

8-21-2001

Enterprise Resource Planning Systems Research: An Annotated Bibliography

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Recommended Citation

Esteves, Jose and Pastor, Joan (2001) "Enterprise Resource Planning Systems Research: An Annotated Bibliography," *Communications of the Association for Information Systems*: Vol. 7 , Article 8.

DOI: 10.17705/1CAIS.00708

Available at: <https://aisel.aisnet.org/cais/vol7/iss1/8>

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**ENTERPRISE RESOURCE PLANNING SYSTEMS
RESEARCH: AN ANNOTATED BIBLIOGRAPHY**

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**BIBLIOGRAPHY;
ERP**

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ABSTRACT

Despite growing interest, publications on ERP systems within the academic Information Systems community, as reflected by contributions to journals and international conferences, is only now emerging. This article provides an annotated bibliography of the ERP publications published in the main Information Systems journals and conferences and reviews the state of the ERP art. The publications surveyed are categorized through a framework that is structured in phases that correspond to the different stages of an ERP system lifecycle within an organization. We also present topics for further research in each phase.

Keywords: enterprise resource planning, ERP lifecycle, ERP publications, formats, references

I. INTRODUCTION

Enterprise Resource Planning (ERP) systems are software packages composed of several modules, such as human resources, sales, finance and production, providing cross-organization integration of data through embedded business processes. These software packages can be customized to cater for the specific needs of an organization. During the 1990s ERP systems became the de-facto standard for replacement of legacy systems in large, and particularly multi-national companies [Parr and Shanks 2000].

Regarding the significant impact of ERP systems on industry, Davenport [1998, p. 122] states “the business world's embrace of enterprise systems may in fact be the most important development in the corporate use of information technology in the 1990s”. The market for people who can work with these systems, implement them, and understand how these systems transform organizations is big, and growing [Watson and Schneider 1999]. Despite the growing interest in ERP systems, publications on these systems within the academic Information Systems (IS) community, as reflected by contributions to journals and international conferences is only now emerging. Research on ERP systems has been treated as a "secondary" and its importance has been neglected by the IS community. But, lately, researchers argue the need for more ERP research [Gable 1998, Gable et al. 1997b].

This study provides an annotated bibliography of ERP publications published in the main IS journals and conferences during the period 1997-2000. It categorizes them through an ERP lifecycle based framework that is structured in phases (Section IV). Originally, this bibliography started as an extension of the one developed by Gable and Rosemann [1999], which focused on ERP and higher education. We extended their bibliography with a significant number of new publications in all the categories used in this paper.

This paper is organized as follows. First, we present the approach used to search for articles (Section II). We then analyze the articles found, categorizing them according to our ERP lifecycle model (Section III). In Section IV we summarize the life cycle model and then use it to organize the bibliography and give a brief summary of each article. Because of the large number of articles that deal with ERP in education, we devote a separate section (Section V) to this category. . Finally, Section VI briefly presents our conclusions. The References section contains 193

citations.

II. SURVEY SEARCH APPROACH

To develop an overview of academic activity relating to ERP systems, key IS journals and conferences were scanned for the period 1997-2000. The journals surveyed were:

- ACM - Association for Computing Machinery
- CAIS - Communications of the Association for Information Systems
- DSS - Decision Support Systems Journal
- EJIS - European Journal of Information Systems
- HBR - Harvard Business Review
- IJIM - International Journal of Information Management
- ISJ - Information Systems Journal
- ISR - Information Systems Research
- JGIM - Journal of Global Information Management
- JIT - Journal of Information Technology
- MISQ - Management Information Systems Quarterly

The academic events surveyed were:

- ACIS - Australasian Conference on Information Systems
- AMCIS - Americas Conference on Information Systems
- ECIS - European Conference on Information Systems
- EMRPS - Enterprise Management and Resource Planning: Methods, Tools and Architectures
- HICSS - Hawaii International Conference on Systems Science
- ICIS - International Conference on Information Systems
- IRIS - Information Systems Research Seminar In Scandinavia
- PACIS - Pacific Asia Conference on Information Systems

The search was made through the use of keywords such as enterprise resource planning, enterprise wide systems, enterprise systems or software packages and

the main ERP vendors such as: SAP, Oracle, Baan, Peoplesoft, and JD Edwards. Publications during the period 1997-2000 were analyzed. Table 1 lists the number of publications identified from IS journals and conferences. We also included relevant articles from other scientific publications we found during the collection process. During 1999 and 2000, nearly all the IS conferences mentioned in Table 1 dedicated panels to the subject, AMCIS [Panel 1999a], ECIS [Panel1999b], ACIS [Panel 1998b] as well as the ICIS [Panel 1998a].

Table 1. ERP Publications at Selected International IS Conferences 1997-2000.

	1997	1998	1999	2000	Total
IS Events:					
ACIS	0	2	1	1	4
AMCIS	1	2	32	29	64
ECIS	0	2	4	5	11
EMRPS	-	-	29	-	29
HICSS	0	0	3	3	6
ICIS	1	4	4	7	16
PACIS	1	-	-	3	4
Others	1	5	9	9	24
IS Journals	0	2	3	16	21
Other Sources	1	2	4	3	10
Total:	5	19	89	76	189

III. ERP BIBLIOGRAPHY ANALYSIS

After we collected all the publications, they were analyzed and categorized using a simplified version of the ERP lifecycle framework proposed by Esteves and Pastor [1999]. One of the ways to analyze qualitative data is to use a classification system that includes a quest for regularity and standards, as well as topics encompassed by the data. The classifications must then be summarized by words or phrases [Bogdan and Biklen 1982]. We used this process to analyze and categorize the publications found.

The ERP lifecycle (Section IV and Esteves and Pastor [1999]) represents the various phases through which an ERP system project passes in an organization. The ERP lifecycle is structured in dimensions and phases, generic enough to permit the classification of publications and comprehensive enough to give a general vision of the whole ERP lifecycle. Publications that did not fall into a specific phase of the ERP lifecycle, were included in an ERP general directions section.

