Information System Integration: A Review of Literature and a Case Analysis

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Abstract: - The article aims at providing an explanation on information systems integration. It is an account that is part of an on-going research. In the first part of the article, the researchers present the literature review. The findings show the characteristics of information systems integration. The types, levels and perspectives of information systems integration signify these characteristics. The subsequent part of the article uses a single case research approach of an institution in higher education sector. The purpose is to gain insights into the underlying characteristics and challenges of information systems integration in meeting organizational effectiveness while simultaneously assuring governance.

Key-Words: - information system integration, case study, higher education, case analysis, innovation

1 Introduction

The advancement of technologies, nowadays, sees rapid use and diffusion of mobile devices in particular notebooks, tablets, iPad and smartphones. This has changed the way people communicate and collaborate. Information has become ubiquitous. New business rules and new means of collaborations have emerged out of the pervasive use of such technologies. This has given rise to contemporary phenomena such as social media, virtual organizations, electronic commerce and virtual teams. The revolutions in new information technologies have indeed changed the systems and dynamics of the workplace environment.

Traditionally, organizations implement information systems to solve internal business problems. As a result, islands of information systems were common sights in organizations. With the advancement of technologies that are outward in orientation [50], organizations see the need to integrate legacy information systems with new technologies. Prior research suggests that the aim of information systems integration is to maximize business performance, productivity and improvement [7; 8]. This in turn is hoped to drive organizational effectiveness and competitiveness in the marketplace.

Perhaps, the most common form of information systems integration need is *data integration*. The literature suggests that this stems from users having to access to many databases, and often times containing similar data, but direct transfer of information between these databases was fairly limited [40]. In islands of information systems, there are multiple databases that hold duplicate and non-standardized data that were entered manually [30]. In the health care industry, for instance, WebIz is a software that is used to integrate data for the immunization information systems (IIS) in a nursing school. IIS are confidential, computerized information systems that collect, consolidate, and analyze vaccination data from multiple users (health care providers). WebIz was successfully implemented in data integration and was claimed to be used by 3,144 clients including school, medical facilities and hospitals [28].

Information systems integration has been regarded as *functions* and *processes* of single organizations or even few units that is rather limited in scope [2]. Nevertheless, based on intense competitive environment and information technology advances, organizations are seen to have been engaged in a variety of large scale integration efforts [38; 47]. Further, a positive relationship between integration and different measure of performance has been found in past studies [3; 12; 24; 41; 62].

On the other hand, in another research, information systems integration is dealt with as a *stage* in moving toward strategic alignment between

business and information technology [13]. There are three levels of strategic alignment. The first level is organizational business and information technology members' awareness of strategic alignment. The second level is integration. Essentially, integration level is recognized as the acceptance of the need for interconnecting the organization's operational plans and those of information systems. The alignment stage focuses on linking organization's fundamental strategies (including information systems strategy) and core competences to central strategic directions of the organization rather than a focus on an organization's

2 Problem Formulation

In consideration of our earlier discussion, in this section we present the gaps and research questions.

- ***Types*** of information systems integration – while traditionally, concerns of information systems integration were confined to data integration, functional integration and process integration, this scenario may have expanded in tandem with advances of new technologies. Further, emerging forms of organization and information systems such as social enterprise and social customer relationship management (CRM) are gradually shaping the need for new forms of information systems integration;
- ***Level*** of information systems integration – the dynamics of organizational changes as a result of mergers, acquisition, strategic alliances and shared services may suggest a different meaning of level in information systems integration.

Therefore, the researchers set out to answer the following research questions (RQ):

- ***RQ1a: What are the types of information system integration in organizations?***
- ***RQ1b: What are the levels of information system integration in organizations?***
- ***RQ2: What are the challenges in achieving a higher level of information systems integration in an institution of higher education sector using an adaptation of Tornatzky & Fleischer [61] innovation adoption framework?***

3 Problem Solution

3.1 Research Design

In answering the first research question, the researchers draw on a review of literature to consolidate the different types and levels of information system integration. The researchers used the following bibliographic databases:

- Scholar Google
- Proquest
- Ebscohost
- Emerald
- ACM
- IEEE
- Springer
- Gale
- IGI-Global E-books

In answering the second research questions, the researchers use a case analysis of an institution in higher education sector. The researchers aim at gaining insights into the underlying characteristics and challenges of information systems integration in meeting organizational effectiveness while simultaneously assuring governance. The researchers used physical and electronic archival records that include meeting minutes, Website references, audit records and posters to collect data about the case.

