Integrated computer-based management information systems: The complexity and diffusion in Rwandan higher education institutions

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ABSTRACT

The current trend in universities is marked by integrating information technologies into their service delivery. Particularly in administration and management, processes are being modernized, although not successful in some institutions. This study aims first to understand the complexity of an integrated educational management information system (UR-IEMIS) at the University of Rwanda and then to evaluate the degree of its diffusion in university services. Complex Adaptive System and Innovation Diffusion theories were used as a conceptual framework for this study. Document survey, observations, and interviews were used for data collection. Findings indicate that the UR-IEMIS is characterized by the complexity features as it is composed of several different subsystems (Organism, Roles, Objects, Method, and Concept) which emerge, interact, co-evolve, and re-organize to adapt to the disruptive institutional structures. It was also revealed that the UR-IEMIS integration is still at the abstraction level for all subsystems while for only few university functions, the system is diffused at knowledge, persuasion, and decision stages. Likewise, concerns related to the current unsatisfactory state of UR-IEMIS integration and proposals for improvement are discussed. Further studies should explore the complexity and diffusion levels for E-learning systems that support pedagogical activities in a similar case study context.

Keywords: *Complex adaptive systems; Higher education; Educational Management; Information systems; Technology integration; Diffusion of innovation; University administration*

INTRODUCTION

The advancement of technology continues to make considerable changes in different areas, and the education sector is not left behind. The administration and management of university services are modernized through the integration of computer-based management information systems (Zainally, 2008; Krishnaveni & Meenakumari, 2010). Once these systems are adopted and used by administrators, faculty members, and students, then universities can make effective managerial decisions based on the recorded data (Hashim, Alam & Siraj, 2010). Computer-based Information systems are used in higher education institutions to support services such as student management, course management, estate management, personnel (teachers and administrators) management. Accordingly, with the emergence of new technologies, the generated educational data are innovatively and appropriately managed in an institutional digitalized working environment. The complexity of ICT integration in the above services, which involves more agents, acquisition of new IT skills, policy redesign, and innovative process re-engineering, is recognized as a constraint of an innovation diffusion process across the university. In information

systems implementation, this complexity depends on a number of factors such as institutional structure, individual culture, and the institutional working environment.

Although the primary activities of educational institutions are teaching and learning, this requires proper planning, management, and administration of services (Zainally, 2008). For this to be innovatively done, information and communication technology (ICT) is overriding as a means to the end. Once well integrated and perceived positively by users, technology contributes enormously to the modernization of university services. Therefore, a number of technology-supported systems, commonly known as integrated computer-based management information systems, are implemented to support traditional processes with the aim to improve the quality of service in universities (Hua & Herstein, 2003; Seeman & O'Hara, 2006; Berggren, Fili & Nordberg, 2015). These initiatives are also considered as ICT capacity building which involves staff training, updating existing ICT policies and strategies, acquisition of new ICT infrastructure, and the establishment of IT governance structure among other activities (Byungura et al., 2016).

A number of scholars explored the complexity of information systems in different domains such as the health sector (Sturmberg & Martin, 2013; Paina & Peters, 2012), strategic organizational leadership (Uhl-Bien & Marion, 2009; Schneider & Somers, 2006), supply chain management systems (Pathak et al., 2007) and natural resource management systems (Rammel, Stagl & Wilfing, 2007) among others. Some others focused on higher education systems, more particularly for understanding the complexity of the modern teaching and learning environment (Mennin, 2007; Wang et al., 2015). However, the theory of Complex Adaptive Systems (CAS) is not widely used in social systems (Rickles, Hawe & Shiell, 2007; Keshavarz *et al.*, 2010) such as to evaluate the integration of information systems in university administration and management. Therefore, research is scarce on the complexity of management information systems that are implemented in higher education to support the innovation in educational management, especially in newly merged institutions from a developing country context.

For the University of Rwanda, the only public higher education institution in the country after the recent merging of all the former public institutions (Government of Rwanda, 2013), an integrated educational management information system labeled as UR-IEMIS is being implemented in the six colleges. Thus, typical research is vital to understand the complexity of this new technology-supported system, for which its successful implementation involves human, infrastructure and structure dimensions. This study elaborated on the concepts of complex adaptive systems (Marion, 1999; Miller & Page, 2009; Cilliers, 1998) and innovation diffusion theory (Rogers, 2010) to explore the complexity of UR-IEMIS and its stage of diffusion at the University of Rwanda. Two research questions guided this study: (1) How complex is the integrated educational management information system, being implemented at the University of Rwanda? (2) What diffusion levels has this system attained since its introduction at the university to improve the administrative and managerial processes?

COMPLEX ADAPTIVE SYSTEM AND TECHNOLOGY INTEGRATION IN UNIVERSITY ADMINISTRATION

With the advance in technology, higher education institutions are required to reorganize their subsystems to adjust to the new working environment (Krishnaveni & Meenakumari, 2010). With this reorganization, the university community at each level might learn new ways of acting for the common university goal. In some cases, the newly implemented technologies fail to adapt to traditional university structures. Hence, it is worth to understand that they are several mechanisms behind such a trend and, thus one can claim that current universities are becoming more complex due to the integration of new computer-based tools into the traditional institutional processes.

The theory of complex adaptive systems (CAS) has attracted a number of scholars (Boal & Schultz 2007; Leeuwis & Aarts 2011; Keshavarz et al. 2010; Paina & Peters 2012). This theory is mainly applied as a multidisciplinary scientific approach to understanding the complexity of interrelated agents (subsystems) and processes within an entire system perception. From the technology perspective, some researchers use the CAS theory to analyze the management of information technologies in the organizations (McCarthy, 2003). While the complexity theory maintains that the universe encompasses several systems including weather systems, social systems, body systems, and immune systems among others, all these systems are explained as constantly adapting (Cilliers, 1998) within the entire system environment. Thus, holistically, they create a complex environment and hence a "complex adaptive systems theory" is grounded. This theory maintains that complex adaptive systems are characterized by the following features such as adaptability, self-organization, emergence, dynamism, non-linearity, co-evolution, and connectivity (Holland, 1992; Cleveland, 1994; Miller & Page, 2009; Cilliers, 1998; Marion, 1999; Boal & Schultz, 2007; Johnson, 2001).

Although it can be difficult to predict what will happen in a particular system environment with CAS theory, this concept can provide a systemic framework for people such as university managers, IT specialists and administrators to think about the current digital university working environment. Based on the above-explored literature, with the theory of complex adaptive systems, it is too possible to analyze a particular implementation of technology in the traditional processes of an organization such as higher education institutions.

