructure on the SAUoT campuses can feed data into the reinforcing loop R3 for a Smart Campus development strategy.

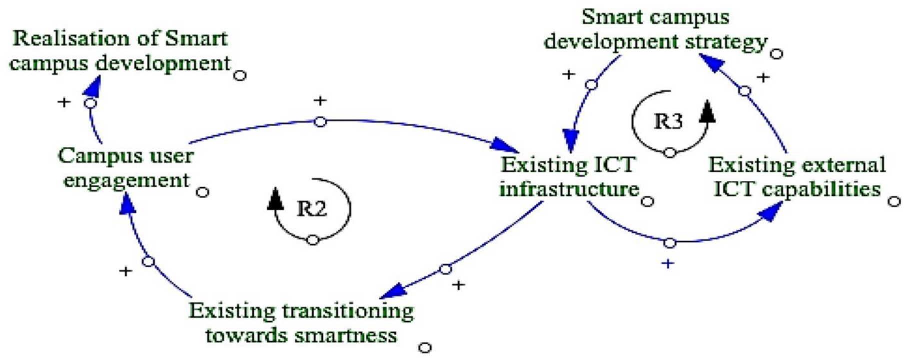

Figure 4. Reinforcing loops R2 and R3.

Reinforcing loop R3 is an archetype that depends on R1 and R2. Reinforcing loop R3 illustrates the strengths of SAUoT where they have an existing ICT infrastructure on campus, a Smart Campus in a city has the capacity to enhance and create a Smart City. Consequently, a Smart Campus strategy can be incorporated into the city of Bloemfontein's Smart City strategy. The existing ICT capabilities in many South African cities is a strength for the integration of digital platforms.

Reinforcing loop R4 and R5 as shown in Figures 5 and 6, emerged from the opportunities section of SWOT causal loop diagram of Figure 2. In R4, revenues generated in SAUoT are opportunities for creating and implementing sustainable Smart Campus objectives. The Smart Campus objectives enhanced the smart knowledge co-creation at the micro-level. The knowledge created for Smart Campuses can further generate revenue for the campuses through grants, international collaboration, and incentives. The location of a university enhances the creation of a Smart Campus. In R5, a campus located in the heart of or near a city can spur the emergence of a Smart City. As such, if SAUoT is situated in a Smart City, this can enhance its agenda by merging with city values for a Smart Campus and City. Furthermore, it is easier to have a Smart Campus when the University is in a Smart City. The quest of SAUoT's host city to transform into a Smart City has been reiterated previously. Accordingly, this quest holds salient potentials for exerting a positive influence on SAUoT's Smart Campus transition.

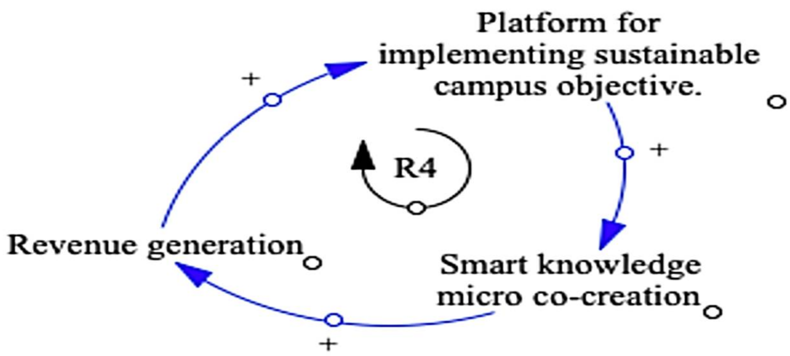

Figure 5. Reinforcing loop R4.

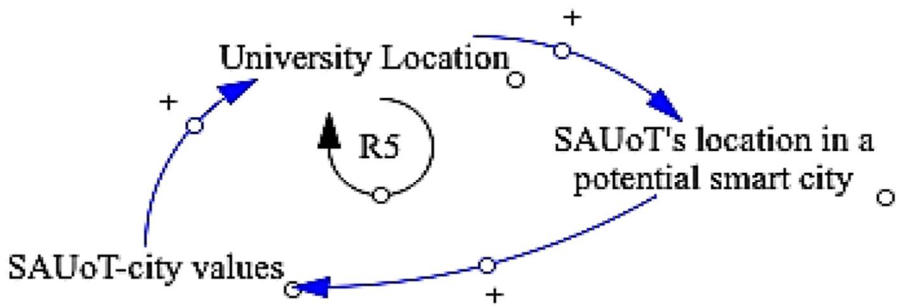

Figure 6. Reinforcing loop R5.

