

Enterprise resource planning (ERP) systems: a research agenda

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Abstract

The continuing development of enterprise resource planning (ERP) systems has been considered by many researchers and practitioners as one of the major IT innovations in this decade. ERP solutions seek to integrate and streamline business processes and their associated information and work flows. What makes this technology more appealing to organizations is increasing capability to integrate with the most advanced electronic and mobile commerce technologies. However, as is the case with any new IT field, research in the ERP area is still lacking and the gap in the ERP literature is huge. Attempts to fill this gap by proposing a novel taxonomy for ERP research. Also presents the current status with some major themes of ERP research relating to ERP adoption, technical aspects of ERP and ERP in IS curricula. The discussion presented on these issues should be of value to researchers and practitioners. Future research work will continue to survey other major areas presented in the taxonomy framework.

Introduction

Enterprise resource planning (ERP) systems can be regarded as one of the most innovative developments in the information technology (IT) of the 1990s. With the growing interest of many organizations in moving from functional to process-based IT infrastructure, ERP systems have become one of today's most widespread IT solutions. According to Heald and Kelly (1998), it was projected that, in 2002, organizations' total spending on ERP applications would reach \$72.63 billion. What have motivated organizations to implement ERP systems are their integration and standardization capabilities, flexible client/server architecture, and their abilities to drive effective business reengineering and management of core and support processes (*ComputerWorld*, 1998).

While ERP systems have traditionally been used by capital-intensive industries, such as manufacturing, construction, aerospace, and defence, they have recently been implemented in the finance, education, insurance, retail and telecommunications sectors (Chung and Snyder, 2000). ERP systems are now considered the standard technology upon which many organizations are operating their business, and they are, therefore, known by the specific ERP standard they are adopting (Sweat, 1998). From a historical point of view, the concept of ERP has advanced from the MRP systems in the 1970s and the MRPII systems in the 1980s. Currently, SAP, Oracle, PeopleSoft, Baan, and J.D. Edwards are considered the top ERP vendors. Despite the differences in the marketing policies of their vendors, these packages have similar offerings and shortcomings, and they still adopt the MRPII's model for the manufacturing planning components of their system

products (Gray and Landvater, 1989). Overall, ERP systems are beneficial in providing support for all variations of best business practices, in enabling the implementation of these practices with a view towards enhancing productivity, and in empowering the customer to modify the implemented business processes to suit their needs (Rao, 2000).

As the widespread application of ERP systems continues, the need for a new research agenda to address various issues in this context has never been more urgent. Having ERP repeatedly topping the list of themes in major academic information systems (IS) conferences reflects the dire need for research in this rapidly emerging field. In one aspect, ERP combines both organizational business processes and total organizational IT into one integrated system (Chung and Snyder, 2000). Neither IT practitioners nor researchers are still able to determine the potential impact of ERP adoption on adopting organizations.

Based on a comprehensive review of much of what has been written so far about ERP, Figure 1 highlights the major streams of ERP research. This paper, by reviewing available studies and exploring future research avenues, aims to present a new agenda to further the research on the ERP phenomenon. In particular, the paper highlights several dimensions relating to ERP adoption, technical aspects of ERP, and ERP in IS curricula. These are discussed in the following sections.

ERP adoption

Total quality management (TQM) and business process reengineering (BPR) movements are believed to be among the contributing factors to the heightened attention to the employment of IT in key business functions (Soliman, 1998). Several researchers point to the linkages between ERP and BPR, where the former is



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Figure 1
 Taxonomy of ERP research



considered a driving technology of BPR. ERP systems are seen to be effective in tying the business functional units with the various organizational information systems and their associated databases, which in the end can support the strategic aims of modern organizations (Soliman and Youssef, 1998).

One of the major challenges in ERP adoption is flexibility assurance. Organizations will always need to integrate newly-acquired business functionalities into its data-processing systems with the minimum time possible (Gupta, 2000). The flexibility of ERP systems refers to the extent to which an ERP system may be dynamically reconfigurable to define new business models and processes (Stedman, 1999). However, one of the major drivers of implementing ERP systems is their competence in being designed based on best practices and their ability to standardize business processes and systems (Cooke and Peterson, 1998; Keller and Teufel, 1998; Rick, 1997). Organizations view ERP-enabled standardization as a vital means to integrate dispersed organizational systems, provide a seamless access to information organization-wide, and make informed decisions on strategic and daily

business matters (Österle *et al.*, 2000). However, standardization in an ERP context is not without shortcomings. Several researchers point to the fact that standardization might be achieved at the cost of flexibility (Bancroft *et al.*, 1998; Keller and Teufel, 1998; Pawlowski *et al.*, 1999; Scapens, 1998; Vercoulen and Wegberg, 1999), which is another important business requirement for organizations to accommodate emerging changes in business processes and IT systems (Österle *et al.*, 2000). However, it is in the ERP package selection phase that a balance between standardization and flexibility should be considered, based on a careful determination of industrial and organizational demands (Keller and Teufel, 1998). Attention to other important factors is also important to ensure a balanced implementation approach.