The CAS in the context of innovation diffusion at university

The theory of innovation diffusion focuses on three aspects namely, innovation characteristics, innovation process, and the characteristics of innovation adopters (Rogers, 2010). In this study, the focus is on the diffusion process on the one hand and then on the complexity as one of the innovation characteristics on the other hand. Since diffusion is a process through which a particular technology is communicated and adopted by members of an organization over a period of time, integrating a specific IT tool in the administration of higher education institutions can be considered as an innovation diffusion process (Omona et al., 2010). Being a new tool for members of a social system, the adoption of a computer-based management information system within a university setting must follow some integration steps. Therefore, some technologies integrate rapidly while for others it takes longer than expected.

Within a context of a higher education institution, the way the university community perceives the characteristics of a new technology affect its extent of adoption and diffusion. Subsequently, the introduction of a computer-based management information system to staff and students creates new information and different perceptions. As a result, this influences an individual's intention, judgment and belief over a period of time during the system's diffusion process (Kaminski, 2011; Rogers, 2010). Therefore, if a system is perceived to have a greater relative advantage, is less complex and for which positive results are easily observable to individuals, it will spread rapidly across the entire institution. The position of Rogers' innovation complexity, as one of the features of innovation, implies that the innovation process can also be linked to the theory of complex adaptive systems. Likewise, as evidenced in the research of (Johannessen & Aasen, 2007; Leeuwis & Aarts, 2011) these two theories can be jointly used to understand the extent of complexity of particular technology integration in an organization such as a university.

As earlier described, an innovation diffusion process is one of the components of Rogers's theory. The diffusion of innovation process involves some steps taken by individuals, units or subsystems in an organization. This process starts from awareness to domestication of innovation (Rogers,

2010). Hence, according to Rogers (2010), the levels of innovation (technology) diffusion process are briefly the abstraction, knowledge, persuasion, decision, implementation, and confirmation. While working as a connected set of subsystems, each part of the system is an essential determinant of the diffusion process stage of a particular innovation. For example, the confirmation stage, the last one for the technology diffusion process, will be attained if all the subsystems have recorded a high degree of adoption and use according to the institution's implementation plans.

For this study, in particular, the UR-IEMIS integration process is considered as an innovation which may be complex to some extent. Therefore, for a university setting, with a number of subsystems and different categories of users, it is important to understand the extent to which a particular technology such as the UR-IEMIS has been diffused. Thus, this study uses the above six stages of the innovation diffusion process for this purpose.

PROPOSED CONCEPTUAL FRAMEWORK

In this section, a conceptual framework (Ravitch & Riggan, 2016; Maxwell, 2013) highlighting the complexity of an integrated computer-based management information system is theoretically proposed. Therefore, as the purpose of this paper is to explore the complexity of an information system which is being integrated as an innovation in an educational institution, it is important to propose a theoretical model that serves as a basis for this investigation in a real-life context and structuring the study findings.

As earlier described, the managerial activities in higher learning institutions consist of student administration, personnel administration, financial administration and assets administration among others. With the highly increasing complexity in these processes for today's universities, technology is integrated as an innovative support component to improve efficiency in service delivery. In addition to these activities, communication among academic, technical and administrative staff can also be handled by some specific features of the holistic educational management information systems.

It is in this regard that in some contexts, a specific educational management information system is viewed as a complex platform which is made of subsystems. Hence, each of these subsystems plays a specific role in each information process for the common goal of the entire system. Accordingly, with the explored literature and the current practice of administration and management of university services, a seven-dimensional conceptual framework is proposed. Figure 1 below, illustrates the relationship between the seven subsystems/actors of the Complex Adaptive Management Information System for education institutions and how they are interrelated with the process of diffusion of innovation from a university context. The key subsystems are namely, Institution, Teacher, Student, Administrator, Institutional Data, Technology, and End-user support.

The institution subsystem of the framework shown below includes all the available strategic managerial mechanisms that are in place at the university to support the integration and use of the system. These include for examples the policies, plans, and strategies that are already in place (Jhurree, 2005; Yusuf, 2005) and the institutional structure and infrastructure in place. The teacher subsystem entails all the university faculty members, and those are important players for effective technology integration in higher educational institutions (Teo, 2011; Anderson et al., 2006). The student subsystem includes both incoming and continuous learners who use the UR-IEMIS. The student's degree of awareness, digital skills and ability to access the UR-IEMIS are paramount for the overall system diffusion process. The administrator subsystem incorporates senior university managers, middle managers, and other system's end users. The administrators

occupy a strategic part of the university's operational processes and decision making (Sife et al., 2007).

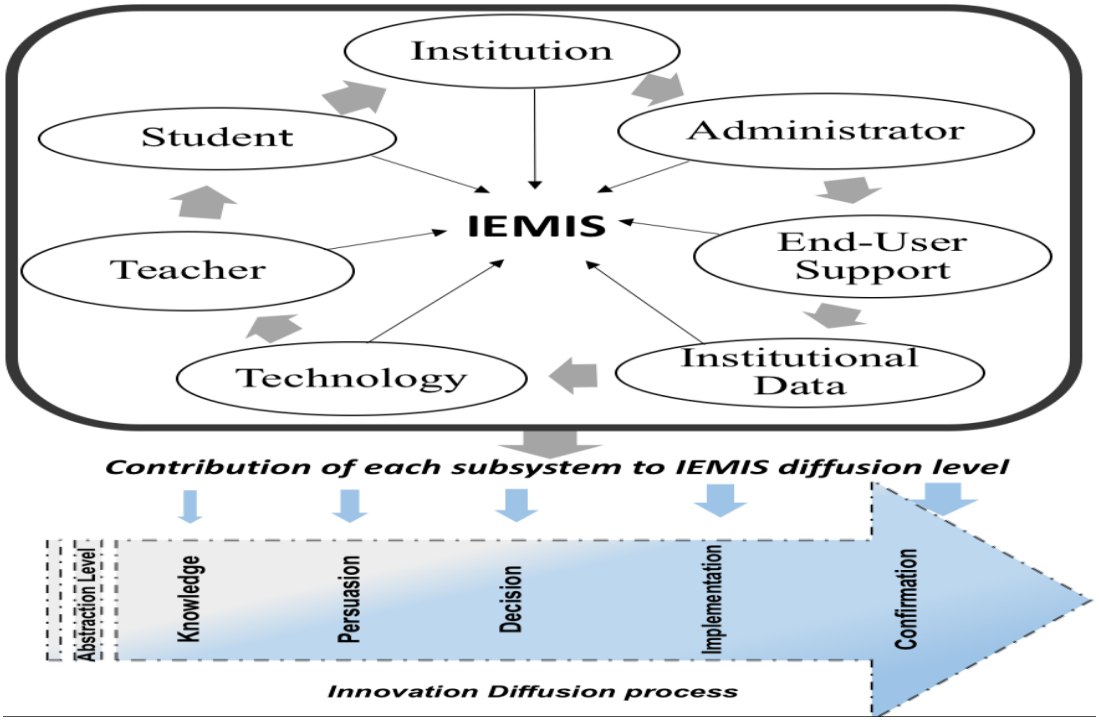


Figure 1: *The framework for Complex Adaptive Management Information System for education institutions.*