The number of publications that are related to the implementation phase is greater than the number related to other phases (Figure 1). This finding corresponds to the focus on ERP systems given by the trade press, which also focuses predominantly on implementation. Because of the great number of papers related to education, we created a section dedicated to that subject (Section V). We reviewed 189 publications, most of them from AMCIS and EMRPS. So far, EMRPS is the only academic event dedicated exclusively to ERP systems.

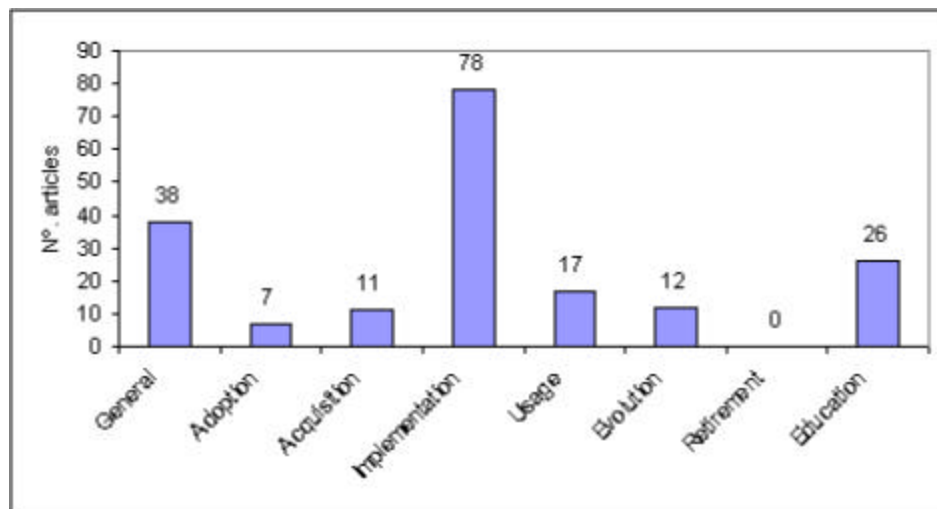


Figure 1. Number of Publications by Category.

GENERAL DIRECTIONS

We categorized the publications on ERP issues not related to ERP lifecycle phases in four main topics (Figure 2):

- research issues,
- business modeling
- organizational knowledge
- ERP product development issues

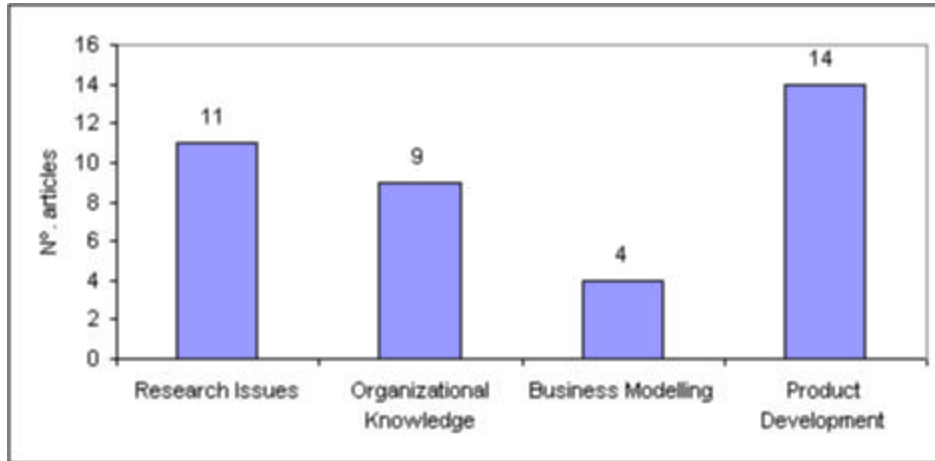


Figure 2. Articles Not Related to Lifecycle Issues

We discuss each of these topics next.

RESEARCH ISSUES

This topic is concerned with ERP research issues and trends. It covers such aspects as research agendas; ERP overview, motivations and expectations; proposals on how to analyze the value of ERP systems; and how to deal with ERP research projects.

- Davenport [1998] presents an overview of ERP systems or Enterprise Systems as he called them, their main functions, their attractiveness and the problems related with their implementation. Davenport also analyzes the impact on a company's organization and culture.
- The research issues and overviews of ERP systems are analyzed and research agendas proposed in Esteves and Pastor [1999] and Mini-Panel [1999].
- David et al. [1999] argue that research in the ERP area must not proceed haphazardly; rather we must develop a systematic means for identifying the patterns underlying these systems and for comparing the symbolic

- abstractions to find differences in function, information architecture, and organization.
- Holsapple and Sena [1999] identified the integration of ERP and decision support systems for further research and development.
 - Sor [1999] suggests that a better understanding of issues surrounding ERP systems could be achieved by moving the discourse towards management theory and dealing with ERP systems as special cases of theoretical premises that were developed in the 1960's.
 - Oliver and Romm [1999] present the motivations and expectations about ERP systems.
 - Chang et al. [2000] summarize a set of issues about public sector ERP implementations and developed by using the Delphi method.
 - Ross and Vitale [1998] present the preliminary findings from a research project that examined how firms are generating business value from their investments in ERP systems.
 - Kumar and Hillegersberg [2000] present an overview of ERP systems, some ERP experiences, and issues and their evolution.
 - Everdingen et al. [2000] analyze ERP adoption by European midsize companies.
 - Markus and Tanis [2000] provide a theoretical framework for analyzing, both retrospectively and prospectively, the business value of enterprise systems.

ORGANIZATIONAL KNOWLEDGE

Organizational knowledge focuses on issues of people skills, know-how, organizational processes, and culture; that is, issues that change an organization so that it can face a new ERP context. It covers aspects of learning and managing competencies from a people perspective and the identification and management of knowledgeable artifacts from an information management perspective.