The researchers make an adaptation of the Tornatzky & Fleischer [61]. The original framework defined technological, organizational and environmental factors that influence the process by which organization adopts and implements technological innovations. In short, *technological* factor refers to both characteristics and availability of internal and external technologies, *organizational* factor comprises resources (firm's size, degree of formalization and centralization, human resources and linkage amongst them, and managerial structure) and, *environmental* factor refers to industry (size and structure), regulatory environment, macroeconomic context, competitors, customers and government [61]. More recently, Chowanetz et al. [16] included business factor in the original model. They refer business factor to the *driving forces inside* the organization.

Our adaptation considers *knowledge* as an additional factor. This is in line with Information Age and knowledge-based economy as a contemporary phenomenon and where knowledge is an asset in organizations. Further, the selection of an institution in higher education sector emphasizes knowledge as intellectual capability. Knowledge in this research refers to knowledge exchanges internally and externally and knowledge characteristics. Knowledge characteristics cover explicit and tacit knowledge. Explicit knowledge is knowledge that can be codified in a tangible form while tacit knowledge represents knowledge that people possess [44].

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3.2 Findings

3.2.1 Organizational Integration

Integration has been the focal point of research in several fields including organization theory, production/operations management, strategy, and information systems [14; 15; 20; 29; 63]. Organizational integration is one type of integration that has appeared in information systems literature. Sikora and Shaw [56] refer organizational integration to integration between different departments and functional units in an organization. Barki & Pinsonneault [2] defined organizational integration as the extent to which discrete and interdependent organizational units or components form a unified whole. These components cover people, processes and technology and could assume organizational departments, units, and/or partners [34]. Besides, such relational and structural characteristic of organizational integration as a broad and general perspective spans from a customer to retailer, manufacturer, and supplier [19; 24; 31]. Organizational integration is not about homogenizing components of a system so that such integration would erode specialization of distinct units, rather, it is about different and complementary components act in unison without becoming a single entity [2].

Organizational integration is characterized by internal integration and external integration. Integration within a firm is internal integration while integration of at least two independent firms is external integration. The value chain perspective and process lens have been used to further differentiate the characteristics of internal integration. Within internal integration, there are operational and functional integration. Operational integration is concerned with primary processes in the organization. Functional integration is marked by the integration of support processes in the organization.

Likewise, external integration comprises operational and functional integration. However, there are three types of external integration. Operational forward refers to integration of processes in the distribution and retail. Backward integration is integration of processes in the supply. Lateral integration is integration into components. External functional integration is the integration of support processes across firms [2].

3.2.2 Information System Integration

In the information systems field, integration has been viewed from two perspectives in information system. A technical standpoint in the first perspective suggests that integration is a mechanism to depict the interconnectedness of information technologies within an organization and the extent to which a common conceptual representation of *data* elements are shared [15; 30]. In other words, integration is defined as the degree to which different systems of an organization are interconnected and are capable of communicating to each other (e.g. islands of technology integration). In the second perspective, integration is the degree to which two or more independent organizations have standardized business processes and those *processes* are firmly linked through telecommunications technologies and computers [18; 37; 56; 58; 60; 62; 63; 64].

Information system integration aims at facilitating exchange and information sharing within an organization [1; 67], and achieving inter-firm coordination (between buyers and sellers) for better monitoring capability as in the case of supply chain [17; 49]. In regard to technological integration, it has been repeatedly stressed that information system integration needs all application systems, data, and communication to be integrated [42; 53] in order to provide a real-time and consistent connectivity within function component across supply chains [49].

Linß [35] and Rosemann [52] classified integration into three main dimensions encompassing: domain, reach, and direction. Accordingly, direction is either horizontal or vertical, reach is either intra-organization or inter-organization, and domain is either data-wise, function-wise and, program-wise. It should be added that Rosemann [52] considers object-wise as another sub-dimension for domain. While Picot, Reichwald, & Wigand [46] categorized it as ex-ante and ex-post integrations, in addition Fuchs-Kittowski [27] grouped ex-ante integration into re-engineering and integrated components, and on the other hand classified ex-post integration into sub-dimensions as data, function, and presentation.

