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Theling, Thomas and Loos, Peter, "Teaching ERP Systems by a Multiperspective Approach" (2005). *AMCIS 2005 Proceedings*. 151.
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Teaching ERP Systems by a Multiperspective Approach

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ABSTRACT

In this paper we describe how a market-leading ERP system can be used to demonstrate theoretical knowledge of Enterprise Systems. Students of business administration with a focus on information systems are taught theoretical backgrounds about modeling, technical architectures, development, and conceptions of Enterprise Systems. They know about business processes like production planning or material management. However, links between business knowledge, theoretical IT-knowledge, and practical IT-experience are not revealed to the students. To close this gap we propose an integrative ERP curriculum, which maps different theoretical IT-knowledge to Enterprise Systems. Therefore an ERP system is determined from different perspectives like end-users or IT-specialists. Using exemplary processes like purchasing or MRP, the integrative aspect of Enterprise Systems is demonstrated. The introduced concept is not about teaching a specific ERP system but illustrates concepts of ERP like data integration, data structure integration, process integration, and maps information models onto ERP systems.

Keywords

Enterprise System, ERP, IS-education, teaching, multiperspective approach, tables, information models, integration.

INTRODUCTION

Motivation and Related Work

Students of business administration know about business processes like production planning or material management. At our university, the major field of information systems deals with theoretical knowledge about modeling, technical architectures, development, and conceptions of Enterprise Systems. Because of the business economical and theoretical orientation of the students, the link between business knowledge, IT-knowledge, and practical IT-experience is not fully revealed.

In literature many articles depict how Enterprise Systems can provide special knowledge about IT (Gant 2001; Nelson 2002; Watson and Schneider 1999). Some papers describe how Enterprise Systems can be an integrative component of a business school or MBA curriculum (Becerra-Fernandez, Murphy and Simon 2000; Reich 2000). With respect to actual discussions about collaboration and inter-organizational concepts, also collaborative education scenarios are presented (Hawking and McCarthy 2000; Rosemann, Scott and Watson 2000; Rosemann and Watson 2001; zur Muehlen and Lederer Atonucci 2001). Evaluations of ERP lectures determine and manifest the significance of ERP systems in education (Nelson and Millet 2001; Noguera and Watson 1999).

While many articles discuss single functionalities of Enterprise Systems or deal with Enterprise Systems on a meta level, our approach in this paper is to work off the facility to integrate different relevant IS-education topics by using an Enterprise System.

Structure of this Contribution

To illustrate implications of business processes on IT, a multi-perspective and process-oriented fictive case study has been designed. It is transferred to the market-leading ERP system called 'SAP R/3', below referred to as 'the ERP system' due to copyright restrictions. The multi-perspective approach is realized by different views on ERP. Figure 1 suggests an arrangement into different user groups of an ERP system. Therefore ERP is segmented into different shells. Core of ERP is a common repository which contains meta data and tables. Table contents are updated by transactions which can be maintained by source coding. The source code is basis for end-user's applications and customizing transactions. The integration of the different skins leads to a complex business process knowledge. We suggest an assignment into following views:

- The end-user's view. End-user parochially know about the processes they are responsible for and have to deal with the user interface (GUI) of the ERP system.

- The business analyst's view. Business analysts have integrative knowledge about different business processes and business functions, and they link the requirements from the end-users to the software consultants resp. the software engineers.
- The software consultant's view. Software consultants know about business processes and the interaction between different economical functions and processes. Based on this knowledge they are responsible for the customizing of an ERP system.
- The software engineer's view. Software engineers know about meta data of the tables, maintain and enhance ERP's source codes, and know about customizing of an ERP system.