Another subsystem is the institutional data. The system collects and stores several types of data objects and processes them into meaningful information to allow for the institution's decision making. These include, for example, records such as student data, staff data, finance data, assets data, procurement data, and academic data and so forth. Another critical subsystem in the framework is the technology. This includes hardware and software applications that are in place to support the system usage. The last subsystem of the proposed conceptual framework is the End-user support which consists of IT specialists with advanced skills to provide timely and adequate support to the system users. As visualized in the conceptual framework, there is an arrow from each subsystem connecting it to the entire UR-IEMIS as a core system. Thus, each arrow signifies that each subsystem or agent of the entire system must fulfill its specific goal by interacting with the whole system. All seven subsystems are interconnected with one another in the same system environment.

For the purpose of this study, the proposed framework also includes the stages of the innovation diffusion theory which enable us to understand the system's level of integration. Accordingly, the conceptual framework shows a relationship of the UR-IEMIS subsystems with the stages of the innovation diffusion process. This relationship indicates that a particular state of each subsystem will determine the level at which the overall system is diffused in the university services. This connection also implies that each subsystem of the seven-complex educational management information system contributes positively or negatively on each stage of the system diffusion in

university services and the overall system's integration level. The five different arrows, connecting the system to its stages of diffusion at university, indicate that the better the subsystem performs well, the more the overall system moves from knowledge to confirmation level of the diffusion process.

DESCRIPTION OF THE STUDY CONTEXT

UR-IEMIS integration into the merged University of Rwanda

The merging of all previous public institutions of higher learning into the one so-called "University of Rwanda (UR)" is a result of a cabinet decision of the Government of Rwanda (GoR) in an Official Gazette nº 38 (Government of Rwanda, 2013). This new university merged the former six public higher learning institutions into one single multi-campus university. The latter is composed of six colleges namely: College of Business and Economics, College of Arts and Social Sciences, College of Education, College of Science and Technology, College of Medicine and Health Sciences, and College of Agriculture and Veterinary Medicine. It was then after merging, that all these UR colleges were requested to use an integrated computer-based management information system in the administration processes. The university top management recommended a system outsourced from Adapt IT Group. The IT system adopted is an Integrated Tertiary Software (ITS) Integrator from South Africa (AdaptIT Group, 2017) and it provides the administrative ERP solutions for higher education institutions. This ITS software integrates modules such as student management, finance management, human resources management including payroll, management information system (MIS), facilities management, and research and library management systems. During the UR institutional reform, the implementation of this system was still at its early stage at the former National University of Rwanda.

The process of integrating the ITS software with the recently merged institution can be complex to some extent. As a new technology being integrated into a new institution, different capacities in terms of human, infrastructure and the reorganization of roles, responsibilities, and processes needed to be taken into consideration to ensure an effective integration and value addition of the this ITS Integrator Software. Considering this UR-IEMIS as a technology-based innovation at the newly created University of Rwanda, the process of innovation diffusion from (Rogers, 2010) is also found important in designing a framework to understand the complexity that emerged after the translation of the UR-IEMIS from the former National University of Rwanda to the new UR colleges. Although there are other small computer-based information systems in place for different administration services, this study was limited to UR-IEMIS as the latter is the only one that is an integrated platform. The figure below is a login page and a lecturer interface of UR-IEMIS.

As can be observed from Figure 2a, the users of UR-IEMIS are mainly the employees (Teachers and Administrators) and, students, especially during the application and registration periods. The university plan for this system intends to include also the parents, government partners, and the alumni. Then in Figure 2b, modules with respective features are listed, which show different services that are handled by the system. At the time of this study, this system was running only on Internet Explorer, but the institution was in the process of customizing it so it can run on other web browsers.

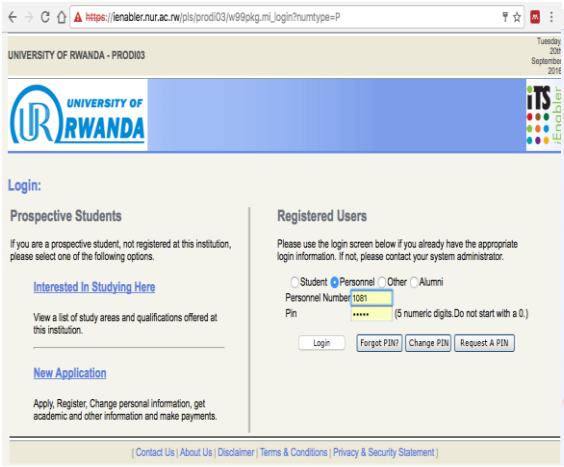


Figure (2a): *UR IEMIS Login Page*

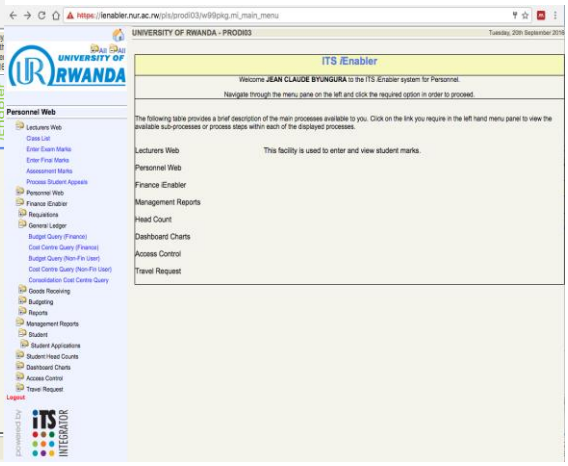


Figure (2b)*: Lecturer Web interface of IEMIS*

METHODOLOGY

Research Design and data collection

This research is qualitative whereby words, visual images, and diagrams are analyzed to answer the research questions (Denscombe, 2010). Being exploratory research, an embedded single case study was used as a research strategy (Yin, 2003). The UR-IEMIS under implementation process at the University of Rwanda was considered as the case study whereby all the university colleges were considered as multiple units of analysis in the participants' selection, data collection, and analysis. A qualitative approach was chosen as appropriate because the case study system is a new intervention that is designed to innovatively reform and change the existing practice (Nastasi & Schensul, 2005) of service delivery at the university. Hence, semi-structured interviews and observations served as methods for collecting primary data, while the survey of documents was used to collect secondary data. This combination of secondary and primary data is advised to produce the most comprehensive, valid and reliable study results, as this technique helps in getting triangulated information that enables the researcher to fully explore the single case study under investigation (Lowry, 2015).