The adoption of ERP system in an organization requires intense efforts, focusing on both technological and business themes of implementation. Critical to the success of these efforts is the adequate organizational preparedness for embarking on ERP. The following list developed by Rao (2000) describes the major factors that have to

be considered in the preparation stage of ERP implementation:

- *Infrastructure resources planning* – making sure that adequate infrastructure is planned for in such a way that it becomes reliably available well in time (both for the pre-implementation and the post-implementation stages).
- *Local area network* – ensuring network support for any ERP or other applications.
- *Servers* – deploying adequate server/network, even during the training/modelling phase.
- *PCs* – introducing new PCs with the latest configuration that would be quite adequate for most ERPs.
- *Training facilities* – establishing an adequate training center to work as a competency center.
- *Human resources planning* – focusing on building a teamwork environment, where team size spans across the entire organization.
- *Education about ERP* – ERP education should be carried out across the organization about ERP success and failure practices.
- *Commitment to release the right people* – ERP is recognized as a difficult but necessary project, and the best people must work full-time on the project.
- *Top management's commitment* – top management must have a change mindset through learning at all levels.
- *Commitment to implement "vanilla version"* – ensuring minimal customisation and quick implementation.
- *Ability and willingness to consider an ongoing site as a Greenfield site.*
- *Reasonably well working manual systems* – carrying out audit exercise to find the current status and their corresponding correction actions.
- *Strategic decision* on centralized v. decentralized implementation.

Gupta (2000) finds that the keys to successful implementation of ERP are relating to securing top management commitment, forming cross-functional task forces to link project management with business units, carrying out an assessment exercise of hardware requirements, making deployment a step-by-step introduction rather than all at once, starting early planning on user training and support, streamlining decision making to move implementation quickly, and being patient, as ERP implementation takes time. Cissna (1998) finds that factors relating to top management support, assignment of the best people to implementation teams, and strong involvement of people from the field

are important in reducing the resistance to changes involved in ERP implementation.

Gupta (2000) illustrates several common problems associated with ERP implementation. Among these is the resistance to change, when, for example, some employees become reluctant to learn new techniques or accept new responsibilities. Another problem is relating to unplanned cost associated with new requirements emerging after the freezing stage. A third problem is poor training of end-users, who, when the system is up and running, do not know how to use it and maintain it continually.

Future research in this area may focus on conducting a series of case studies and empirical studies on ERP deployment with regard to specific stages of implementation. It would be interesting to investigate, through a critical factor approach, how organizations have gone through the ERP implementation. Other themes of study can be ERP's influence on IT and human resources infrastructure, strategic alignment, knowledge management and organizational learning, outsourcing and application service provider and competitive advantage.

Technical aspects of ERP

A number of researchers highlight several ERP issues related to the technical side of implementation. One of these issues is related to the increasing use of the Internet, which has raised the biggest challenge facing ERP suppliers. This challenge relates mainly to the need of addressing the global access issues and deployment of information systems that would accommodate to intra-organization and extra-organization needs effectively. Moreover, ERP systems need to stimulate these technologies to provide complete (best business practices), usable (highly productive) and adaptable (easily installed and maintained) application systems (Rao, 2000).

Chan (1999) proposes an evaluation framework for the different IT architectural choices for ERP systems based on identifying the requirements of eight components relating to:

- 1 network infrastructure;
- 2 server operating systems (OS)/platform;
- 3 database;
- 4 data ownership;
- 5 client OS/workstations;
- 6 Web enablement;
- 7 prerequisite user skills; and
- 8 IT capacity.

In addressing the problem that many organizations face when attempting to keep up with the new versions of their already implemented ERP system, Pu Ng and Chan (1999) develop an economic model of ERP life-cycle cost to assist in determining the best time to select an upgrade and the best time to complete its implementation. Umar and Missier (1999) illustrate a knowledge-based decision workbench tool to reduce the time and effort spent on integration and migration tasks in ERP implementation. This workbench helps the user to define appropriate strategies, decide architectural configurations, select a software package and plan for the implementation project. Seethamraju (1999) suggests that future ERP systems will be developed based on components rather than modules and will be designed for incremental migration rather than massive reengineering. He also predicates that the focus will be on managing dynamic rather than static configuration, which, in turn, requires managing multiple sourcing and partnership relationships. Sato *et al.* (1999) puts forward several areas for future research, including integrating ERP and other systems on the Internet, modeling the effects and outcomes of various customizing changes in ERP, developing an ERP-oriented approach to process modeling, and the application of ERP systems in home business domains. Gable *et al.* (1997) suggest researching whether ERP implementation requirements should be specified in the same way as for designing and developing a custom system. They also suggest examining those unique characteristics of R/3 that influence both the audit of its implementation and its post-implementation review, as well as on measuring the cost of switching from legacy systems to ERP systems and exploring the organizational approaches used in anticipating costs.