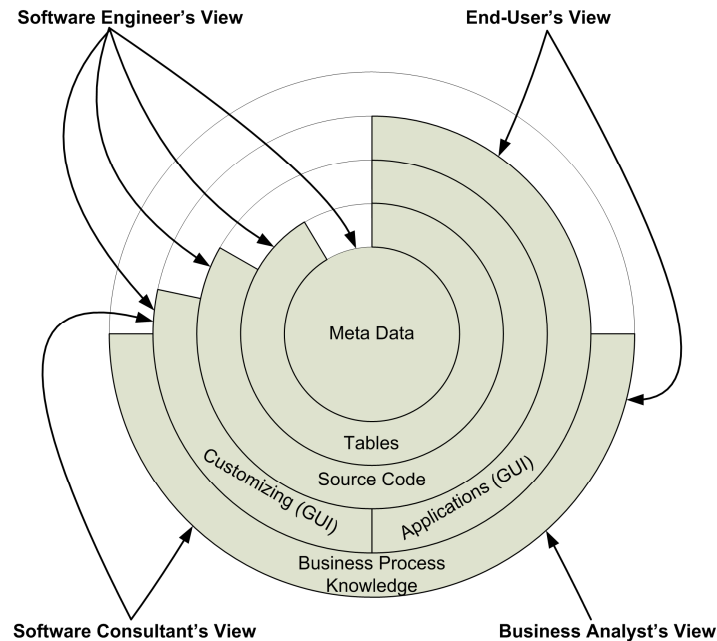


Figure 1. Different perspectives onto an ERP system

In this paper we describe how an ERP system can be used to perform selected contents of our IS-curriculum by using a case study and considering the introduced views. After defining relevant terms and giving a brief introduction to the students' precondition, the case study is described. Main part of this paper maps theoretical knowledge of our lectures to an existing ERP system. The paper ends by giving a short summary and pointing out capabilities for future work.

Definitions and theoretical background

Referring to Noguera et al. (1999) the terms Enterprise System and ERP system are used conterminously (Noguera and Watson 1999). ERP (Enterprise Resource Planning) is an evolution of MRP-II (Manufacturing Resource Planning) and PPC (Production Planning and Control) (Markus, Tanis and van Fenema 2000). Nowadays ERP is a generic term for standard software. Following main characteristics can be considered (Davenport 2000; Lee, Siau and Hong 2003; Scheer 1994):

- Integration of all functions, processes and data of a company by using one single database and defining individual roles and views
- Applicable to most economic sectors
- Modular design

E-business and EAI (Enterprise Application Integration) features are integrated in so called Extended-ERP or ERP-II systems (Bond, Genovese and Zrimsek 2000; Kulmar and van Hilleegersberg 2000; Lee, Siau et al. 2003). Technologies like component ware, web services, best-of-breed solutions, and integration of multimedia or virtual reality are discussed, too (Loos 2000).

Students' Precondition and Allocation of the ERP lecture into the IS-curriculum

Target group of the considered lecture are students of business administration which focus on information systems (IS). The standard period of studying business administration at our university is eight semesters. The curriculum of the major field of

study is arranged in three semesters and should be chosen at an advanced stage of study, regularly beginning with the fifth semester. It contains four lectures and a seminar paper. Optionally, students can work on a project report, which might be a programming project. As a prerequisite for both, the seminar paper and the programming project, the students must have basic knowledge of a programming language. The ERP lecture is held within a facultative 24-hours-unit for students, who have almost finished their major field of study.

Case Study

Different business process scenarios are discussed by using an example of a bicycle-manufacturer. Therefore the organization structure (one company, one plant, one storage location, one purchase organization) is introduced and the manufacturing strategy is explained. To depict different processes of material management and production planning, 12 different bicycles consisting of 30 subassemblies and approx. 110 materials in total are presented. The bicycles’ structured bills of material contain three explosion levels. Bought-in-parts are purchased from 25 vendors, which leads to 50 purchase info records. MRP is based upon primary requirements predicted from the sales department.

PERFORMING LECTURE CONTENTS WITH ENTERPRISE SYSTEMS

This section depicts the link between exemplary contents of our theory-based IS-lectures and our ERP lecture. The presented cases might give an idea of how ERP systems may help to illustrate and to understand theoretical knowledge. Although we introduced four different views onto an ERP system, it is not provided to unequivocally map these views to our four IS-lectures. We rather use the different views throughout the discussed topics in order to sensitize students, why problems within an ERP implementation, within customizing, or within an ERP application may occur.

Modeling of Enterprise Systems

The lecture *Modeling of Enterprise Systems* deals amongst others with data modeling. As an example, bills of material are chosen to apply the modeling method of Entity Relationship Models (ERM). The created model is mapped to the ERP system.