- Ronca [1999] considers the need of investing in organizational knowledge and change management for an enterprise to be successful in adopting ERP.
- Taxen [1999] proposes a strategy for organizational knowledge evolution and describes how it can be applied in the ERP system context.
- Eliciting information about organizational culture via laddering in ERP environments is discussed by Rugg et al. [1999].
- Gable et al. [1998] develop a research project to understand which ERP knowledge exists within the key players (vendors, implementation partners, and clients) and to understand better what these three key players can do with ERP knowledge.
- Al-Mashari [2000] explores the ERP phenomenon from a process change management perspective, provides a foundation, and recommends several ideas for future research.
- Rosemann and Chan [2000a and 2000b] propose a framework which structures the knowledge required to manage enterprise systems. They suggest how knowledge can be modeled in the enterprise systems context to identify what is relevant during different stages of an enterprise systems project.
- Klaus and Gable [2000] explore the conceptions of knowledge management held by senior managers who are 'immersed' in ERP systems.
- Hedman [2000] presents a competing value approach enterprise systems (CES) framework to discuss enterprise systems from an organizational effectiveness perspective.

BUSINESS MODELING

The objective of the business modeling process is to help an organization to define a good business vision that will reduce the effort involved in adopting the ERP business model. It helps organizations to understand, manage, and communicate their business processes. It covers aspects such as usage of modeling tools

applied in ERP contexts, new business modeling approaches, and comparisons between processes.

- Konstantas et al. [1999] propose the active business objects (ABOs) as a new paradigm to build business IS. The ABO project aims at the design and development of an agent platform where mobile agents represent business processes. The agents encapsulate the policies, business practices and models of different business activities.
- Stirna [1999] analyzes the acquisition of Enterprise Modeling tools. He also outlines a number of situational factors to be considered by organizations when choosing among enterprise modeling tool acquisition strategies.
- Formica and Pizzicannella [1999] discuss a new approach for high-level enterprise modeling referred to as reification. The approach is based on the reification of the Business Processes of an enterprise, that is, their representation as static entities by using the object-oriented paradigm.
- Wagner [1999] shows that enterprise and business process modeling could greatly benefit from agent-oriented approach, called Agent-Object-Relationship (AOR) modeling.

ERP PRODUCT DEVELOPMENT ISSUES

This topic is related with the first-hand development and manufacturing of ERP products. It covers aspects such as: new modules, interfaces, componentization, increased flexibility, and introduction of new emerging technologies and platforms.

- Sutcliffe [1999] proposes a framework for engineering reusable components that serves two purposes. First, it can help designers think by making design trade-off explicit. Second, it proposes a cost driven evaluation of reusable components which can inform decision making during reuse oriented development.
- Frank [1999] uses research within extended transaction models, replication methods, and countermeasures against the missing isolation property in

- order to illustrate how to design distributed ERP systems with high performance and availability.
- Klueber et al. [2000] propose an architecture for e-Business that extends ERP-centric architectures to address the new challenges of business networking.
 - Platner [1996] describes the SAP R/3 software development process and the possibilities R/3 offers for "configuration to order".
 - Sprott [2000] describes how the componentization of ERP packages is likely to evolve.
 - Fan et al. [2000] discuss the design methodologies for component-based enterprise systems architectures development.
 - Huang [1998] analyzes the influence of customer requirements in the ERP software development process.
 - Loos [2000] focuses on future development of ERP systems, emphasizing technical aspects of information technology application as enabler.
 - Sato [2000] introduces quick iterative process prototyping methodology for the analysis and design of business process dynamic properties.
 - Chellappa and Saraf [2000] adopt a framework called network theory to represent the complexity of the ERP market. With this framework, authors relate alliances formation by business application software firms and compability issues.
 - Kobryn [1998] analyzes the requirements of enterprise software architectures and examines the UML constructs and techniques to specify them.
 - A historical perspective has been taken by Chung and Synder [1999] and Kelly et al. [1999] who, from different contexts, emphasize the maturing of IS towards an unambiguous business focus, as attributed to ERP systems.
 - Other traditional approaches in systems development proved to be less beneficial in the long-term than ERP systems [Holland and Light 1999b].

MAIN TOPICS RESEARCHED

ERP systems overview, their expectations and motivations are well-covered subjects in the publications found. Recently, some researchers focused on knowledge management concerns and applied knowledge theories in the ERP context. Few issues are addressed in terms of business modeling and how modeling can be improved. Our review shows that development of ERP products centered in technological issues.

TOPICS FOR FURTHER RESEARCH

Unanswered issues (such as ERP complexity, integration, and flexibility) should be addressed in the future. Technologically, other areas where researchers can help are the development of interfaces, componentization, and integration of technologies. The improvement of business modeling techniques, analysis of business models fit, and adequacy of ERP systems to business models are also areas that lack research.

IV. ERP'S ALONG THEIR LIFECYCLE

THE ERP LIFECYCLE

In this section we use the ERP lifecycle framework proposed by Esteves and Pastor [1999]. This framework is structured in phases, which consist of the several stages that an ERP system goes through during its whole life within the hosting organization. The stages are:

- adoption decision,
- acquisition,
- implementation,
- use and maintenance,
- evolution, and
- retirement phase.

Next, we describe each phase

Adoption Decision Phase. In this phase, managers must question the need of a new ERP system while selecting the general information system approach that will best address their critical business challenges and improve the organizational strategy. This decision phase includes the definition of system requirements, its goals and benefits, and an analysis of the impact of adoption at a business and organizational level.

Acquisition Phase. This phase involves selecting the product that best fits the requirements of the organization to minimize the need for customization. A consulting company is also selected to help in the phases of the ERP lifecycle that follow, especially in the implementation phase. Factors such as functionality, price, training and maintenance services are analyzed and the contractual agreement are defined. In this phase it is also important to analyze of the return on investment of the product selected.

Implementation Phase. This phase deals with the customization or parameterization and adaptation of the ERP package acquired. to meet the needs of the organization. Usually this task is performed with the help of consultants who provide implementation methodologies, know-how, and training. Although training is present in all the phases, the largest training investment is made during the implementation phase.