Therefore, published articles, related to the current study, were deeply explored through a thematic analysis process (Creswell, 2009; Anderson et al., 2015). More specifically, scientific articles related to the theory of complex adaptive system and the diffusion of innovation were mainly reviewed to get thematic dimensions that later served as a reference to code and analyze the data from the interviews. The two theories were paired in this study by assuming that it is complex to introduce a new information system for managing traditional university services, and at the same time, this is a diffusion of an innovative tool in an existing university context. Therefore, the explored literature enabled the researchers to design a conceptual framework that was used later to examine the complexity and diffusion of UR-IEMIS at the University of Rwanda.

Prior to collecting data, the project team leader, in charge of UR-IEMIS implementation at UR, was approached and a request for undertaking this research was submitted. An authorization to undertake the research on UR-IEMIS was granted before contacting interviewees. The pirncipal investigator was granted access to reports and the system's training manuals. The login details were also provided to the main research investigator. The interview guide was first of all evaluated and validated by two expert researchers in computer science and information systems.

Participants

This study was limited to the UR-IEMIS users who have been, to some extents, involved in this system implementation process. Using a purposive sampling technique (Denscombe, 2010; Creswell, 2009), twelve respondents were purposively selected and interviewed to get their insights from the user perspective on the complexity and the current state of UR-IEMIS integration. This sampling approach is a non-probability sampling technique for which suitable participants can be selected to inform the research questions and help in understanding the phenomenon under investigation (Creswell, 2009). Additionally, we retained this sample because they were revealing the same information, assuming that we have met the data saturation criteria (Creswell, 2009). Among the participants, six are academic staff while the other six are from different administrative units. Two of the six respondents from the administration are the project managers while another one was a system administrator with strong technical expertise. The remaining three administrators are the UR-IEMIS end-users on a daily basis. All participants have experience of more than five years in higher education institutions and more especially in the senior and middle management positions. In addition, with the posts they were occupying during the institutional merger, all the participants have been hugely involved in the UR-IEMIS implementation across the university. Hence, although this sample is not representative, it is constructed and is deemed to be in a strong position to serve the purpose of this research.

Considered as the key players for an effective UR-IEMIS implementation, the system administrator and the project managers were further contacted for in-depth interviews (Denscombe, 2010) to get a deeper privileged knowledge on the UR-IEMIS complexity and challenges associated with the plan, acquisition, and implementation of this system in the university services.

Data analysis

The analyzed qualitative data (Denscombe, 2010; Creswell, 2014) include the interview manuscripts, observation notes, and the institutional reports and training manuals of UR-IEMIS. The analysis aimed at getting factual pieces of evidence regarding the state of UR-IEMIS integration at the University of Rwanda. The interview data were first recorded and transcribed before the analysis. Due to the types of research questions for this study, a triangulated data analysis technique (Leech & Onwuegbuzie, 2007) was used, whereby multiple data analysis approaches are used for a more in-depth and complete understanding of the phenomenon under investigation. Firstly, a constant comparison analysis approach (Glaser & Strauss 1967) was used to identify the underlying themes deductively and categorize them into predefined codes. This process, which is similar to descriptive phenomenological data analysis (Colaizzi, 1978), was helpful in understanding and describing the complex phenomenon of UR-IEMIS at the University of Rwanda using different data sources. Thus, the case study context was analyzed holistically by analyzing both the artifact, the reports, and the users' expressions and their individual assessments vis-à-vis the UR-IEMIS system. Secondly, a classical content analysis approach (Onwuegbuzie & Teddlie, 2003) proceeded to understand the diffusion levels of UR-IEMIS in the institutional services by extracting the frequency of these levels from the collected data. Transcribed data and reports were analyzed using MAXQDA 11, a qualitative data analysis software (Corbin 2008; Denscombe, 2010).

Prior to the data analysis step, all interviews were recorded and transcribed verbatim by the principal investigator. With a verbatim transcription, everything recorded has been transferred exactly the way it was delivered by interviewees (Mero-Jaffe, 2011). After that, the interview manuscripts were read at least three times for cleaning and removing unnecessary texts before starting the coding and further analysis process. While the first author did the interview

transcriptions and the initial data coding, further analysis, and initial findings were jointly discussed with the rest of the authors to benefit from their multidisciplinary expertise.

For ethical consideration, the informed consent, confidentiality, anonymity of individuals and willingness to participate in the research are the key ethical issues in social research (Cohen et al., 2013; Denscombe, 2010). Hence, an institutional approval, issued by the Directorate of research at the university, was granted before contacting the individual respondents and accessing some documents related to UR-IEMIS implementation. Respondents were prior informed about the purpose of the research and that the data will only be exclusively used for this research. The informed consent was also obtained from each involved participant. Prior to this, participants were informed that the participation in this research is voluntary and that they are free to withdraw from the research any time they feel uncomfortable. In addition, confidentiality has been assured during data collection and analysis, and when reporting the study results by following the key principles of research ethics (Denscombe, 2010).

RESULTS AND DISCUSSION

The study was carried out from January 2016, three years after merging all public universities to form one University of Rwanda. Prior to this institutional merger, the UR-IEMIS was under use solely at the former National University of Rwanda. This section contains a description of the current complexity of UR-IEMIS with reference to its identified subsystems. It also explains in detail the extent to which this system has been diffused across university services for which it was intended to support as a new technological tool in an innovative way. The results presented below are organized according to the two research questions. The first subsection explains the complexity of UR-IEMIS from its identified subsystems and related categories. The second subsection presents findings regarding UR-IEMIS levels of integration in university services following Roger's stages of the innovation diffusion process.

The conceptual framework (Figure 1), which is drawn from the explored literature about the complex adaptive systems and diffusion of innovation, served as a reference to design the interview protocol used for this study. Therefore, the data analysis relied heavily on this conceptual framework to extract text segments containing the themes that confirm the UR-IEMIS categories of subsystems and the system diffusion levels.

The complexity of UR-IEMIS system at University of Rwanda

With the research framework, researchers were able to extract the categories (codes) and sub-categories (main subsystems) of UR-IEMIS with their related themes as visualized in Figure 3 below.

As can be observed from data in Figure 3, through the analysis of data, eight main sub-categories (subsystems of UR-IEMIS) were identified and assigned to their emerging categories with reference to their properties (codes). The main categories which emerged during data analysis are (1) roles (*Teacher, Student, Administrator*), (2) method (*End-user support*), (3) concept (*Technology*), (4) objects (*Institutional data*), and (5) organism (*Institution, External Partners*). In total, 67 themes were identified in the interview manuscripts and the secondary documents. The technology subsystem recorded the most themes (14) followed by teacher, administrator, and institutional data with (12) themes respectively. The following subsystem is the institution which registered (10) themes while the external partners recorded (9) themes. The remaining subsystems which are end-user support and students recorded (5) themes respectively.