Bills of Material

Bills of material (BOM) explain which material is needed as input to create an output material (Scheer 1994). The data model of BOM is depicted by an Entity Relationship Model (ERM, cf. figure 2).

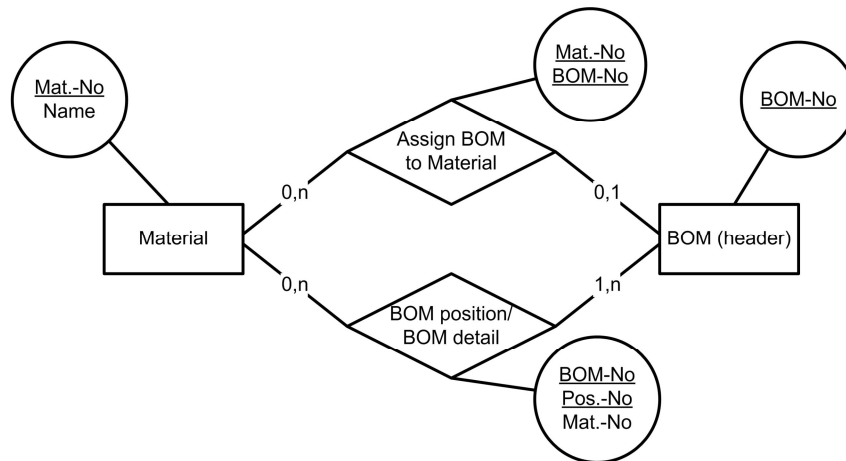


Figure 2. ERM for Bills of Material

BOM are used for different kinds of input-output-relations like document- or maintenance-structures (data structure integration). This leads to differing BOM numbers and material numbers. To link BOM headers to materials, the relation ‘Assign BOM to material’ is used. BOM details include the material numbers of the input materials. These are stored in the relation ‘BOM position/BOM detail’.

The ERM identifies all tables and relations as well as foreign keys needed to store BOM. All tables are shown at the ERP system: The entity ‘Material’ corresponds to the material master table, the entity ‘BOM (header)’ corresponds to the table

‘STKO’, the relation ‘Assign BOM to Material’ corresponds to the table ‘MAST’, and ‘BOM details’ are stored in the table ‘STPO’. Students are advised to create and evaluate BOM by using the end-user’s transactions of the ERP system, e. g. CS01 (create BOM), CS12 (evaluate multi level BOM), or CS15 (material usage). They can testify their created data by using different reports like multi-level-BOM or level-by-level-BOM. By changing to the software engineer’s perspective, students learn the interdependence of the tables within the system.

Technical Architecture of Enterprise Systems

The lecture *Technical Architecture of Enterprise Systems* deals amongst others with Client/Server technologies and data warehouse/OLAP.

Client/Server Technology

Client/Server technologies have been discussed for many years (Sinha 1992) and are a basic concept of nowadays IT. The architecture of the ERP system is based on a three-tier Client/Server model with a presentation layer, an application layer and a database layer. Students discover the basic information flow in this Client/Server architecture and get an impression of scalability while different distributed scenarios are explained:

1. One option is to implement the database layer and the application layer onto one system. In this case only the client (SAPGUI) has a remote access to the hardware-server.
2. Another possibility is to separate presentation, application, and database layer. In this case a distributed application layer is conceivable.
3. Finally, access to the ERP system via web browser is conceivable. In this case an additional layer is necessary to transform proprietary communication protocols into HTTP and HTML. This is realized by the Internet Transaction Server (ITS), which enacts Internet Application Components (IAC). IAC communicate with Web Transactions of the ERP system. Results of a task are transferred via a Dynpro to a HTML-Template of the ITS and finally presented on the end-user’s client (cf. figure 3). The ITS consists of an Application Gate, which communicates with the ERP system’s Application Server via proprietary formats RFC and DIAG. The application gate communicates with the web gate via TCP/IP, while the web gate receives CGI-, NSAPI or MSIIIE queries from a Web Server. This Web Server converts transceived data into web-browser-compatible HTML.