Regardless, it has been equally emphasized in many information systems literature that information system per se is not a source of sustainable performance and value creation [48]. Consequently, integrating resources and aligning them in organization's cultural and social context is crucial [4], in particular, in developing workflow and operations coordination [49]. In sum, integration per se has been found to be a socio-technical phenomenon beyond a mere technological aspect such that it includes an assortment of economical, organizational, and even social facets of the phenomenon [2].

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Below we describe other forms of integration as evident in information systems literature:

Strategic integration – This integration is about whether different integrated systems are supporting an organization's core strategic plans. In this manner integration is not considered as goal by itself, though, it should be rather identified as a means to achieve the central strategic directions of the organization [13; 22].

Horizontal integration – Horizontal integration is evident in manufacturing function and coordination amongst them [9]. Horizontal integration is concerned with how easy decisions are made and data are passed among the islands of technology as well as the degree to which they are collaborating, coordinating, and facilitating task performance [22].

Vertical integration – This form of integration enables access to information at various levels of the organization hierarchy, in particular, for managers and decision makers [22].

Electronic integration – Zaheer & Venkatraman [68] first introduced it as a form of vertical quasi-integration. Thus, deploying computers and communication systems among relevant actors in adjacent stages of value chain are the means to achieve electronic integration. In fact, its focus on the role of IT in restructuring vertical relationships, has made it an important concept in information research [68].

From organizational integration perspective, vertical integration is concerned with a firm covering two single output production processes in which all or part of the upstream output processes are employed as either entire or part of intermediate input into the downstream processes [45].

It also involves internal integration (units linked within firm) and external integration (links among firm with customers, suppliers and retailers) [43]. For instance, e-procurement which reflects the transactional nature of using IT in supply-chain context, is one aspect of electronic integration that represents the operational aspect of sourcing over information technology enabled platforms [21].

Communication network integration – Agents deploy integrated communication networks by transmitting information around the globe in structured data, text, visual forms or audio format, via flexible standards including satellites, cable or fibers [66]. Such electronic inter-connectivity between organizations would be expected to cut costs and enhance services and efficiency through tightening inter-relations [7]. This is also needed for organization to coordinate internal activities in an effective and efficient manner toward attaining competitiveness [36]. Steinbart & Nath [59] have also emphasized the essential role of standards and network connectivity. In addition, the lack of standardization of key technologies that support network connectivity is one major factor that impedes prompt responses of information systems [6].

Physical integration – Physical integration works on supporting and encouraging cooperation between several departments or production facilities of an organization which are dispersed in various geographical zones [22].

Data integration – Data integration focuses on the degree to which the activities of different business units and departments within an organization are consistently coordinated by sharing a number of databases [7; 30]. Organizations could initiate developing systems integration by enhancing standardization of data codes and definitions throughout the organization or on a larger scale of the industry [7]. Wendt, Brigl, & Winter [65] propagates data integration as enabling users to enter data only once in several application components, e. g. patient identification data.

Temporal integration – provides access to historical data or information in order to facilitate efforts of future planning process.

Semantic integration – Semantic integration refers to when several application components using the same data also use or provide the same concept system, e. g. the same diagnosis classification system, for interpreting data [65].

Context integration – Context integration refers to when several application components are synchronized automatically with regard to context descriptors like user login or patient identification data.

Presentation integration – Presentation integration refers to when several application components used by the same users provide equally designed user interface elements for equal presentation and interaction functions [65].

Process integration – Process integration involves the minimization of communication and coordination effort between activities of a process [5].

Electronic data integration – This refers to complex integration to many internal applications using many different protocols over LAN and WAN [11].

Specification integration – This type of integration shares the similar characteristics by those of middleware integration [32], internal integration [62], and level-1 integration [39]. This integration is related to providing the specifications of system technical design at the hardware, software, and

application level of stand-alone. This type of integration works on a minimum specification of any information system and that needs minimum computer hardware.

Compatibility integration – Integration could be achieved by satisfying the level of compatibility between different system components. Human resource plays an integral role in compatibility integration [6; 54].

Ergonomic integration – Ergonomic integration is concerned with users' comfort with graphical interface, software, keyboard, and hardware. User-friendliness and environmental consideration are also within ergonomic integration.