The identified subsystems and their associated categories for an educational management information system framework serve as a basis for (1) exploring the complexity of UR-IEMIS

system, and (2) understanding its stage of integration (diffusion) as an innovative tool at University of Rwanda.

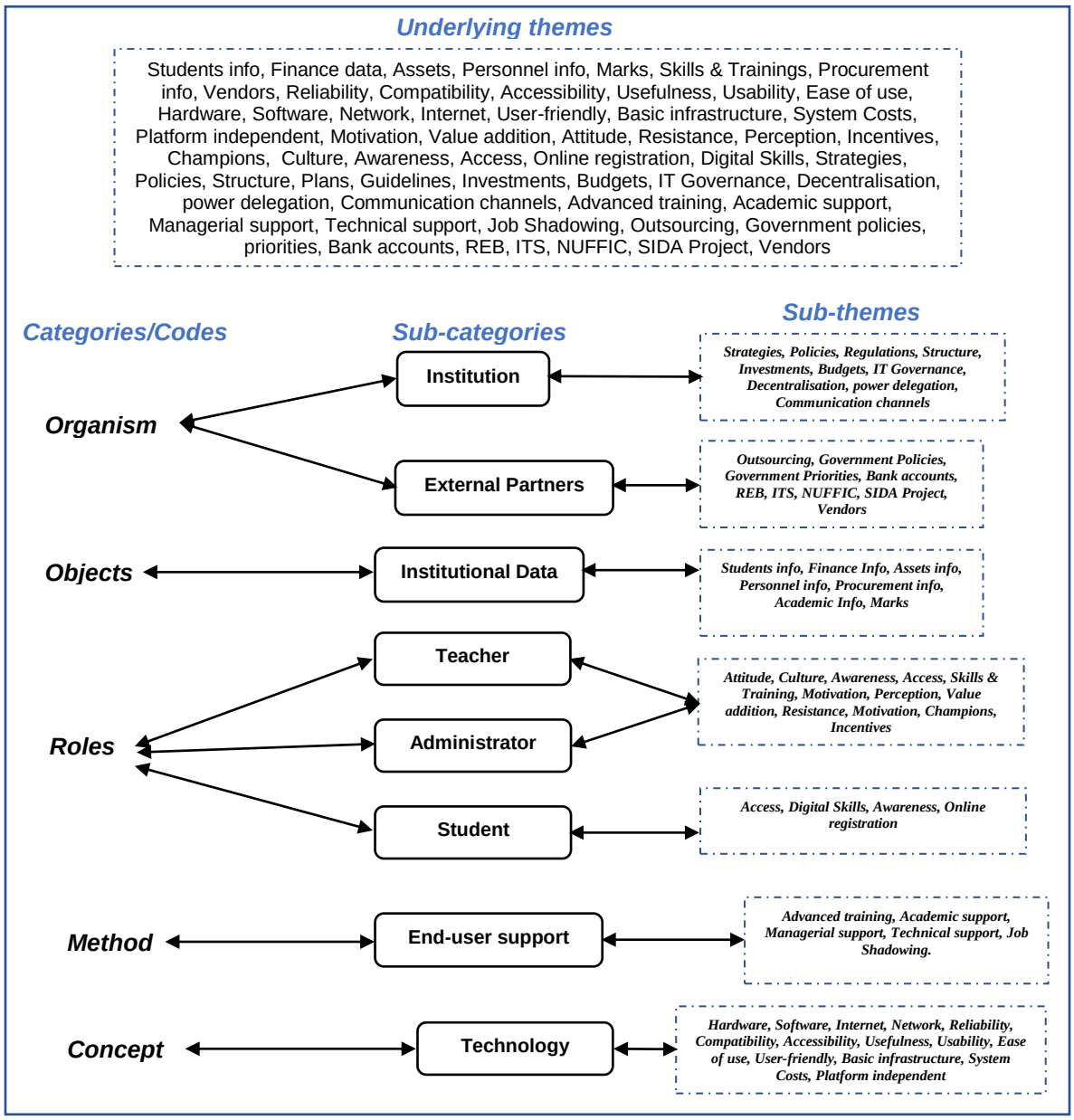


Figure 3: *Codes, categories, and sub-categories*

As a continuation to understanding the degree of UR-IEMIS complexity, a reference was made to the theory of complex adaptive system (Miller & Page, 2009), considering this system as an innovative artifact that was under implementation in a new reformed institution. Although the literature explains several features of complex adaptive systems (Boal & Schultz, 2007; Johnson, 2001; Miller & Page, 2009), due to the nature of this study, we only focused on four important aspects: *Connectivity*, *Self-organization*, *Co-evolution, Non-linearity,* and *Emergence*.

Hence, with reference to the above four attributes of a complex adaptive system, and by using the data collected from the secondary data sources and the UR-IEMIS users, five different categories of UR-IEMIS subsystems were identified. Using MAXmaps of the MaxQDA visual tools, the map in Figure 4 summarizes the UR-IEMIS complexity and its properties.

