An Enterprise Information Model for Knowledge Transfer with Application Systems: The Current State of Enterprise GPS

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Abstract: The artifact presented in this paper contributes to enhanced knowledge transfer with a comprehensive, integrated online enterprise information model. It can improve knowledge and understanding of Enterprise Resource Planning (ERP) systems from different perspectives such as business and IT as well as enable recognition of the dependencies between the relevant information objects and information models. The authors develop the Enterprise Global Positioning System framework based on existing enterprise architecture frameworks with a special focus on the integration between the business and IT views in order to reduce the inherent complexity of cross-view corporate knowledge. The successful use of Enterprise GPS (EGPS) focusses on the university context in this paper at first, but also shows its utility in non-university environments. EGPS supports companies not only in terms of knowledge transfer between all parties being involved but also facilitates further phases of the process life cycle like controlling, implementation, and monitoring of processes. This paper shows the current state of development and highlights in detail the extensive validation of the artifact.

1 INTRODUCTION

Business application systems, in particular, Enterprise Resource Planning (ERP) systems, are a central theme in information systems research (Esteves and Pastor, 2001; Esteves and Bohórquez, 2007). Due to the widespread use of business application systems (Klaus et al., 2000), companies expect students to be able to use, adapt, enhance and operate these systems (Hess et al., 2012). With the aim of providing practical training, lecturers at universities are in great demand for comprehensive training materials and access to complex application systems. The students mainly come from the fields of management, information systems, and computer science. This paper focuses on classical ERP systems as business application systems, even though companies today often rely on industry-specific special solutions and increasingly use big data as well as artificial intelligence solutions. However, ERP systems still form the backbone of most companies' IT application landscape (Kappelman et al., 2018).

In practical parts of courses, one or more business processes are independently worked on by the students in a teaching and learning environment. This environment usually consists of a fictitious company, one or more application modules in the provided ERP system and the teaching materials which contain tasks and content explanations (Léger, 2006; Magal and Word, 2009). The teaching materials are geared to the needs of the various courses (e.g. introduction to business administration, controlling, introduction to information systems or application systems) or are integrated by the teachers into their own courses (Leyh, 2016).

The teaching materials created and used before 2010 mostly focused on the view of a system user. They neglected the interaction between the IT system and the business process and thus reduced the sustainable learning success (Scheruhn et al., 2012). With regard to the process life cycle, the learner can be assigned to the phase of process execution. Many teaching case studies only describe the data input and output required for process execution in the user interface of the ERP system. However, the acquisition of context knowledge by the students about the entire process life cycle, adjacent processes and relevant information from different views at different levels of

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detail is not supported. The importance of this, however, is illustrated by practical use cases (Weronek, 2012), which emphasize the importance of education in which students learn to correctly contextualize and fully understand the business information system and its components.

This paper, aligned with the design science research paradigm (Hevner et al., 2004), addresses the problem (Peffers et al., 2008) that the described teaching materials offer only a limited overview and presents a solving artifact. The artifact is called the Enterprise Global Positioning System (GPS) and complements the described existing teaching materials.

Contributions both to academia and practice are made. The paper has the following structure: The next section briefly summarises related work and highlights the research gap. Subsequently, the research design aligned with design science is presented. The artifact itself is presented in detail in section four in its development and current state. The framework-based evaluation for validation takes place in section five. Section six discusses the results and the contribution. Finally, the paper concludes with a presentation of the limitations as well as an outlook on future work.

2 RELATED WORK

Teaching with and about ERP systems has employed teachers for many years (Davis and Comeau, 2004; Ruhi, 2016). Different teaching formats exist to convey economic content and ERP system concepts to pupils and students: Lectures and seminars, case discussions, demonstrations with systems, simulations, workshops, case studies, and simulation games as well as project work (Ruhi, 2016). Simulations, simulation games, and case studies are often used in other formats. Simulations and simulation games have their origin in military training programs from the middle of the last century (Kurbjuhn, 2012). However, both formats have also found widespread use in non-military domains. These include school and university education, health training and in-house training (Kurbjuhn, 2012). In simulations and simulation games, the term "serious games" is often used (Breuer and Bente, 2010).

Various learning case studies have been carried out in recent years. SAP itself uses the Internet Demonstration and Evaluation Software (IDES) (SAP AG, 2008) for its product demonstrations and training programs. In addition, there are the case studies which accompany ERPsim (Léger, 2006) based on IDES, Super Skateboard Builders Incorporated (Magal and Word, 2011) and the case studies which have been built around the fictitious company Global Bike Incorporated (GBI) (Scheruhn et al., 2012). The GBI case studies have become widely used in school and university teaching and are prominently placed by SAP (LoBue, 2010).