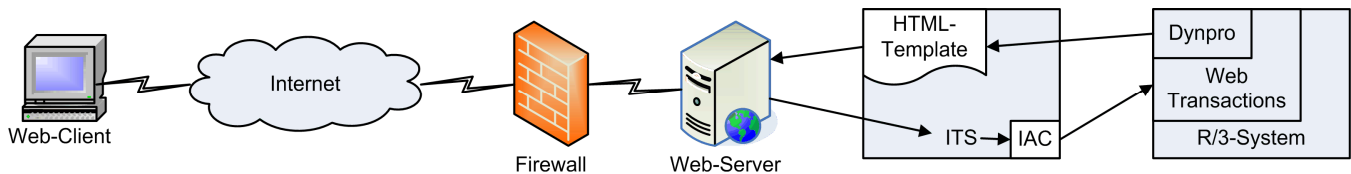


Figure 3. Transactions via Internet Transaction Server

Data Warehouse/OLAP Methodology

Although ERP systems are primarily Online Transaction Processing Systems (OLTP), Online Analytical Processing (OLAP) can be depicted within respective system. Data Warehouse and OLAP theory (Codd, Codd and Salley 1993; Inmon 2002; Wigand 2003) predicates the reported data to be arranged in several dimensions within a hypercube. Multi-perspectiveness like slicing and dicing of the cube is realized by selecting distinct dimensions of the hypercube. For performance reasons, a separation of operational databases and data warehouse tools is recommended. While operational databases contain data for each transaction, data warehouse systems contain aggregated values. So data is intentionally redundant, but the reporting may be faster by using aggregated values and predefined reports.

In our ERP lecture OLAP is illustrated by using the Logistics Information System (LIS). It is a typical example of an ERP-integrated Data Warehouse and provides aggregated information of logistics like material management or production planning. LIS collects data in two different ways:

- a) Some transaction data is booked twice within the ERP system: At first each transaction updates the operational ERP database. At second the values are aggregated to the belonging records in the LIS.

- b) Some LIS-information is imported by regular batch jobs from the operational ERP database system. In this case not each transaction is booked twice, but batch jobs read relevant values from the operational database tables, aggregate the needed values, and fill the LIS tables.

In both cases a separation of the operational database and the LIS is recognizable. The hypercube is stored in relational database tables using concatenated keys. Each key represents a single dimension of the cube. Tables are evaluated by filtering belonging key values.

Within an exercise students perform end-users' ERP transactions (MIGO, goods receipt). Afterwards they activate LIS and start reporting transactions (e. g. MC.9, material stock or MC.A, receipts/issues) from an end-user's view and examine respective tables from a software engineer's view.

Development of Enterprise Systems

The lecture *Development of Enterprise Systems* deals especially with Software Development, procedure models for software development, CASE tools, quality management in software engineering, project management, and organization of IT.

Software Development

Within this lecture several software development lifecycles (SDLC) are discussed. In contrary to traditional software development, ERP systems are primary customized by the set up of parameters. Source code changes should be minimized. This emphasizes the difference between standard software and individual software, and has effects on the tasks of an SDLC (Appelrath and Ritter 2000).

CASE-Tools

In many cases business models of an ERP system can be explained by using meta data of the concerned tables. Meta data contains information about table structures, data types, possible values, and table keys as well as relationships between tables caused by foreign keys. The meta data is stored within the repository of an ERP system. For accessing the repository, a CASE-Tool called 'ABAP' Development Workbench is provided. It is used to explore the discussed tables from a software-engineer's perspective.

Regarding aforementioned examples, students can evaluate e. g. BOM by browsing the introduced tables STKO, STPO, MAST, and material master with the data browser (transaction code SE16). Table contents are presented independently from the application logic. The Development Workbench is also used to depict some exemplary source codes and to explain the programming language ABAP/4 roughly.

Concepts of Enterprise Systems

The lecture *Concepts of Enterprise Systems* discusses the integration of Enterprise Systems, subsystems of Enterprise Systems, Information Systems in manufacturing, retail, and financial services as well as industry-independent Information Systems.