Use and Maintenance Phase. This phase consists of the use of the product in a way that returns expected benefits and minimizes disruption. During this phase, functionality, usability, and adequacy to the organizational and business processes are important. Once a system is implemented, it must be maintained, because malfunctions have to be corrected, special optimization requests must be met, and general systems improvements have to be implemented.

Evolution Phase. In this phase, additional capabilities are integrated into the ERP system to obtain additional benefits. The extensions can be classified in two types:

- Evolution "upwards". Functionality is oriented to decision making with applications such as advanced planning and scheduling, data warehouses, and business intelligence systems;
- Evolution "outward" to the system's environment, with applications such as customer relationship management, supply-chain management, inter-organizational workflow, and electronic commerce.

Retirement Phase. When new technologies appear or the ERP system or approach becomes inadequate to the business' needs, managers decide if they will substitute another information system approach that is more adequate to the organizational needs of the moment. Some organizations already passed through this phase for reasons such as strategic changes, lack of trust in the ERP vendor or the implementation partner, or bad implementation experiences.

IMPLEMENTATION PHASE

The publications related to the implementation phase were categorized into four main topics: implementation approaches, implementation success, other implementation issues, and implementation case studies (Figure 3).

Implementation Approaches

This topic focuses on how to deal with an ERP implementation project. It covers aspects such as taxonomies of ERP implementations, implementation methods and techniques, and comparisons with other software implementation projects.

- Davenport [1996 and 1998] says that the package implementation process is equally distinct and roles, responsibilities, and the necessary skill set changed substantively from those associated with a more traditional custom implementation.

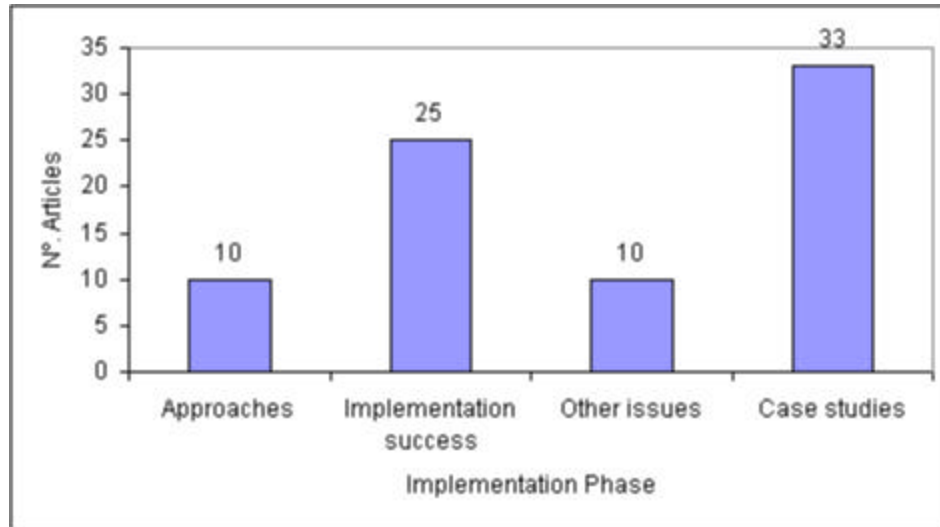


Figure 3. Number of Publications Related to Each Topic of the Implementation Phase.

- Gibson et al. [1999] argue that ERP software implementation requires a different approach that places less emphasis on the technical aspects of software implementation and instead seeks to balance the business process design, software configuration, and project management aspects of information technology implementation with the overall strategy and structure of the firm.
- Milford and Stewart [2000] describe the design of a qualitative research project that seeks to determine if ERP implementations are qualitatively different from other large system implementations.
- Somers et al. [2000] propose an integrative framework and taxonomy derived from the socio-technical view of organizations and other existing theories that illustrates the multifaceted nature of ERP implementations.
- Rebstock and Selig [2000] present a framework of three strategies to implement ERP in international companies. They also report case studies that allow the comparison of these strategies.

- Parr and Shanks [2000a] argue that the concept of an ERP implementation is not a generic concept, and they present a taxonomy of ERP implementation categories. They further argue that understanding the differences between the different categories is crucial to future research in ERP implementations.
- Hazebrouck and Frerichs [1999] analyze and describe the usage of ASAP methodology.
- Fichtenbauer [1999] treats the problems, experiences and solutions of the organization of processes in combination with SAP-projects. The author used an ARIS approach.
- Scheer and Habermann [2000] explain the benefits of using business process models to achieve positive results.

Implementation Success

Implementation success deals with the issues of how to succeed through an ERP implementation. It covers aspects such as ERP project success and failure definitions, problems and outcomes, critical success factors and risk management.

- A number of publications [Gibson and Mann 1997; Bancroft et al. 1998; Holland et al. 1999c; Holland and Light 1999e; Parr et al. 1999; Stefanou 1999; Sumner 1999a; Sumner 1999b; Vikram et al. 1999] attempt to identify critical success factors for ERP implementations.
- Esteves and Pastor [2000] integrated these works into a unified model of critical success factors.
- Parr and Shanks [2000b] present a project phase model of ERP projects and analyze the critical success factors in each phase.
- Shanks et al. [2000] define a set of critical success factors and analyze which of them are important in which ERP process model phase, based on two case studies: one in Australia the other in China. They also analyze the differences between them using national cultural characteristics.

- Sumner [2000] identifies the risk factors in ERP projects that are unique to these projects.
- Markus et al. [2000] describe the results of a study of problems and outcomes in ERP projects.
- Bingi et al. [1999] discuss the critical issues affecting an ERP implementation.
- Brown and Vessey [1998] started the identification of ERP implementation variables that may be critical to a successful implementation. These variables are then incorporated into a preliminary contingency framework.
- Dong [2000] proposes a conceptual model exploring impacts of top management on enterprise systems implementation effectiveness.
- Stewart et al. [2000] describe a research program being undertaken to identify the variables that inhibit an ERP implementation.
- Southwick and Sawyer [1999] argue the importance of analyzing managerial and social issues surrounding ERP implementation by applying critical social theory.
- Bunker [2000] analyzes the ERP contextual skills issues that need to be addressed to facilitate the successful transfer and implementation of these information systems to varied organizational contexts.
- Willcocks and Sykes [2000] analyze the role of the CIO and IT function in an ERP implementation, providing three scenarios of this role.
- Densley [1999] sets out the key issues to enable successful ERP implementations.
- Gable and Stewart [1999] analyze the ERP issues in small and medium enterprises.
- Rosemann and Wiese [1999] adapt the balanced scorecard approach to evaluate the implementation and usage of ERP systems.
- Soh et al. [2000] survey the different misfits observed, i.e. the gap between the functionality offered by the package and that required by the adopting

organization. They also analyze the strategies employed, and the related impacts on organizations.