However, the case studies are problematic in that they provide little contextual information to the student other than the instructions given (Scheruhn et al., 2012). For example, it is difficult for a student to understand which primary business process of a case study he is currently involved in, who his internal or external customers are, what the customers' goals are and what the required competencies are to enter the data correctly. This paper addresses these shortcomings and builds on enterprise architecture frameworks for facilitating an overview in ERP case studies with its solution artifact.

Examples of enterprise architecture frameworks (EAFs) are TOGAF (The Open Group, 2009) or LEADing Practice (Rosing et al., 2015), many of which originate in the Zachman framework for enterprise architecture (Zachman, 2011) from 1984. Examples of tools for modeling information objects are ARIS from Software AG, Visio from Microsoft, aeneis from Intellior, IBM Rational Software Architect or E+ from LEADing Practice. Examples of information objects from different views and hierarchical levels of an information system are *department goal*, *process step*, or *data table*. The manufacturers of standard business software offer supporting software, often embedded in a multitude of IT service management functions, which enable the support of implementation projects of standard business software. In particular, the exchange of modeled information objects between this software and the business standard software is of importance for this paper. Examples are the SAP Solution Manager or the Oracle User Productivity Kit.

The discipline of enterprise architecture tries to coordinate the views business (strategy to process) and IT (software and data) as well as technology (platform and infrastructure) by means of an integration layer (Winter and Fischer, 2007). The Zachman framework has a matrix structure that is also found in standardized frameworks such as TOGAF (The Open Group, 2009). Metamodels are an important part of EAFs. They depict information objects and their relationships to each other in a formal, calculable model (Strahringer, 2013). Metamodels can be modularized in EAFs, according to the matrix structure, in views (layers) and hierarchical levels.

The Open Group Architecture Framework (TOGAF) is a recognized standard in enterprise architecture (Buckl et al., 2009). TOGAF subdivides the architecture of an enterprise information system into the three domains Business (1), Information Systems (2) and Technology (3). In addition, six domains are subdivided: Motivation (1.1) Organization (1.2), Function (1.3), Data (2.1), Application (2.2) and Technology (3.1). In TOGAF, however, the breakdown of the levels of detail is not consistent. Although TOGAF uses an integrated level concept for the information system and technology aspects, it does not define this concept for the business aspect. Corresponding inconsistencies can also be detected using formal methods (Polovina et al., 2016).

Due to the missing localization of information objects of the aspect business in the metamodel of TOGAF further reference models and related artifacts are regarded. While the Supply Chain Operations Reference (SCOR) model (Supply Chain Council, 2010) and APQC's Process Classification Framework (APQC PCF) (APQC, 2015) describe the process view in detail, the LEADing Practice Framework considers all of the above views (Rosing et al., 2015). SAP Solution Manager, as an example tool for enterprise architecture management (SAP SE, 2018) and its partially also inconsistent Best Practice Content (SAP SE, 2019) are implemented in the application view.

Finally, the aspect "Technology" should be compliant with standards in the context of industry 4.0 such as RAMI 4.0 and IIRA. (Bundesministerium für Bildung und Forschung, 2018; Heidrich et. al., 2016).

In the following, the research approach of this paper is explained in more detail.

3 RESEARCH DESIGN

The research approach follows the design science process model presented by Peffers et al. (2008). The main steps of the research are shown in Figure 1. Demonstration and evaluation are summarized into one step (Hevner et al., 2004). The artifact has been iteratively extended in many research cycles (Hevner et al., 2004). Here, these many cycles are summarized into two phases.

Phase 1: Conventional teaching materials used in teaching with ERP systems have the following problem: They support learners in independently exploring (and learning) contexts of the enterprise architecture of the example company under discussion (Identify Problem & Motivate) only in an inadequate way. In order to improve students' understanding of information objects and their dependencies, it is therefore proposed to enrich conventional teaching materials (in text or slide format) with a comprehensive and integrated enterprise information model (requirements A, see Table 1).

Requirements A are addressed by the development (Design & Development) of a first artifact part (EGPS Content, see Figure 3). Extensive and integrated models are created on all essential views of the enterprise architecture framework. These models have been successfully used in university teaching for several years and thus extend conventional teaching materials. In a first step, the