Exemplary Customizing of an ERP system

Main challenge within the implementation of ERP systems is to set up correctly defined organizational structures and business processes ("customizing") (Kirchmer 1999; Norris, Hurley, Hartley, Dunleavy and Balls 2000; Shields 2001). Customizing means to configure an ERP system by changing parameters with minimum changes of the system's source code (Appelrath and Ritter 2000). In our lecture we refer to organizational structures as an example. They are stored in system parameters like companies, plants or storage locations. Within the ERP system the organizational structure of a corporation is defined in the following way (SAP 2004):

Corporation/Client	A legally and organizationally independent unit which uses the system
Company	The smallest organizational unit for which a complete self-contained set of accounts can be drawn up for purposes of external reporting
Plant	Organizational unit within Logistics, serving to subdivide an enterprise according to production, procurement, maintenance and materials planning
Storage Location	Organizational unit that allows to distinguish material stocks within a plant
Purchase organization	Organizational unit within logistics, subdividing an enterprise according to the requirements of purchasing

Table 1. Organization of an Enterprise within the ERP system

Organization units are hierarchically arranged. Each superior unit can consist of no, exactly one, or many subordinated organization units as shown in figure 4.

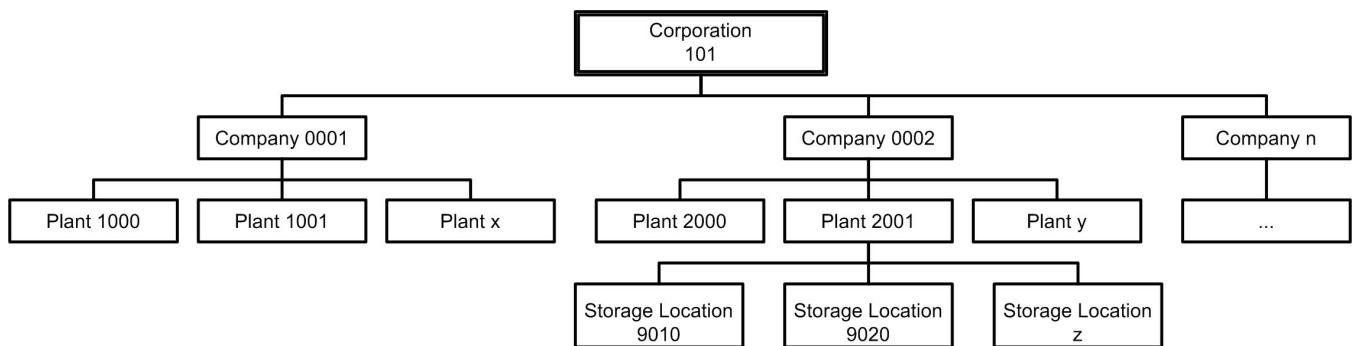


Figure 4. Exemplary Organization Structures in an ERP system

In our ERP lecture students are taught how to customize a company’s structure and how to assign organization units to each other. Therefore the example of setting up a purchasing organization is given. In this context three different assignments of a purchasing organization are possible (SAP 2004):

1. Centralized, corporate-group-wide purchasing. Exactly one purchasing organization is responsible for the purchasing processes within the whole corporation.
2. Company-specific purchasing. Within the corporation each company has its own purchasing organization, which might be responsible for different plants of the belonging company.
3. Distributed, plant-specific purchasing. Each plant has its own purchasing organization, so a single company might have several purchasing organizations.

All options are mapped to the ERP system. The customizing application allows assigning a purchasing organization to companies as well as assigning it to plants from a software consultant’s perspective. After presenting the customizing transactions, meta data and table contents of the respective tables are explained from the software engineer’s view.

Nevertheless, this is only a small example for customizing an ERP system. During an ERP implementation process, configuration of an ERP system is much more complex. In many cases business processes and organizational settings are redesigned in order to optimize processes and to take advantages of integrated Enterprise Systems (Appelrath and Ritter 2000). Therefore, corporate strategies have to be taken into consideration. This requires a holistic view of the organizational needs, which includes all presented views and all affected shells of an ERP system (cf. figure 1). Typically, such implementation projects involve a large number of employees and consultants. This leads to a complex project management in order to manage all information and resources during the implementation process (Kirchmer 1999). Further on, also running ERP systems have to be adjusted to occurring organizational changes. Resulting key issues are change management, integration, interoperability management, and organizational collaboration in order to minimize development efforts.