Other Implementation Issues

This topic encompasses issues not covered previously such as the role of consultants, applied theories to specific ERP issues, general conclusions, and organizational change management in ERP projects.

- Adam and O'Doherty [2000] analyze 14 ERP implementation projects in Ireland.
- Markus et al. [2000] examine the variety of multi-site structures and the configuration and implementation associated with them.
- Krumbholz et al. [2000] describe the usage of several social sciences theories of culture to model and predict the impact of culture on ERP implementations.
- Umar and Missier [1999] develop a knowledge-based decision support workbench with the goal of reducing the integration and migration effort.
- Westrup and Knight [2000] analyze how the mediation by consultants is of importance in ERP implementations.
- Daneva [1999] suggests an approach to deal with the identification and measurement of reuse in requirements conceptualization phase of the SAP R/3 component configuration cycle.
- Decision making on whether to implement ERP with or without BPR is surveyed and analyzed by Bernroider and Koch [1999].
- Theoretical considerations focus on global business processes [Basu and Palvia 1999] and information technology architecture options [Chan 1999].
- Lindvall [2000] discusses the changes before, and just after, the implementation of a SAP/R3-system. He examines changes in the implementing organization especially focusing on the effects of the finance function.

Implementation Case Studies

We found several case studies that document specific ERP implementations. They cover different perspectives in particular situations such as: ERP impacts, organizational change management, business process reengineering, people roles, and decision-making. The objectives of these case studies were:

- to analyze the ERP impacts based in a benefit/costs analysis [Gattiker and Goodhue 2000];
- to describe the impact of ERP on job characteristics [Pawloski et al. 1999] and on organizational knowledge [Baskerville et al. 2000];
- to test the role of three key social enablers in ERP implementations: strong and committed leadership, open and honest communication, and a balanced and empowered implementation teams [Sarker and Lee 2000].
- to make recommendations on how to maximize the benefits from ERP [Niehus et al. 1998] or how to avoid ERP project failures [Scott 1999a];
- to demonstrate how myth-making served to construct an ERP system as an 'ideal' system and the legacy system as a 'dying system' [Alvarez 2000];
- to analyze the key decisions of the development team and key success factors [Clemons 1998];
- to decide onto an ERP adoption and implementation [Hirt and Swanson, 1998; Hirt and Swanson, 1999];
- to analyze ERP implementations from a knowledge transfer perspective [Lee and Lee 2000];
- to demonstrate tradeoffs between Big Bang versus slower ERP implementation approaches that allow time for organizational learning [Brown and Vessey 2000];
- to describe the journey of Geneva pharmaceuticals through the first two of three phases of SAP R/3 implementation project [Bhattacharjee 2000];
- to compare the best of breed strategy with the single vendor ERP alternative [Light et al. 2000];

- to identify the critical elements of business processes and ERP systems alignment [Smethurst and Kawalek 1999; Volkoff 1999];
- to define business process requirements for large-scale public sector ERP implementations [Blick et al. 2000];
- to explore strategic options open to firms beyond the implementation of common business systems [Holland et al. 1999d];
- to describe the implementation of a SAP system in a multi-cultural organization [Gulla and Mollan 1999];
- to standardize ERP templates within the different ERP systems of an organization [Huber et al. 2000];
- to study business process reengineering [Slooten and Yap 1999; Ross 1998; Ross 1999] and change management [Pérez et al. 1999; Amin et al. 1999];
- to determine the causes and nature of changing requirements in user's requirement definition [Rugg and Hooper 1999];
- to analyze the special challenges of ERP implementations outside the business world [Hanseth and Braa 1998; Sieber and Nah 1999; Sieber et al. 1999; Holland et al. 1998; Holland and Light 1999a];
- to describe global supply chain management [Chatfield and Andersen 1998];
- to examine a model that proposes various antecedents to successful e-business change management in ERP environments [Ash 2000].

Main Topics Researched

Some authors studied implementation approaches and others proposed new ones. However, we found that 'implementation' does not mean the same thing to everyone. Each author has his own model of implementation phases/stages. We think that critical success factors research is quite well covered although some of the studies do not provide a precise definition of the critical success factors found and some of them are based in only one case study. Therefore, more effort should be put in the definition and subsequent validation of critical success factors.

Only one study focuses on ERP success definition [Markus et al. 2000].

A few studies focused on ERP impacts at the organizational, technological and business level, on business process reengineering, and on organizational change management issues. The number of studies is not sufficient to create a body of knowledge in the area.

Case studies constituted the largest category of publications. However, in some of them, there is no explanation of research methodology or not enough data to interpret some of the results presented. Most of them lack assumptions or hypotheses (in theoretical terms) for future studies.

Topics For Further Research

Adequate ERP implementation methodologies were pointed out as a critical success factor. However, there is a lack of studies about the definition, usage and adequacy of these methodologies and their value in ERP projects.

As mentioned above, critical success factors are quite well studied. However, we noted that their operationalization is not. There is the need to develop approaches to put in practice and manage the critical success factors identified in some studies. The development of techniques and approaches for the control and monitoring of ERP implementation projects is an area to be improved. It is also important to relate critical success factors with implementation methodologies.

More in-depth case studies that document ERP implementations are needed. It would be useful to analyze knowledge transfer and knowledge management during ERP implementations. User involvement and satisfaction have not been studied in depth. Some studies show that implementing ERP systems is far more likely to succeed when user involvement is high and when users have realistic expectations

about the scope of the project and system functionality (Bonner 2000). Finally, we need to understand the different stakeholders (such as steering committee, project members, consultants, vendors) in ERP implementation projects.