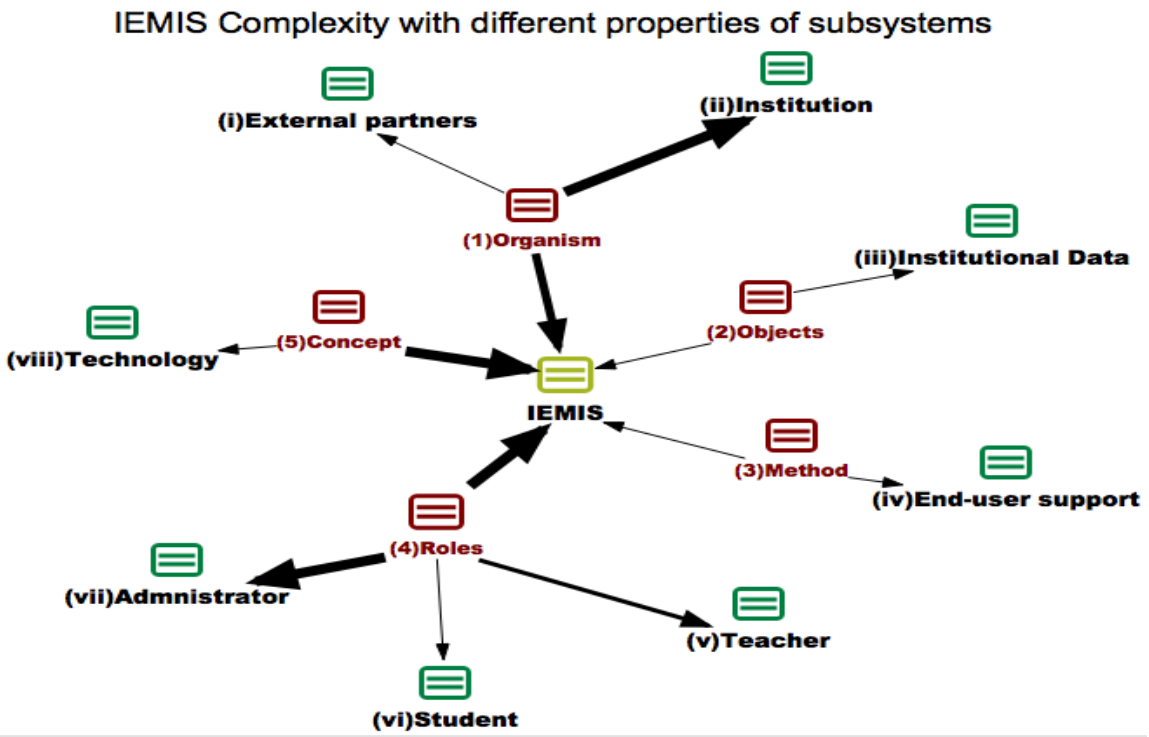


Figure 4: *The identified complexity of UR-IEMIS: Different properties of subsystems*

As visualized in Figure 4, the findings indicate that the UR-IEMIS is composed of eight distinct subsystems and each of which interacts with one another for the common goal to improve administrative service delivery across the university. This system's complexity is also explained by the fact that these eight subsystems are scattered into five distinct properties, described as follows.

Category 1: Organism

This property involves an institution and external partners. These two subsystems have been revealed from the analyzed data (Figure 4) as the networked entities that contribute enormously to the overall UR-IEMIS implementation.

Some example of extracts that express an organism such as Institution" and "External Partners" include the following:

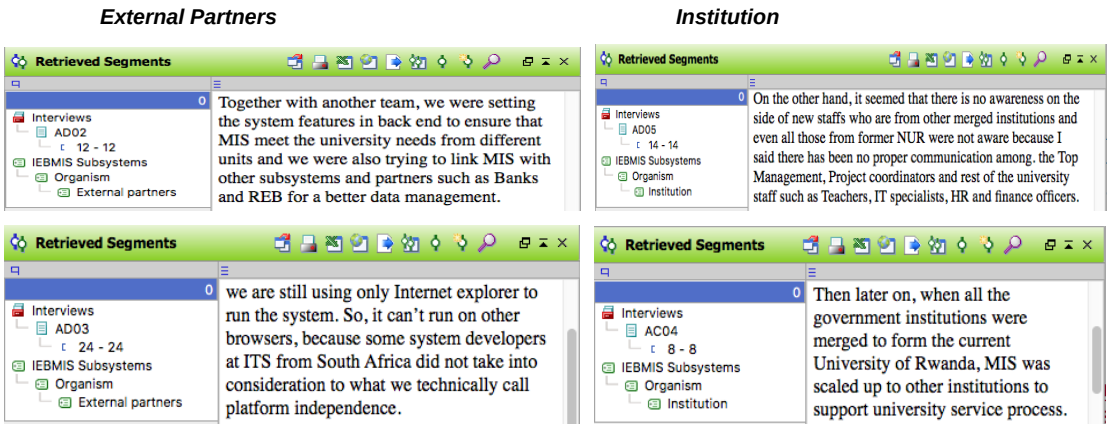


Figure 5: *Some extracts from interviews about External Partners and institution as subsystems*

The above two examples of excerpts on the left in Figure 5, are the retrieved text segments from MAXQDA 11. As can be observed, themes such as REB "Rwanda Education Board", partners and banks are expressed by respondent AD02 as external entities that act on their side for effective UR-IEMIS implementation. In the second retrieved segment section, themes such as system developers and ITS "Integrated Tertiary Services" from South Africa indicate clearly an external partnership with the University of Rwanda for the integration of UR-IEMIS as expressed by respondent AD03.

For the institution subsystem, on the right in Figure 5, respondent AD05 mentioned themes such as merged institutions, NUR "National University of Rwanda", Top Management, Projects coordinators and the university staff which represent an institutional structure, reform, and governance. Another interview respondent AC04 discussed the merger of government institutions to create the University of Rwanda.

The merger of several institutions having different external partners supporting the development and implementation of UR-IEMIS indicate an overall system complexity. The latter is explained by the features of emergence, co-evolution, and connectivity for the organism category which include institution and external partners subsystems that interact with other UR-IEMIS subsystems.

Category 2: Roles

This category is described as any position, post or a responsibility handled by an individual using UR-IEMIS at the University of Rwanda. Under this category, the analyzed data indicated that the extracts from transcripts from "AD02", "AC03, "AD05", "AC02", "Media1" and "AD01" enabled the identification of teacher, administrator, and student as the key roles under the UR-IEMIS integration process at the University of Rwanda.

Accordingly, these three subsystems (roles) contribute to UR-IEMIS complexity by interacting with other subsystems (connectivity) within the UR-IEMIS environment. On the other hand, these roles have been emerging, co-evolving, and adapting in a non-linear process as the system keep integrating over time in the entire merged institutional units.

Category 3: Method

This cluster is described as any process, approach or technique expressed as being used in support of UR-IEMIS implementation. It includes an End-user support subsystem which is divided

into managerial and technical support. For example, as part of UR-IEMIS implementation, a dedicated key user group was trained for advanced IT skills to support UR-IEMIS end users. Training manuals were also developed and adapted to the new institutional structure and policies to serve as a reference for using the system across departments and schools. Again, for example in the interview transcripts from respondents “AD02” and “AC05” the terms related to End-user support, as a method that supports the UR-IEMIS implementation, have been mentioned.

Hence, the End-user support contributes to the UR-IEMIS complexity as it has to be adapted to the institution, while external partners such as system vendors also have to be involved in making sure that the appropriate IT support is provided by trained IT experts. This subsystem also co-evolves and is linked with different roles described above and the institution through the provision of adequate managerial and technical support for the overall UR-IEMIS integration in the institution.

Category 4: Concept

The fourth category of UR-IEMIS subsystems is described as any expressed concept related to innovation or ICT tools. Concepts such as hardware, software, network, internet, email system and the like have been included together to form “Technology” as a subsystem of UR-IEMIS. In almost all the transcripts used in this study, these themes related to technology, as a concept, have been expressed.

This subsystem contributes to UR-IEMIS complexity as the institution has to put in place different IT tools that are adapted to UR-IEMIS and the latter has to be customized to fit with the other available ICT infrastructure and the overall institutional environment.