Views onto Master Data

Different organizational units imply introducing different views onto material master data, because each organizational unit needs individual information about materials. To comprehend this theoretical concept in the ERP system, the students first create material master data by using the end-user’s ERP transaction (MM01, create material master data).

Afterwards students use the development workbench for evaluating meta data and contents of material master tables from a software engineer’s view. Several tables using different concatenated keys are defined to assign multiple organizational views (cf. figure 5, attributes constituting the concatenated key are marked grey.). Information, which is important for the whole corporation, is stored in the ‘A-Segment’. The unique key of this table consists of the corporation number and the material number. Data used by different plants is stored in the ‘C-Segment’, having the unique keys corporation number, plant number, and material number. By using adequate authorization concepts, members of each plant can evaluate appropriate information. Regarding the example, Plant 1000 and 2000 have different lot sizes and processing times for the same material. This concept is enhanced by assigning material master data to storage locations within the ‘D-Segment’.

Corporation	Material	Material Type	Weight	...
101	4711	Subassembly	270	...

Corporation	Plant	Material	Lot Size	Proc. Time	...
101	1000	4711	15	25	...
101	2000	4711	20	22	...

Corporation	Plant	Storage Loc.	Material	Storage Bin	Total Stock	...
101	1000	8000	4711	52.13.5.8	36	...
101	2000	9010	4711	13.7.2	45	...
101	2000	9011	4711	60.1.13.12	3	...

Figure 5. Unique Keys of Material Master Data Segments (marked grey)

Data Structure Integration within Pricing Conditions

A basic concept of ERP systems is data structure integration. As an example conditions of purchase info records are depicted. From a business-economical perspective, purchase info records are the link between vendors and materials. They show which material can be purchased from which vendor and vice versa (cf. figure 6).

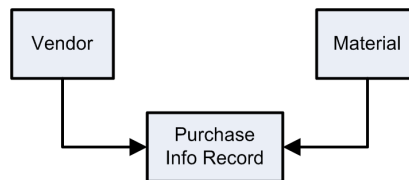


Figure 6. Assignment of Vendors and Materials

After creating purchase info records and pricing conditions from an end-user’s view (ME11), the perspective onto the ERP system is changed to a software consultant’s view. Tables concerning the corporate-wide and purchase organization-wide purchase info records are introduced. To get the focus onto data structure integration, the pricing conditions are analyzed: Different concatenated keys are used to identify the correct condition number. These pricing conditions are structured like pricing conditions in sales order processing or tax conditions. For the reason of data structure integration conditions of all business functions are stored in the same table. To assign conditions to business functions, an identifier (e. g. sales, purchasing, or tax) is used. The link from a pricing condition to the belonging purchase info record is realized by an assignment table, which contains purchase info record numbers and condition numbers. This issue is depicted in an ERM. Based on this theoretical knowledge students are advised to comprehend the ERP from a software engineer’s view using the repository and the data browser.

Gross-Net-Calculation

A topic of *Concepts of Enterprise Systems* deals with MRP and Gross-Net-Calculation (Scheer 1994). To depict this process an Event-driven Process Chain (EPC) is used (cf. figure 7). The EPC-method is taught in the lecture *Modeling of Enterprise Systems*. Gross Net Calculation is depicted within the ERP system: At first students create a primary requirement for finished goods and calculate the gross-net-scheme ‘on the desk’ without an ERP system. Finally they use the ERP system for MRP and compare both results, which are predicted to be the same. With this exercise the students should get an imagination of how Enterprise Systems have rationalized the operational work of a disposition department.