OTHER ERP LIFECYCLE PHASES

Adoption

- Oliver and Romm [1999] emphasize the need of further research into the planning phase of the adoption process and outline some of the principles that should form the basis of empirical research in this area.
- Rugg and Krumbholz [1999] stress the importance of correctly modeling the organizational culture before selecting and installing a system. They describe a model of culture which can be applied to the ERP context and describes a framework to select an elicitation technique for modeling organizational culture.
- Fulford and Solanki [2000] describe the requirements, risks and rewards of an ERP adoption in a manufacturing organization.
- Hirt and Swanson [1998 and 1999] develop a case study where one ERP adoption process is analyzed.
- Monday [2000] examines the potential scope of ERP for supply chain management in the wine industry and the extent to which ERPs can be considered as a potential solution.
- Oliver and Romm [2000] outline the significance of ERP systems and analyze the factors that lead to ERP adoption within universities.

Main Topics Researched. The research in this phase focused on how some types of organizations adopted ERP systems and the associated requirements, risks and benefits. One study is centered in the modeling of organizational culture before selecting and installing an ERP system. Some insights for researchers that want to research in this phase are proposed by Oliver and Romm [1999].

Topics for Further Research. A main issue for this phase is developing approaches to help the adoption decision. The results would help in assessing why a particular ERP approach is best for a specific organization and why ERP should be substituted for the current information system. This work would include the definition of requirements, goals and benefits of the new solution. Studies are recommended of how organizations, once they decide to adopt an ERP system, evaluate the impact of the new adoption decision on the business and organizational processes, and in some cases on the organization strategy.

Acquisition

- Sistach et al. [1999] and Sistach and Pastor [2000] propose a method for the acquisition of an ERP system in small and medium enterprises (SMEs).
- McQueen and Teh [2000] present an acquisition process model that shows a progression from an organization-oriented acquisition process to a market-oriented acquisition process and describe influence factors in the process.
- Stefanou [2000] provides a framework for the selection process of ERP Systems, which can be useful for both identifying critical issues for further research and assisting managers considering ERP projects.
- Brown et al. [2000] identify a set of business and IT factors that are associated with the purchase of ERP systems.
- O'Leary [2000] investigates the game-playing behavior that can manifest itself in the requirements analysis process, evaluation, and choice of ERP software. This study is based on three cases and two sets of requirements analysis software.
- Stafyla and Stefanou [2000] report the findings from empirical research about managers' cognition about key factors affecting the selection of ERP software. A cognitive mapping approach is used to investigate project leaders' perceptions engaging in SAP R/3 projects in Greece.

- Shakir [2000] maps six models of decision-making for the evaluation, selection, and implementation phases of an ERP system and uses a case study to conceptualize the models.
- Bernroider and Koch [2000] detail the results from an empirical study concerning differences in characteristics of the ERP system selection process among small, medium, and large sized organizations.
- Leist and Winter [1998] developed a cost-based model of information systems optimization to derive an optimal allocation of business packages.
- Sammon and Adam [2000] present a literature-based model of ERP software selection that claims to be the foundation for a model of managerial decision making in ERP projects.
- Maiden et al. [1999] propose the usage of use cases and scenarios to help vendors specify their products.

Main Topics Researched. The research in this area focuses on ERP selection methods and criteria affecting ERP selection, specially the ERP selection process for SMEs. One of the studies analyzed the differences in characteristics of the ERP system selection process between SMEs and large organizations. One of the studies proposes a novel way to help vendors specify their products.

Topics for Further Research. Future research should include the selection of both product and implementation consultants. The role of each party (vendor, customer and consultant) and their influence in ERP selection should be investigated. An important issue is the definition of those decisions organizations face prior to implementing the ERP solution. Other open issues are: contractual agreements analysis, different price models, analysis of returns on investments and analysis of hardware and base software needs associated with ERP system acquisitions.

Use and Maintenance

- Holland et al. [2000] present a framework for understanding the process and content of the development of the maturity of ERP systems in organizations.
- Shang [2000] presents a framework that tries to classify the types of benefit that organizations can achieve by using ERP systems and provides a comprehensive foundation for planning, justifying, and managing the system.
- Pozzebon [2000] identifies the factors affecting ERP usage, combining a structuration perspective with a behavioral-based model.
- Kelley et al. [1999] analyze the 'individual's' reactions to ERP technology and subsequent behaviors through the combination of Self-Efficacy Theory and Attribution Theory.
- Poston and Grabski [2000] present a study on the impact of ERP systems on a firm's performance.
- Askenäs and Westelius [2000] show how a set of roles of an ERP system (viewed as an IS) form a vocabulary for discussing the role played by the ERP system in relation to its users.
- Stijn and Wijnhoven [2000] apply the systematic analysis method of memory mismatches (SAMMM) to ERP systems in the usage stage and identify the method's theoretical and practical value and its limitations.
- Granlund and Malmi [2000] analyze the effects of ERP systems on management accounting and management work, especially whether ERP systems alleviate or limit the added value gained from management accounting systems for organizational decision making and control.
- Fahy and Lynch [1999] examine the impact of ERP systems on organizations and, in particular, on the management accounting functions of large organizations that implemented ERP systems.
- Stamper [1999] points out the limitations of current ERP systems and introduces the principles on which the second generation could be built to

achieve massive reductions in development, support, and maintenance costs.