Category 5: Objects

This property is defined as any digital data or information that is processed and stored in UR-IEMIS servers. Objects include, for example, student information, marks, faculty information, financial information and so forth. The institutional data with instances of themes such as “marks”, “financial codes”, “general ledger” have been expressed in the transcripts.

When different users (roles) use UR-IEMIS, these data are increasing in volume over time. These digital data are saved in the institutional database server for future access. Hence, this subsystem contributes to the overall UR-IEMIS complexity through, for example, its features of emergence, co-evolution, adaptability, and connectivity with other subsystems.

Overall, it can be observed, from the findings above, that UR-IEMIS is complex in the sense that it is composed of eight different and interrelated subsystems, each of which acting upon one another for effective diffusion of the entire system in university services. Likewise, the identified subsystems have been emerging, interacting, co-evolving, adapting and self-organizing either in a non-linear (negative or positive direction) within the disruptive working environment of the merged several institutions into a single multi-campus university.

A general view of this complexity can also be visualized in Figure 6 below, with the frequency of coded text segments related to the UR-IEMIS subsystems as visualized using MaxQDA software.

Within the same perspective of understanding the UR-IEMIS complexity, a further step of analysis led to determining the frequency of each subsystem that explains its importance to the effective system diffusion from the respondents’ perspective.

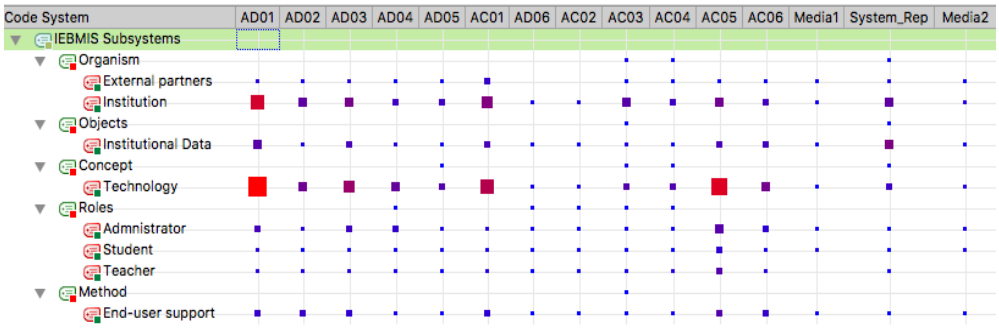
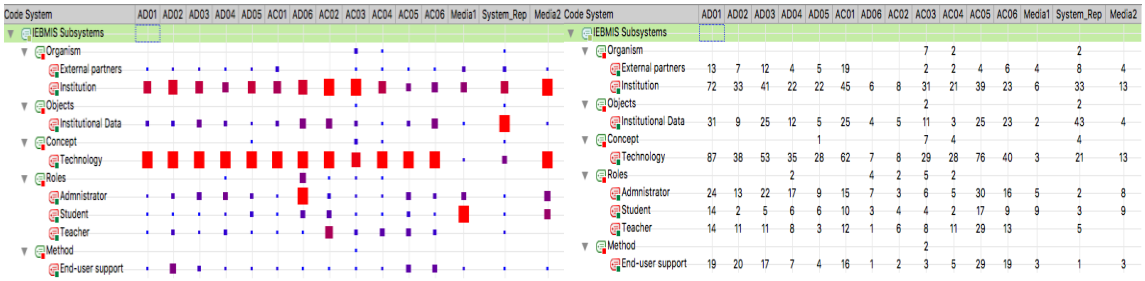


Figure 6: *A general visualization of UR-IEMIS complexity by the frequency of text segments*

After a systematic data codification in MAXQDA 11, each UR-IEMIS subsystem's frequency of occurrence in the data sources has been identified in line with the extracted text segments. This is illustrated in Figure 7 below.



Symbol Size calculated with reference to columns/subsystems (1) ***Subsystem nodes displayed by values (4)***

Figure 7: *Visualization of UR-IEMIS complexity from the subsystem's frequency of occurrence*

As illustrated above, the data show the frequency of text segments that explain the extent to which each subsystem of UR-IEMIS has been expressed in the extracted texts segments from data sources. The frequencies of subsystems are entirely different whereby "*Technology*" and "*Institution*" subsystems recorded the highest score, followed by "*Administrator*", "Institutional Data", "End-user support," "Teacher", "External Partners" and "Student" respectively. These findings indicate that the more the subsystem was mentioned, the more it is given a weight in support of the overall UR-IEMIS implementation process at the university.

The level of UR-IEMIS diffusion in university services

This study was also interested in understanding the levels of UR-IEMIS diffusion since its introduction at the University of Rwanda. Using the code matrix browser tool of MaxQDA, a visualization of the system diffusion level was revealed by considering the frequency of occurrence by the symbol size of all the coded text segments throughout the entire interview manuscripts. As indicated in Figure 8 below, the integration of the UR-IEMIS is still found at the lowest levels according to the theory of Innovation Diffusion (Rogers, 2010) applied in this study.

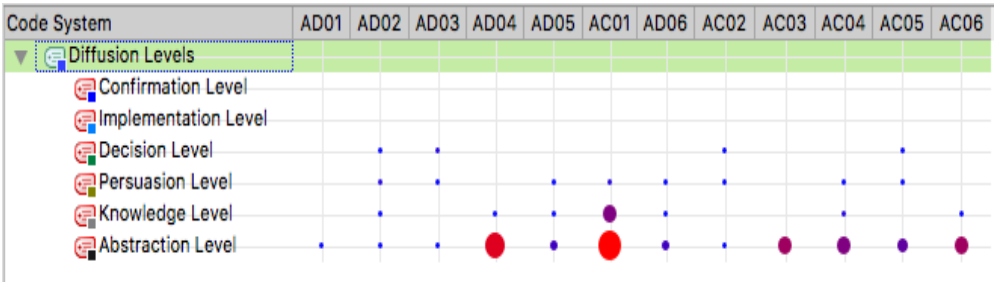


Figure 8: *Visualization of UR-IEMIS diffusion levels*

The integration of UR-IEMIS falls behind the expected level as all 12 respondents reported that this system was still at an abstraction level and only some parts of it at knowledge, persuasion and decision levels. This can be observed from the data in Figure 8. More particularly, the respondents "AC01", "AD04", "AC06", and "AC04" argued strongly that this IT system was still at an abstraction level. Likewise, this level can be asserted by their increased number of occurrences from the text segments as visualized in Figure 8.