Balancing loop B1 in Figure 7 emerged from the weaknesses section of the SWOT campus causal loop diagram in Figure 2. The existing of funded ICT capabilities and local examples will invariably encourage the utilization of knowledge capabilities on campus. However, lack of effective utilization of the knowledge and existing challenges of compartmentalization of University campuses can decrease the integration of digital platforms required as end-user interface for data harnessing. It becomes increasingly difficult to create a Smart Campus when there are funding issues and underutilization of the existing knowledge in the University. This scenario may result from University governance issues.

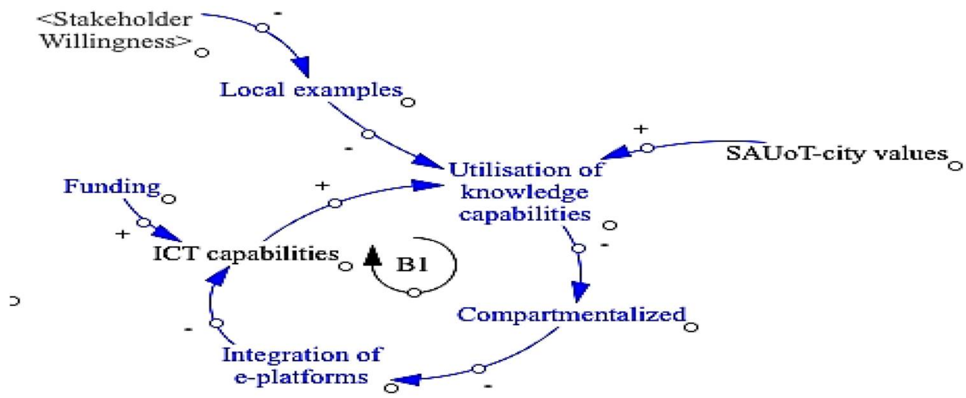

Figure 7. Reinforcing loop B1.

The major threats to Smart Campus transitions as expressed through balancing loop B2 in Figure 8 are economic and funding issues. Most universities have lower revenue and funding because of the current coronavirus disease 2019 (COVID-19) epidemic. The executive management will encourage grant applications for the development of a Smart Campus. However, negative feedback from the grant applications will hinder or deter the transitioning of campus into Smart Campus. Competition from universities situated within the same geographical location with the same Smart City agenda may delay or boost the transitioning process.

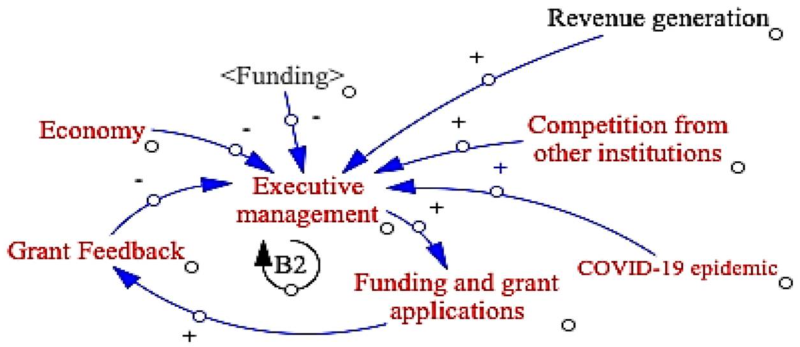

Figure 8. Reinforcing loop B2.

5.2. Developing a Framework for Managing SWOT Factors during Smart Campus Transitions

The archetypes in Figures 3–8, culminated into the SWOT Smart Campus transition framework which is presented in Figure 9. The factors which are repeated in more than one category (presented in white-colored boxes in Figure 9) are considered key factors. These factors are the most critical of the range of SWOT factors identified and should be prioritized in the strategic planning and management process for Smart Campus transitions. For instance, revenue generation is a strength when there is a high level of revenue in the SAUoT. Moreover, it has the potential to pose as an opportunity when the transition is expected to contribute towards widening the revenue generation streams available to SAUoT. An example of this could be seen in the potential of the significant deployment of digital platforms and sensor networks for managing energy and water consumption on campus. Such deployment has the potential to bring about cost-effectiveness whilst allowing the institution to utilize this technology and knowledge to attract external funding from entities undergoing digital transformation. Therefore, administrators of SAUoT and other universities trying to engage in Smart City transitions should not concern themselves with enhancing revenue generation alone, but should also make sure that existing revenue streams are not negatively impacted upon by during such transition, lest it become a threat. This is the case with the COVID-19 pandemic.