- Glass and Vessey [1999] analyze the maintenance and enhancement tasks of ERP systems, trying to determine whether ERP maintenance follows the 60/60 rule (i.e., approximately 60 percent of the cost of an information system is maintenance and approximately 60 percent of that maintenance is enhancement) and whether user-driven ERP system enhancement is treated the same way it is for traditional IS.
- Loo [2000] proposes the implementation of an information technology service management capability to help in the management of information technology associated with the ERP solution implemented.
- Rosemann and Wiese [1999] propose the evaluation of ERP software usage through a balanced scorecard approach.
- Eriksen et al. [1999] propose exploring the advantages of competence centers to support and maintain ERP systems.
- Kremers and Dissel [2000] discuss the motives and inhibitors for migrating ERP to a new version of the system, considered from the provider and customer viewpoint.
- Doppelhammer et al. [1997] study the database performance of SAP R/3 using a standard benchmark for decision support queries in business environments, named TPC-D.
- Riet et al. [1998] study how ERP systems deal with security.
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Main Topics Researched. The main issues researched on this area are ERP post-implementation benefits, limitations and factors that affect ERP usage. Some studies analyze the impact of ERP systems in organizations performance and accounting functions. Some authors analyze technological issues such as ERP upgrades, security, maintenance tasks, and databases performance.

Topics for Further Research. When most organizations start this phase, many issues arise; issues which focus mainly on the technology. ERP impact on organizations at all levels (technological, organizational, and business) should also be analyzed.

The level of integration of ERP systems in organizations requires study. It would be interesting to define critical success factors for the usage and maintenance phase. User satisfaction and human factors affecting this satisfaction should be studied. Usability is also an important topic and probably the human computer interaction area can help in this analysis. The way organizations create and manage knowledge related to their ERP systems and the use of knowledge theory would be a valuable research topic. Other open issues for ERP maintenance are outsourcing services, maintenance models, and techniques, improvement of ERP maintenance based in previous maintenance, management of upgrades and their impact.

Evolution Phase

Several authors analyze new emerging ERP technologies and new business models.

- Shaw [1999] analyzes the use of Web technology and its relation to supply-chain management.
- Lenzerini et al. [1999] propose a framework for providing an integrated view of data. The framework can deal with data used from different kinds of applications.
- Park [1999] develops a framework for a design interface module in ERP systems that automatically extracts features required for a process planning.
- Meier et al. [2000] develop an Editorial Workbench that helps to manage knowledge spread in internal and external sources in order to distribute the right information to the responsible manager in time.

- Rosemann et al. [1999] introduce two different approaches for possible workflow-based ERP architectures and discuss the related advantages and constraints.
- Bergamaschi et al. [1999] propose a data replication model, called DOT (Dynamic Ownership Transition), to realize the integration between workflow and database technology to support data intensive workflow applications.
- Schönefeld and Vering [2000] present a concept for integrating ERP systems and Computer Supported Cooperative Work (CSCW) and describe the benefits of the integration of both worlds.
- Last and Maimon [1998] provide an approach to knowledge discovery in databases (KDD) applied to ERP databases.
- Assogna [1999] presents a project to explore the possibility of "automating" the generation of a decision support and operational IS, starting from an initial "business idea" of top management.
- Mylopoulos [1999] reviews goal-analysis research in requirements engineering and illustrates how it can facilitate the customization of a customer relationship management system.
- Becker and Bölsche [2000] present an approach to facilitate electronic coordination in enterprise spanning business-to-business relationships.
- Themistocleous [2000] describes application integration and proposes a taxonomy. He also analyses the factors related with the impact of application integration on organizations.

Main Topics Researched. The evolution phase issues studied are also mainly technology-oriented, such as development of interfaces with other systems, the integration of customer relationship management modules and use of web technologies. Another important issue studied is workflow management, with new approaches and architectures being proposed.

Topics for Further Research. How are ERP vendors improving their platforms and what is the effect on ERP systems installed in organizations? Research on how ERP platforms may be combined with other tools is needed, especially for the creation of standards and improvement of ERP efficiency. When should an organization introduce emerging ERP capabilities and how should they integrate them in the overall IS function. Finally, what is the impact of these emerging capabilities in organizations from an organizational perspective..

Retirement Phase

We did not find any publication related to the retirement phase but some publications [e.g. Davenport 1998; Scott 1999a] cite cases of ERP systems retirement. Some publications in the Press [e.g. *New York Times*, *Wall Street Journal*, *the Economist*] describe some ERP implementation disasters. The most famous retirement case is FoxMeyer Drugs [Scott 1999a]. At present, the majority of organizations are in the implementation or in the use and maintenance phases.

Topics for Further Research. This phase is surely the least studied. When, why and how an organization abandons its ERP systems is an important issue. Some failure cases have been reported; however, no author defined exactly what is meant by ERP system failure nor identified what factors are most significant in the failure of these ERP projects. Another unanswered issue is the definition of the expected useful life span of an ERP. It would be also interesting to analyze how the ERP retirement affects the organization.

V. ERP AND EDUCATION

The interest on ERP systems by the universities is evidenced by the number of publications published (Figure 4). Universities analyzed the use of ERP in education, ERP courses and how to change the IS curricula to incorporate ERP systems.

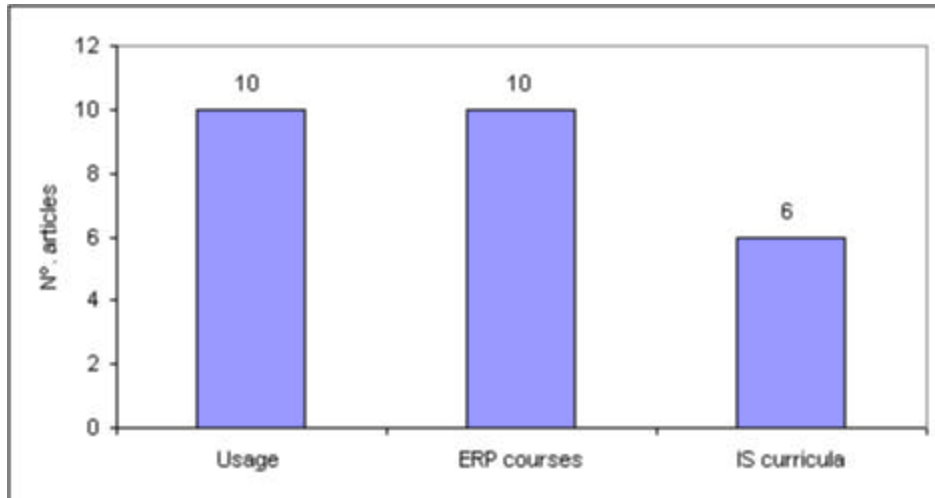


Figure 4. Number of Publications Related to ERP and Education.