Cognitive integration – Intangibility, usefulness, and consistency of communication between user and system are referred to as cognitive integration. Besides, it covers communication encompassing error messages and other related information.

3.2.3 Enterprise Integration and Level of Integration

The perspectives presented earlier suggest that an organization applies both forms of organization and information systems integration. We characterize this integrated use as enterprise integration. Grant & Qiang Tu [22] suggested within enterprise integration, there are levels of information systems integration.

Level I: System-specification integration – this is the lowest level of integration that is marked by compatibility integration and specification integration on stand-alone basis.

Level II: System-user integration – this integration is characterized by the integration of users with technology and environment.

Level III: Islands of technology integration – Linking islands of technology that are dispersed geographically by focusing on the ability of these islands to link to each other is the aim of this level. This level of integration is characterized by internal integration, data integration, horizontal integration and vertical integration.

Level IV: Organization integration – Integrating the organization as a whole rather than a mere technological integration is the major focus of this level. It is marked by value-chain integration where efforts of variety of functions across value-chain are managed in regard to functional integration [10; 66], electronic exchange environment, internal vertical integration, internal horizontal integration, internal temporal integration, and strategic integration.

Level V: Socio-organizational integration – This level of integration encompasses the social-external (socio) environments such as civic institutions, industry, and government by going beyond the traditional business practices. Electronic data integration is one enabler to achieve this level where it would be possible to conduct business in several industries [23]. Hence, interface integration is regarded as level V integration [62] whereby e-commerce could be a valuable strategy to accomplish socio-organizational integration [55]. External horizontal, external vertical, external temporal, and shared vision integration, are four types covered in this level [22]. This integration highlights the extreme importance of these four types whereby affiliate programs, business alliances, and collaboration are facilitated.

Level VI: Global integration – This is the highest level of integration. Organizations move beyond the cultural and national borders [52]. Accordingly, there are a variety of issues involved at this level ranging from customs, management styles, politics to time and language differences [33; 57]. Global integration considers three types of integration: (1) international horizontal integration, (2) international temporal integration, and (3) cultural integration. The supply-chain that cuts across geographical border exemplifies this level of integration.

3.2.4 Case study analysis

The research uses a single case study analysis to explain the types and levels of integration using the taxonomy identified earlier. The case is a public institution of higher education sector in Malaysia. This sector is chosen in view of many prior literatures that used business, supply chain and health care to demonstrate information systems integration characteristics. Thus, an institution in higher education sector should contribute to distinct theoretical and practical knowledge in information systems integration.

The institution has a total of 12,883 postgraduate students with about 4,455 doctoral students. There are 11,392 undergraduate students. It was established in 1904 and is currently recognized as a research university.

Altogether, there are 1,160 faculty members who are doctoral degree holders. The institution offers diverse programs in engineering, management, architecture, computing, education and Islamic studies. It has two main campuses.

As it is a public institution, its governance structure differs from commercial organizations. There are faculties, schools, institutes, research alliances and administrative offices. The case has institutionalized various committees at the top management level that make strategic and operational decisions in line with the support it

receives from the government. Centralized decision-making and formalization through policies and procedures is a key feature of the institution.

Recognizing the need to remain competitive in the higher education sector and reforms made in higher education as evident worldwide, the institution established a transformation plan in the year 2010. Information and communication technology plan is another key improvement plan. Table 1 shows the information systems category and of historical and current description of information systems integration at the institution.

Table 1. Case analysis on information systems integration (source: archival records)