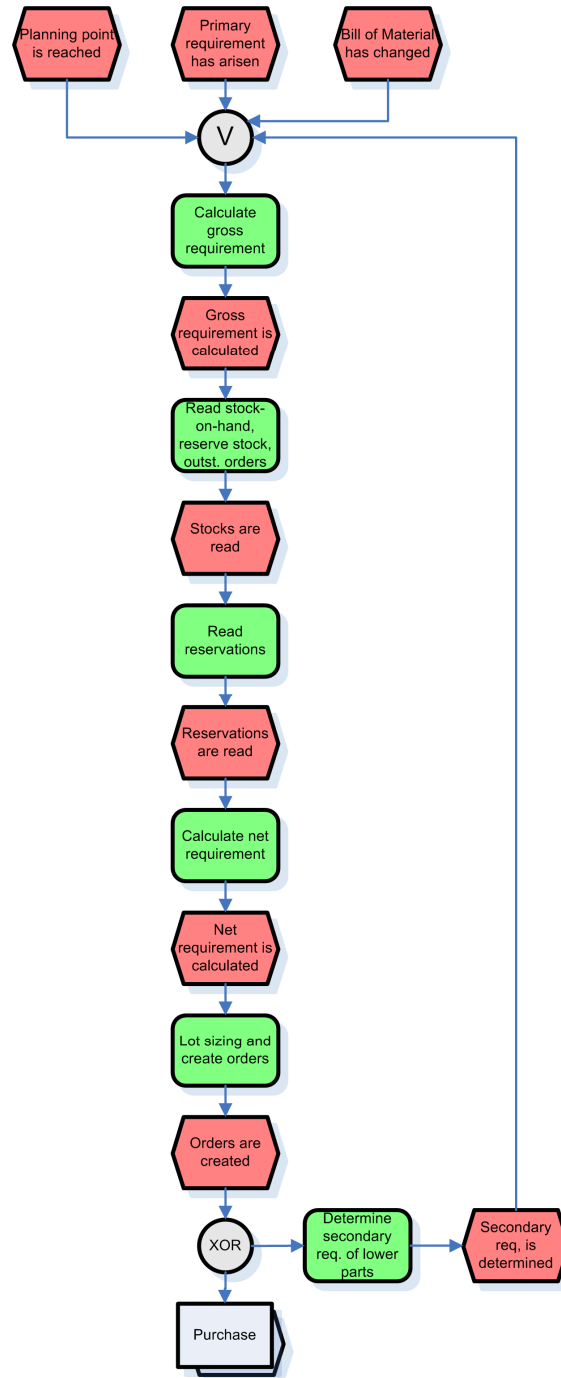


Figure 7. EPC for Gross Net Calculation (Scheer 1994)

Purchasing

A topic discussed in the lecture *Concepts of Enterprise Systems* is the amendment of documents during reversed processes in purchasing and sales order processing. Each document created within the purchasing process is a copy of the foregoing document, enhanced by relevant information. A purchasing process starts by writing a purchase request. All available information is copied into a request for quotation (RFQ) and enhanced by vendor data. Vendors can use these documents by copying the RFQ to a quotation and simultaneously adding pricing information. This quotation is copied into a purchase order and becomes a sales order at the vendor. All necessary information of sales orders is copied into shipping documents and invoices etc. During this process each document is enhanced by additional information.

This process is executed from an end-user’s view and afterwards explained from a software engineer’s view. Many of the mentioned document types are stored within the same table and refer to each other, so this is again an example for data structure integration.

CONCLUSIONS AND FUTURE WORK

The ERP curriculum

By linking several aspects of our IS lectures to ERP system’s features, an integrative ERP curriculum considering several aspects of each lecture was established. Nevertheless the chronological order of the ERP lecture is not parallel to the IS curriculum, but is structured like an ERP implementation process. The lecture starts with an initialized ERP system. Step by step all necessary data is created in order to perform valid business processes. This leads to the following ERP curriculum (cf. table 2):

After a short introduction some features of ERP like internationality or integration facilities are depicted. The three-tier Client/Server architecture is explained. Based on this general knowledge the case study is explained and organizational structures are mapped to the ERP system.

Students create all master data needed in the following sections of this course: material master data, bills of material, vendor master data, and purchase info records. As described, all data is viewed from multiple perspectives: on the one hand, the data models of the master data are discussed. On the other hand the students create the master data from an end user’s perspective. Finally the students evaluate the created records by using the ERP case tool and browsing the dictionary and the tables.

Having created all necessary data, two business processes (purchasing and material requirements planning) are discussed. Both business processes are explained by using process chain diagrams and event-driven process chains (Scheer 1994). Organizational charts and entity relationship models are used to depict the connections between different business functions and data tables. Details of the curriculum are shown in table 2. Beside each topic the corresponding theoretical lecture of the IS-curriculum is mentioned.