ERP USAGE BY UNIVERSITIES

This topic focuses on the processes and mechanisms that some universities use to introduce ERP system gradually in their curriculum and sometimes the adoption of an ERP system by universities.

- Over the past few years, some of the ERP vendors provided a special arrangement that encourages universities to incorporate ERP concepts and technologies into the education process [Watson et al. 1999; Scott and Gable 1997; Panel 1999a].
- The benefits and pitfalls of teaching conceptual knowledge with ERP systems as a learning vehicle are evaluated critically in terms of learning outcomes and effort by Noguera and Watson [1999] and Scott [1999b].
- Individual experiences of universities implementing SAP R/3 into their IS curriculum can be found in Antonucci [1999] Watson and Schneider [1999] and Stewart et al. [1999].
- An analysis of how ERPs may affect operation research practice and research in the future and potential areas of interest within the broad field of operations research [Robinson and Dilts 1999].

ERP COURSES

This topic describes the different types of ERP courses offered by several universities and some ERP course proposals.

- The university ERP-vendor link already spawned new curricula at the postgraduate level, either under the banner of a new breed of MBA program [Winter 1999] or within the Information systems area as a Master of Science program [Holmes and Hayen, 1999b].
- Rosemann et al. [2000b] describe a teaching model, in which postgraduate students analyze selected enterprise-system-supported processes in a company as part of their study.
- Some experiences related to teaching SAP can be found in Watson and Schneider [1999] and Stewart et al. [1999].
- The use of case studies of ERP implementation are discussed by Avital and Vandebosch [1999], Hirt and Swanson [1998], and Ross [1998].
- Foote [1999] describes accounting SAP-related courses in the US.
- Shoemaker [1999] sketches a six-hour ERP-introduction for sales and marketing professionals.
- Stewart et al. [1999] report the impact of reorganizing ERP subject matter into existing curricula and the special challenges posed to faculty.
- ERP cannot be properly understood without a concept of object-oriented programming; a syllabus by Flatscher [1999] aims at making these systems concepts comprehensible to MBA students.
- Holmes and Hayen [1999a] give an example of a syllabus for remote delivery of an introductory subject via the web. They cite the SAP university alliance is a good source of information about ERP courses.
- Rosemann et al. [2000a] present the results from an empirical survey that gives an overview about current activities in collaborative ERP teaching. They also present an international pilot to teach ERP by forming virtual teams.

IS CURRICULA

This topic is concerned with the integration of ERP system in IS curricula, the need for people with ERP knowledge, and how universities can improve and re-structure their curricula to satisfy these needs.

- The potential and challenges for IS education and research in tertiary education posed by this new category of manufacturing and business packaged software were initially identified by Gable et al. [1997a].
- The demand for people who specialize in ERP systems and the related lack of experience with ERP in IS curricula, resulted in an answer from the universities that try to follow market needs. Becerra-Fernandez et al. [2000] summarize the ongoing processes followed and challenges encountered by Florida International University's College of Business Administration to achieve their vision of an integrated curriculum.
- Watson and Schneider [1999] identify opportunities for incorporating the ERP body of knowledge into an IS program. They also discuss related cost and critical success factors.
- Gable and Rosemann [1999] present the results of an international survey about ERP use in universities. They propose the creation of a Web portal to publish and promote the sharing of information between academicians.
- Stewart [2000] presents and discusses the design of a problem-based learning approach that seeks to embed industrial knowledge in the curriculum. He describes a project that is developing a business reference model using process-engineering techniques.
- Rosemann [2000] describes a workshop that provides lecturers new in this area with practical guidelines for the management of an ERP-related curriculum.

MAIN TOPICS RESEARCHED

The analysis of IS curricula is quite well covered in research studies as is the response of universities to the demand for people with ERP knowledge. Some ERP

courses are described in detail. However, their importance in relation to the ERP market is not. Studies of ERP adoption and use by universities are useful for universities that are in the process of adopting an ERP system.

TOPICS FOR FURTHER RESEARCH

An important issue is how universities deal with ERP evolution and how they plan and adapt their courses to this evolution. Another issue is the ERP market's satisfaction with the people that acquire ERP academic knowledge. With respect to ERP adoption and usage by universities, studies related with all the phases of the ERP lifecycle could be undertaken.

V. CONCLUSIONS

The number of publications within the information systems community on ERP systems appears small compared to the size of the business they generated. The publications identified in this paper originate from a small number of sources and are quite recent. All major IS conferences in 2000 dedicated at least a track or mini-track to ERP systems.

This study shows that ERP researcher mainly concentrated on issues related to the in implementation phase of the ERP lifecycle. Until now, the other phases have been almost forgotten. One of the reasons is that the majority of organizations are in the implementation phase. Also, in some phases, namely acquisition and implementation, the strong intervention of consultants makes it difficult to access information.

Although several ERP systems are in the market, the majority of case studies analyze SAP systems. Few studies and little research generalizes the findings to other ERP systems.

ERP systems offer many potential areas for research, several of which are

discussed in this article. Due to their pervasive nature, ERP systems are of interest for a wide range of professional and scholarly communities (from software engineering to accounting), apart from the IS field. This suggests that ERP-related research could or should be interdisciplinary. In our opinion, the number of publications on ERP systems will grow exponentially in the next two years, because many universities created research areas in ERP systems and the interest of the IS community is also growing..

Editor's Note: This article was received on April 13, 2001 and published on August 21, 2001. It was with the author approximately 2 months for 1 revision.

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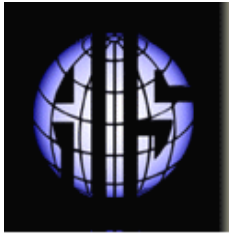
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Communications of the Association for Information Systems

ISSN: 1529-3181

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