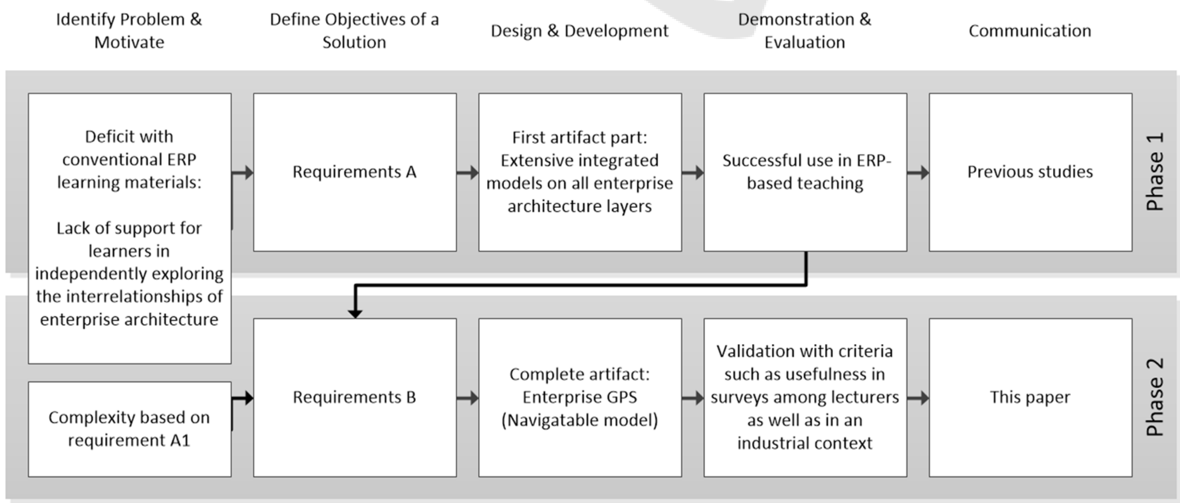

Figure 1: Research cycles (summarised into two main phases).

successful and beneficial application validates the artifact (demonstration & evaluation).

Phase 2: A large number of models used meets A1. Model diversity is justified because it reflects reality. However, this diversity leads to a high degree of complexity in the learning situation and can have a negative effect on the learning objectives (Scheruhn et al., 2013).

Table 1: Requirements for the artifact Enterprise GPS.

ID	***Description***
A1	A comprehensive description of all architectural views of a company
A2	Integration of the model types of all views
B1	A clear delimitation of views
B2	Cross-view definition of detail levels
B3	Assignability of information object and information model types
B4	Horizontal and vertical navigation between the individual models

To handle this additional complexity, the Enterprise GPS will be developed based on existing enterprise architecture frameworks with a special focus on the integration between business and IT aspects (Design & Development). The requirements B are addressed (Define Objectives of a Solution). The Enterprise GPS has recently been successfully used in an industrial context (Demonstration & Evaluation). Its evaluation is performed using multiple criteria (Sonnenberg and Brocke, 2012; Prat et al., 2015). Its current state is presented in this article (Communication).

The next section describes the artifact. The complete current state is described.

4 ENTERPRISE GPS

When comparing the above reference models, the problem arises that information objects are described synonymously on different levels (e.g. *process and process step* (APQC, 2015; Rosing et al., 2015)). A clear view of the levels of detail and corresponding subdivision of the views is necessary to ensure vertical navigation within the views and horizontal navigation between the views (requirement B4).

In Enterprise GPS, therefore, three hierarchical levels are defined first, with the level of detail increasing from top to bottom. Level three forms the logical level (Scheruhn et al., 2015). Below the highest level of detail, a fourth level is introduced, the physical level (Scheruhn et al., 2015). In fact, the fourth level should contain the attribute structure of all media or documents involved (such as measurement protocols, certificates, contracts, and general business documents), which regulate the data input/output process (requirement B2).

The metamodels examined are combined into a single process layer with the following information object types (excerpt) on the four levels developed: 1. process, 2. process step, 3. process activity and 4. process attributes.

In order to transfer the four levels of detail to all views (layer) (requirement B2), a typical hierarchy of an enterprise must be derived, which can be applied consistently to all layers and always follows the hierarchization concept of the process layer (requirement B2).

For the definition of the layers, the standard of the LEADing Practice Framework (Rosing et al., 2015) was used and the nomenclature for 38 of the 78 meta object types defined there was mapped. Accordingly, the Enterprise GPS Framework consists of eight different layers. Each of the eight layers is always

		Business				IT Application		Technology		
		Value	Competency	Service	Process	Application	Data	Platforms	Infrastructure	
Organization	1	Balanced Scorecard	Org. chart	Function tree	BPMN	Value Chain	DW organization	UML	UML	
Department	2	Balanced Scorecard	Org. chart	Function tree	BPMN	Value Chain	DW ** department	UML	UML	
Workplace	3	Balanced Scorecard	Org. chart	Function tree	BPMN	EPC	ERM, HANA views	UML	UML	Logical Level
Document	4	Objective agreement *	Business compliance *	Service level (SLA)*	Business Document*	Screen diagram	HANA Output Struct. *	System landscape	UML	Physical Level

* attribute allocation diagram
** Data Warehouse (DW)

Figure 2: Enterprise GPS Framework Map.