The Smart Campus transition framework further buttresses the criticality of funding. SAUoT and universities globally depend on funding from the government, donor (agencies), and other relevant bodies. Funding ICT infrastructure remains a major challenge in universities, particularly in developing countries like South Africa. This funding challenge has become a major constraint in the present pandemic economy. Considering the social and fiscal constraints caused by the COVID-19 epidemic, lack of funding remains a weakness and a threat to the realization of Smart Campuses in South Africa and elsewhere. It is evident that the pandemic has led to a re-ordering of government fiscal priorities and this may impact negatively on the availability of funds for driving the transition, thereby constituting a weakness and a threat. University administrators need to prepare for such uncertainties, especially as it pertains to funding shortfalls during these transitions.

SAUoT-city values and plans for a Smart City have been shown as acting as an opportunity for Smart Campus development and a weakness. This is dependent on the availability of a Smart City development aspiration or plan within the host local government and/or municipality. The relationship between Smart Campuses and cities was studied by Villegas-Ch et al. [19]. In that study, the authors posited that local administration and governance were sacrosanct to achieving Smart Campuses. SAUoT is fortunate to be situated within a geographical context where the local and provincial government have successfully reiterated their desire to transform into a Smart City. In addition, these levels of government have established a partnership between themselves and the SAUoT to accentuate the actualization of this mandate.