ERP in IS curricula

In response to the widespread application of ERP systems, academic institutions are becoming more concerned about how to integrate the teaching of these emerging technologies into their current IS curricula. This originates from the market demand for highly qualified ERP specialists (*Hewitt Survey*, 1999). Various frameworks and models have been put forward to meet this critical demand.

Elam *et al.* (1999) consider the ERP educational strategy as a curriculum integration mechanism to readjust the

educational delivery by moving from a focus on standard functional areas towards an integrated business process approach. Their approach is that this strategy can be accomplished by providing an intimate understanding of business processes, integrating management and technology skills, imparting knowledge on the power of integrated business processes, and using the ERP as an enabler of cross-functional education. However, Gibbon and Aisbett (1999) suggest that ERP systems should be taught through understanding the history of business information requirements. The rationale behind this approach is that the complexity of ERP systems can be best understood by looking at how modern requirements have developed over time from simple beginnings. Based on a realization of the barriers of the lack of ERP knowledge and experience of academic staff, and the perceived need for students to gain hands-on experience, Hawking *et al.* (1999) illustrate an approach to integrating ERP teaching in the IS 1997 curriculum model across 11 levels of knowledge relating to fundamentals of IS, personal productivity with IT, IS theory and practice, IT hardware and software, programming, data, file and object structures, networks and telecommunications, analysis and logical design, physical design and implementation with both DBMS and programming environments, and project management and practice. Hawking *et al.* (1999) suggest that alliances with ERP vendors have enabled some universities to offer innovative ERP teaching. This principle of such vendor partnership is adopted by Ongkasuwan (1999), who proposes a framework for incorporating R/3 into the MIS curriculum of MBA and BBA programs. The aim of his framework is to arrive at a cost-effective approach to a high-level teaching standard based on nine essential R/3 software modules.

Other research efforts in this area include the work of Stewart and Rosemann (1999), who develop a "win-win" collaborative approach that local universities can use to capitalize on their own expertise and compete in the global educational market. Their approach adopts the principle of task allocation based on local expertise, together with the establishment of collaborative curriculum development teams across various institutions. Quinton (1999) also provides some recommendations and guidelines concerning the inclusion of R/3 into a business curriculum in the context of a strategic alliance with an ERP vendor. He suggests five steps necessary for developing

knowledge about R/3. These are introduction to the ERP concept, introduction to the business process approach, introduction to the basic concepts of the R/3 system, instruction in a particular business module, and faculty training in the application of the individual system modules. On the other hand, Victor *et al.* (1999) study the interdisciplinary approach of the University of Applied Science, Cologne, which focuses strongly on practical demands and requirements by industry and commerce, and encourages students to attend lectures that impart knowledge and skills ranging from programming to business process modeling using R/3. Stewart and Gable (1999) propose the use of case study and action research approaches in researching and teaching aspects of postgraduate ERP-related programs. They believe that this approach enriches the theoretical side of practice and provides insights into industry sponsors. They argue that it also has the potential to provide students with pragmatic skills of research and increase their ability to understand problems associated with ERP implementation.

From a practical perspective, Gable *et al.* (1997) identify a number of issues that need to be addressed before incorporating ERP teaching in the IS curriculum. These include knowledge of how ERP systems are utilized in the current IS curriculum, justifying the need to incorporate ERP teaching in the IS curriculum, and ascertaining ways of covering ERP systems in IS major subjects in undergraduate programs. From a research point of view, Elam *et al.* (1999) propose the development of a set of metrics for measuring the effectiveness of ERP teaching and the curriculum. This includes measuring the real and exact value of ERP knowledge in the job market and the impact of teaching quality and quantity on it. It also concerns measuring the increase in course or program relevance or school prestige. Gable (1998) suggests examining the influence of factors like the pervasiveness of the ERP packages in the world/regional/local market, the anticipated longevity of the inherent technology, and market demand for related expertise on research and curriculum.

Conclusion

With the increasing organizations' consideration to measure customer profitability and retain customers, many customer-focused applications and analysis have begun moving from theory to implementation through creative, innovative

and motivated organizations that aim to provide a tremendous and unbeatable strategic advantage (Rao, 2000).

ERP vendors will continue to extend their systems to include Web-based procurement applications, to support the online outsourcing and maintenance processes of ERP systems (Gupta, 2000). Other major efforts relating to the continuous development of ERP systems are dedicated to embedding more Internet-based features that provide organizations with a global reach to their supplier and customers.

This paper has presented a survey of research relating to some major ERP issues. It has illustrated a taxonomy of ERP research that is believed to be covering the major issues in this important field. Much research is still needed to better understand the ERP phenomenon from a balanced perspective. Several themes have been discussed in this paper, and future work will continue to survey the other areas described in the framework. It is expected that the current and future work will collectively provide researchers and practitioners with a good reference to research and practice in this emerging field.

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