	Modeling of ES	Technical Architecture of ES	Development of ES	Conceptions of ES
ERP curriculum				
Introduction				
Handling of the ERP system				
ERP Features				
Integration				
Client/Server Architecture				
Introduction to Case Study				

Bicycle Manufacturer				~
Organizational Structure				~
Material Master Data				
Aims and Functions of Material Management and Production Planning				~
Aims and Attributes of Material Master Data	~			~
Exercise: Creating Material Master Data				
Explore Meta Data and Table Contents	~		~	
Bills of Material (BOM)				
Aims and Attributes of BOM				~
Gozintographs, ERM	~			~
Integration of Material Master Data and BOM, ERM	~			
Exercise: Creating BOM				
Explore Meta Data and Table Contents	~		~	
Vendor Master Data				
Aims and Attributes of Vendor Master Data				~
Exercise: Creating Vendor Master Data				
Explore Meta Data and Table Contents	~		~	
Info Records				
Aims and Attributes of Info Records	~			~
Exercise: Creating Info Records				
Explore Meta Data and Table Contents	~		~	
Purchasing Processes				
Logistic Chain	~			~
Documents (Purchase Requisition, RFQ, Quotation, Purchase Order)	~			~
Electronic Data Interchange		~		
Exercise: Performing the Logistic Chain				
Explore Meta Data and Table Contents	~		~	
Material Requirements Planning				
Theory of Gross-Net-Calculation	~			~
Gross-Net-Calculation within the ERP system				~
Exercise: Create Planned Independent Requirements				
Exercise: Perform MRP (single-item, multi-level)				
Exercise: Raise Purchase Orders				
Exercise: Goods Receipt				
Explore Meta Data and Table Contents	~		~	
Management Information Systems				
Logistics Controlling		~		
Explore Meta Data and Table Contents	~		~	

Table 2. ERP curriculum and corresponding IS-lectures

Lessons Learned

The integration of several IS-topics into one ERP lecture provides students the opportunity to get practical ERP experience. Within this lecture they get an impression of ERP system’s facilities and get an integrative and practice-oriented overview of different IS-topics. Students learn to understand end-user’s problems, to map them to a complex ERP system, and to communicate these problems to software engineers. This is one of the main facilities students focusing information systems should have.

Although the integration of business processes and business functions is presented in an illustrative way, students sometimes have problems with understanding such a ‘big picture’, especially when they have not visited all mentioned lectures before. The integration of different IS-topics within this lecture seems to be predominant. Nevertheless actual evaluations of the lecture point out the use to participate in this lecture and to learn further aspects by studying on their own.

Cognition of prior lectures is that many students get lost within the system’s menu, so mapping theoretical contents to the ERP system becomes quite difficult. Therefore an overview of transaction codes has been created to minimize the ‘frustra-

tion' caused by operating the ERP system. Another problem is the recurrent change of different perspectives. Every perspective change has to be pointed out strongly, so students realize the new situation.

The elaboration for lecturers to prepare the ERP session is quite low. The ERP system needs a few customizing settings, and some of them are even done within the lecture. All master data (materials, BOM, vendors, purchase info records) has to be created by the students within the lecture. Therefore some information about important master data has to be explained. This information can be extracted from a prior ERP lecture. Nevertheless, initial work on documentation and testing is quite large.

The problem of system updates etc. is in our case solved by outsourcing the system to a specialized university-partner. As a consequence we take part in a competence network dealing with research and education and can exchange experiences within this network.

Future Work

The ERP lecture will be enhanced regarding inter-organizational cooperation. This leads to topics like ERP II and integration of systems like SCM or CRM (Bond, Genovese et al. 2000; Markus, Tanis et al. 2000; Österle, Fleisch and Alt 2000). Therefore the vendor's 'Netweaver' platform will be evaluated and integrated into the ERP curriculum in order to extend the discussed topics of *Technical Architectures of Enterprise Systems*. In future the evaluation of this lecture will be enhanced to identify specific problems of the students and to continually improve the content of this lecture.

DISCLAIMER

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