As an example, one text segment was extracted from the administrator's interview manuscript, where he had to state the following during the interview:

> *You know many more are still at the abstraction level box there to the framework; very few others are at the persuasion and even decision for some units such as Registrar's office. (AD03)*

The reason for the Registrar's office unit to be at decision level, regarding UR-IEMIS diffusion, is because the institution has made compulsory all students' administration and registration services to be processed online via the iEnabler page of this system. Hence, at least with this registration policy, staff in that office have been trained and supported to use the system. Therefore, as a result, you can realize that a substantial amount of student registration data are recorded and the student iEnabler page is improved to make it user-friendly. Other examples of interview extracts from respondents, confirming this system integration at an abstraction level, have been expressed as follow:

> *If I understand well this stages as you call them, I think MIS was still at the abstraction level. (AD04)*

> *But for others like in finance and the general administration, or even on teacher side, this is still at the abstraction level (AD05)*

> *Actually, I can assume that those from other institutions that were merged with UR are still at the abstraction level as you are saying (AC01)*

While eight respondents explained that UR-IEMIS was diffused at persuasion level for some of its subsystems, seven out of twelve respondents explained with a low emphasis, some UR-IEMIS subsystems reached to the knowledge level of diffusion to support the institution in administrative services.

Overall, respondents views allow us to claim that the UR-IEMIS is not successfully integrated at the level it can effectively add value to the university services. Therefore, there is still a lot to

improve on each identified subsystem more especially on the institution, teachers, technology and end-user support subsystems.

CONCLUSION

The aim of this study was to understand the complexity of the UR integrated educational management information system (UR-IEMIS) and its integration levels at the University of Rwanda. Two theories of (1) complex adaptive systems and (2) diffusion of innovation were used to get a conceptual framework that was used as a reference for this study.

The complexity of UR-IEMIS

Overall, the results show that the UR-IEMIS under implementation at the University of Rwanda to support the administrative services is complex. The reason is that the UR-IEMIS subsystems are characterized by complexity features such as co-evolution, emergence, adaptability, self-organization, connectivity, and non-linearity. The findings indicate also that the UR-IEMIS subsystems affected each other as the overall system was emerging in the institutional working environment. Furthermore, the eight identified subsystems of UR-EMIS interacted, co-evolved and re-organized to adapt to a specific system environment and the disruptive structures of this university. This complexity is also characterized by the diversity of its subsystem's categories (Organism, Roles, Objects, Method, and Concept) that were identified in the collected data. This information has been illustrated in the results section (see Figure 3 and 4).

With reference to the frequency of extracted text segments for each IEMIS subsystem as visualized in Figure 8, findings show that Technology and Institution should be the most considered subsystems for effective UR-IEMIS implementation at the University of Rwanda. Therefore, the institutional policies, strategies, guidelines, top management involvement, clear structures and the IT governance of the university are the key important capacities that should be developed to support UR-IEMIS implementation. Moreover, adequate hardware, software, accessibility and maintenance of UR-IEMIS and existing infrastructure were also given a high priority by respondents.

Institutional Data, Administrator, Teacher, and User-support subsystems are also increasingly important for UR-IEMIS implementation (see Figure 8). Surprisingly, primary data analysis showed that there is another key subsystem "*External Partners*" of the UR-IEMIS under the "Organism" category (see Figure 4). This subsystem came as an addition to the ones that were proposed in the conceptual framework. As another actor, this subsystem includes for example system vendors, donors, and other government institutions such as the Ministry of Education, Rwanda Education Board, and the Higher Education Council. Respondents highlighted the importance of these agents for an overall effective UR-IEMIS implementation. Therefore, this concurs with (Rogers, 2010) who maintained that, with the lack of adequate IT skills which delay the adoption of complex technologies, newly created institutions avoid this barrier by outsourcing technology expertise from external companies.

The UR-IEMIS Diffusion Level

The five stages of innovation diffusion process (see Figure 1) were used to understand the level of UR-IEMIS integration from respondents' perspectives. After explaining each diffusion level to respondents using the proposed conceptual framework, they were asked to report the degree of this system diffusion at the University of Rwanda. The findings visualized, indicated that the UR-IEMIS was still at abstraction and knowledge level of diffusion. This level was observed with reference to the frequency of extracted text segments that highlighted these levels.

For some university units, this system has been diffused at persuasion and decision level according to the visualized respondents' views. Some respondents, who acknowledged these last two diffusion stages, supported their statements by indicating that there have been at least some training sessions for administrative staff on using the UR-IEMIS, although this training was not adequate. Accordingly, they also explained that there is still a lack of training and awareness of this system to academic staff. Respondents also had to mention that this UR-MIS is not a user-friendly system and it is not compatible with existing ICT infrastructure and the overall institutional working environment.

From the institution subsystem viewpoint, some respondents reported that the existing ICT policies do not clearly inform about the UR-IEMIS implementation plans. In addition, there are no specific strategies, procedures, and guidelines on creating a system awareness and motivating users to use this computer-based management information system. In addition, the existing communication channels between the top management and employees have also been reported ineffective, which keeps this system at the abstraction level.

As the overall conclusion, to make it a success, the integration of systems such as the UR-IEMIS, which is outsourced from external companies, need to consider adapting it to the institutional, cultural, political and social contexts of the university. In addition, both technical and non-technical aspects of this system have to be taken into consideration to encourage success in the innovation of service delivery in higher education institutions such as the University of Rwanda. Lastly, owing to the research strategy used for this study, the findings cannot be generalized to other institutional settings. However, some insights related to the contextual propositions, actors, and factors for the effective implementation of information systems in higher education institutions can be drawn from this study.

Implication and future research

This study has significant implications for future research. First, it contributes to the body of knowledge about information systems in organizations. This research applied the Complex Adaptive System and Diffusion of Innovation theories to understand the complexity of an integrated computer-based management information system within a higher education institutional context. Although these theories have been previously used in other domains such as E-learning (Wang et al., 2015; Lee et al., 2011) and health systems (Emani et al., 2012; Tan et al., 2005; Lupu et al., 2008) and supply chain systems (Pathak et al., 2007), this study proves that the complexity of IT systems integrated in university administration services can be as well analyzed using a combination of these two theories.

Today's universities, especially in the developing world, are adopting information systems that have success stories from the western world. But, in some countries, effective implementation has been far from being materialized. Therefore, it is important to understand the complexity of these emerging technologies that are being integrated and the associated challenges. This study enabled us to propose appropriate mechanisms to manage the system complexity, which results in boosting the diffusion process across the institution.

This study is part of an ongoing overall Ph.D. research about IT and institutional alignment in the higher education sector. Thus, for this study, we exclusively explored the complexity and diffusion level of a single case of UR-IEMIS system that is being integrated into the administration of university services in a single university. Hence, this is recognized as a limitation of this study. However, there is a scope for future research to undertake some explorative research to understand the integration of E-learning management systems focusing on teaching and learning activities at the University of Rwanda or similar contexts across the region. This can help to

elucidate whether they are similarities related to the systems' complexity and diffusion level in higher education institutions.

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