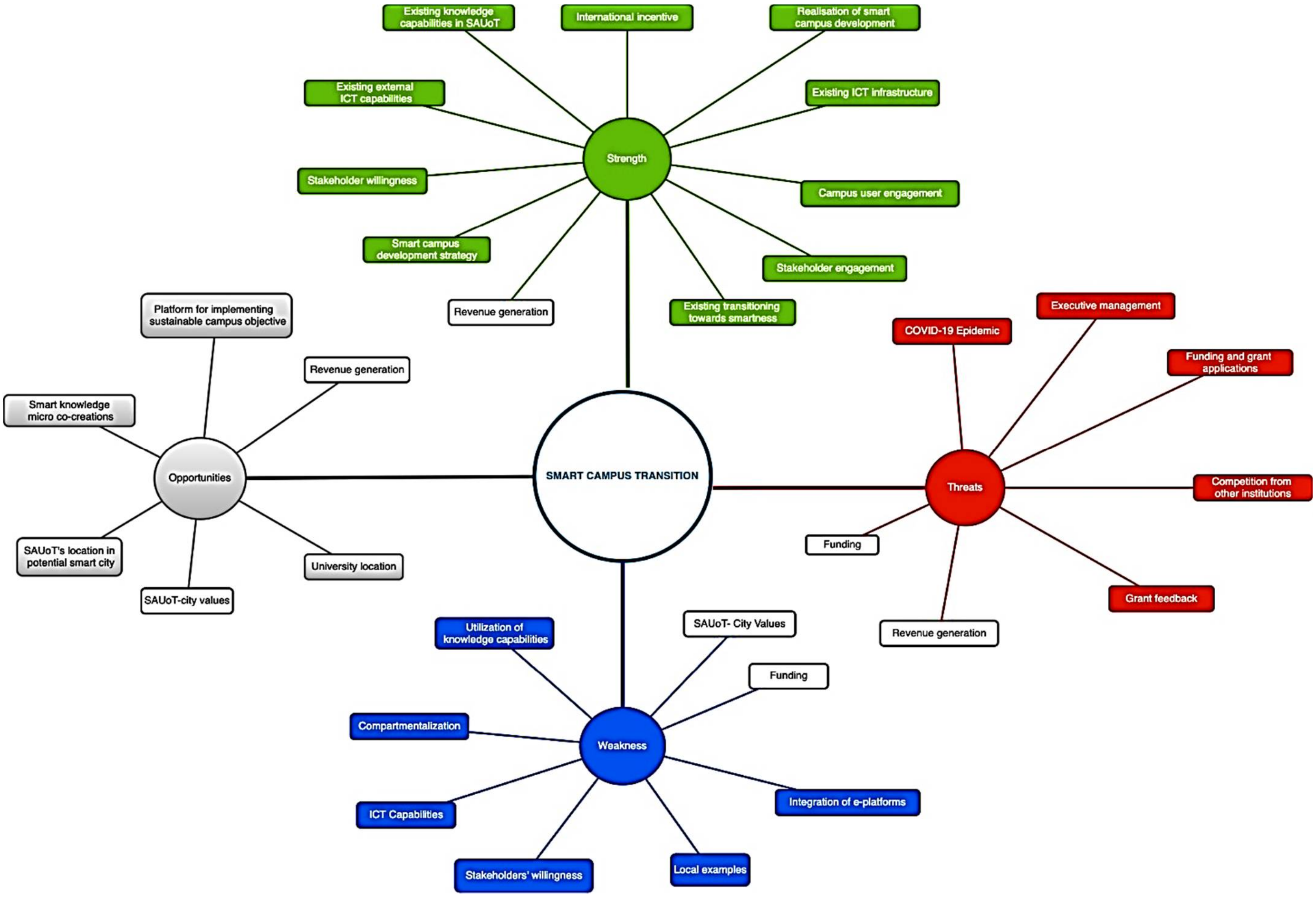

Figure 9. A framework for managing SWOT factors influencing Smart Campus transitions.

To develop strategic blueprints for achieving Smart Campuses in SAUoT and other universities, the green- and grey-colored factors in Figure 9 should be focused on as the positive factors, while the blue and red factors must be monitored and reduced.

6. Conclusions

This study outlined the need to develop an appropriate a management framework for engendering successful Smart Campus transitions in universities as previous undertakings have not been able to purposefully capture and represent intrinsic system components and interrelationships. In this respect, several challenges were highlighted, including contextual positioning and archetypes. Acknowledging these challenges, this research engaged a systems theory-led SWOT analysis, relying on causal loop diagrams to unpack these issues, given the need to embrace interrelated and interdependent aspects, context, and operational dynamics. A framework approach could help provide additional clarity on how to plan and manage successful Smart Campus transitions.

Data from a case study research strategy involving a brainstorming session and expert opinions were used to develop a management framework for engendering successful Smart Campus transitions which was designed specifically to help the SAUoT's leadership to manage the Smart Campus transition process successfully. This incorporated four key opportunities, ten areas of strengths, six areas of potential weaknesses, and four areas of potential threats. The framework standardizes transition management practice that provides a systematic "blueprint" for understanding how campuses can transit into a Smart community within a city. Core findings include the need to optimize and maximize ICT infrastructure, stakeholder engagement and management, location of universities, utilization of knowledge capabilities, and funding.

Universities in the developing country context have been reluctant to engage with Smart Campus transitions due to the paucity of knowledge concerning the subject. Moreover, relevant literature detailing procedures for enabling these transitions within universities are lacking and at best, nascent. The absence of this literature posed a limitation to this study as it negated an ability to compare the SWOT factors and the established interrelationships with the findings of similar studies from other institutions globally. However, from a contribution to knowledge perspective, this study provides an understanding of the archetypes and complex interrelationships between the SWOT factors associated with the Smart Campus transitioning process within the SAUoT context.

Finally, from a generalizability and repeatability perspective, whilst this framework was developed for the SAUoT-city methodologically, it is transferable to other contexts and particularly useful for universities trying to successfully transition into Smart Campuses. This feat was engendered using the views of subject-experts from different countries aside from South Africa. However, from an operationalization perspective, additional research to establish the areas needed to meet local context may be required. Another limitation of the proposed frameworks lies in its transferability, given the differences in universities. Universities are influenced by contextual peculiarities and other variables like size, location, ownership, leadership and governance systems, history, etc., all of which makes the development of a one-size-fits-all Smart Campus transition framework, challenging, if not impossible. However, administrators from other institutional contexts can adopt the steps taken in this study to articulate the SWOT factors and the interrelationships between them to develop a context-dependent Smart Campus transition framework. Therefore, future research imperatives include the need to involve multi-case studies to support external validity and reliability for different country settings.

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