Information systems category	Historical and current description of information system specification
Internet Gateway	**Main campus:** 135 Mbps (in 2006) 180 Mbps (2008), 612 Mbps (2010)
	Secondary campus: 32 Mbps (in 2008), 61 Mbps (2011)
	Plan for 500 Mbps for administration and up to 1 Gbps for students Internet gateway for main campus and 200 Mbps for secondary campus in 2012
	Plan for main and secondary campus uplink upgrade from the 4 to 100Mbps in 2012
Wireless access points (AP)	500 AP (in 2008), 800 AP (2010) in main campus (90% coverage, IEEE 802.11g, best effort 1 – 2 Mbps individual uplink)
	Minimal Wifi AP in 2008, hotspots in all building in 2011 in secondary campus
	Plan for 100% coverage in main and secondary campuses utilizing much faster IEEE 802.11 of Wimax technology (min 5 Mbps individual uplink) in 2012 to support IPTV
Data centre	A new disaster recovery center (DRC) in secondary campus will be ready in 2012
	Plan for a new DRC in main campus is awaiting government's approval
	Plan to utilize cloud data storage in 2013
Electronic learning (eLearning) / Learning Management System (LMS)	WebCT LMS (2004)
	Moodle LMS single server and database (2005)
	Moodle LMS 3 high-availability servers & database (2008)
	Moodle LMS with Web 2.0 support (2010)
	Moodle LMS with Facebook integration (2011)
	Moodle LMS with ePortfolio integration and Plan for Mobile Apps (2012)
	Plan for integration with collaboration system and video streaming (2013)
Academic Information Management System	Terminal application (Undergraduate) (2000)
	Web application (Undergraduate) (2005)
	Integrating Post-Graduate Studies System (2010)
	Reengineering for Outcome Based Education requirements (2012)
	Plan for Mobile Apps (2013)

In terms of organizational integration, the evidence suggests that internal operational and internal functional characterizes the institution. Strategic and operational information systems plan place an emphasis on technology-enabled academic operations and administrative functions that are enabled by human resource information systems, financial information systems and research and development information systems.

In regard to enterprise integration and level of information systems integration, the findings suggest the institution is making attempts to achieve ***level III*** (***Islands of technology integration***) and ***level IV*** (***Organization integration)*** in parallel. Moving forward requires the institution to build capabilities in encountering challenges along the way. Below is the discussion of the institution's key challenges (among others) in the pursuit of attaining these levels:

Organizational – organizational factor entails strengthening coordination among decision-makers, faculty and supporting members of the institution. Coordination requires harnessing both social and technical capabilities including in technological and project management skills for on-going projects;

Technological – data integrity in terms accuracy, timeliness delivery and completeness in information systems integration has often been cited as demanding utmost attention. The lack of a repository of historical information is a cited challenge in reporting of trends and making predictive analysis. Further, another key challenge facing the institution is constant technological threats;

Environmental – being a public institution, the institution reports to the Ministry of Education. The institution is subjected to requirements as imposed

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by the national accreditation body. This places pressures for the institution to deliver timely reports to these bodies. Although some efforts have been made by the ministry to integrate research grants application information (***level V: Socio-organizational integration***), to date only selected institutions have access to this integration.

Business – the institution's envisages "to be recognized as a world-class center of academia and technological excellence". Challenges exist in aligning operational activities to strategic directions in particular, assuring that information systems integration efforts of the institution are not treated in piece-meal approach, rather, receiving adequate budgetary support and skillful human resources to implement identified key projects;

Knowledge – while the institution has made commendable efforts in information systems integration, it remains that knowledge sharing is important impetus to sustain in Information Age. Much still remains to be done in terms managing knowledge. "… for knowledge to be gathered, analyzed, categorized and organized…" to support knowledge sharing activities among faculty members, decision-makers, administrative members and students [26].

4 Conclusion

At the onset, the article began with the following research questions:

- ***RQ1a: What are the types of information system integration in organizations?***
- ***RQ1b: What are the levels of information system integration in organizations?***
- ***RQ2: What are the challenges in achieving a higher level of information systems integration in an institution of higher education sector using an adaptation of Tornatzky & Fleischer [61] innovation adoption framework?***

The research has fulfilled its aims in identifying the types and levels of information systems integration in organizations. Besides, using a single case study approach, the research demonstrates the application of this information systems integration characteristic in higher education sector.

The research acknowledges the challenges in the pursuit of moving upward in the hierarchy of information systems integration. Using an adapted Tornatzky and Fleischer [61] innovation framework, the researchers shows the technological, organizational, environment and knowledge challenges facing the institution. The research has contributed to theoretical knowledge in integrating the contexts and perspectives of information systems integration. Besides, the research has shown the applicability of the adapted Tornatzky and Fleischer [61] innovation framework in explaining the higher education context. Academic administrators, information technology managers and university's key decision makers may find the outcomes of this on-going research useful to take heed of key challenges and identifying means to overcome barriers in information systems integration.

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