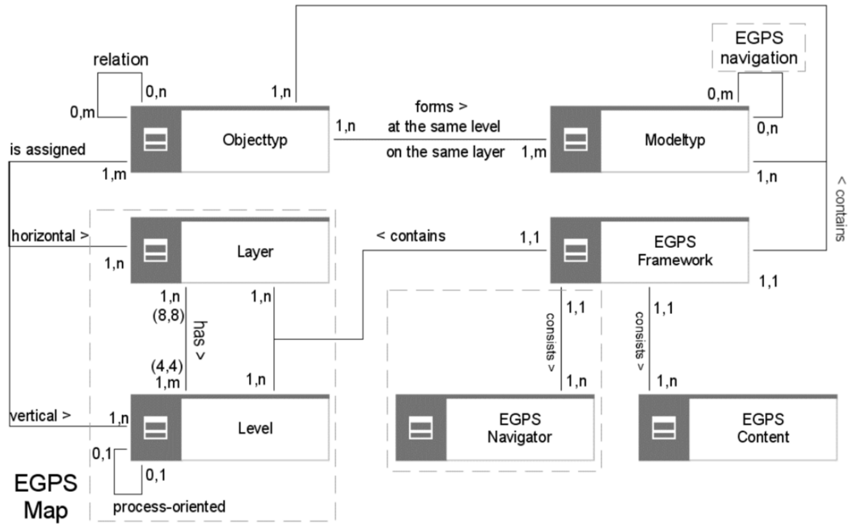

Figure 3: Enterprise GPS metamodel.

assigned exactly four identical levels. All information object types defined in the framework are always assigned to a combination of these. The model types that comprise the information object types can also be assigned to several combinations (several levels). This is referred to as a location in the EGPS Map (Figure 2). This means that the layer and the level of the model types must always be the same as that of the object types contained. The object types are connected to each other by vertical (level) or horizontal (layer) relations.

These relations are the basis for the so-called horizontal or vertical navigation between different model types. A so-called vertical navigation takes place between the model types at different levels. You can branch to several lower-level model types or aggregate them into several higher-level model types.

Both are always process-oriented in EGPS. In this case, the object types are subordinate or superior to other object types (or the same object types) at different levels via relations (object types from different levels or layers can be equated). Vertical navigation is required whenever the vertical relationships between object types extend beyond a model. The same applies to the horizontal relationship between the object types. These can also be mapped in one or more model types and can be reached by the user through horizontal navigation between different layers.

A documentation of the EGPS Framework is typically done in a table representation. The permitted object and model types, their relations and navigation options between the eight layers and four levels are also defined and thus assigned to 32 different cells. When implementing the EGPS framework, two further artifacts arise. These are the EGPS Content (built in research phase 1, see section 3) and EGPS Navigator (see EGPS metamodel in Figure 3).

The EGPS Content for GBI/SAP currently describes a large part of the SAP University Alliance case studies for SAP ERP (incl. SAP S/4 HANA) based on the model company GBI with the focus on the instantiation of model and object types. By adapting the GBI organizational structure to the EGPS competency layer, an automated transfer of the remaining views to already mentioned demo companies such as IDES or others is possible.

The EGPS Navigator enables the user of the EGPS Framework or the EGPS Content to automatically move from one model (type) to another in order to illustrate the relations between the contained objects (types). Essential components are an instantiation of the EGPS navigation (right grey dotted-line frame) and the EGPS Map (left grey dotted-line frame).

The evaluation of Enterprise GPS is presented below.

5 EVALUATION

A difficulty of design science projects lies in the validation of the results (Sonnenberg and Brocke, 2012). In this regard, Sonnenberg and Brocke (2012) propose a framework with four evaluation steps. EGPS is validated according to this framework. EVAL 1 validates the research approach (research gap). EVAL 2 validates the artifact design. EVAL 3 evaluates EGPS on the basis of an instantiation of the artifact but in an artificial environment. In EVAL 4, validity is represented by the real and beneficial application of EGPS. The evaluation steps are shown in Table 2. We used various criteria for evaluation. These evaluation criteria match with those identified by Prat et al. (2015) and Sonnenberg and Brocke (2012).

Table 2: Evaluation steps.

Step (EVAL)	***Methodological approach***	***Evaluation criteria***
1	Validation of the research justification	Novelty
2	Ontology-based formal analysis of the artifact's structural integrity	Consistency and comprehensibility
3	Feasibility study based on prototypical implementation	Technical and operational feasibility
4	Field study amongst students and teachers as well as case study with two company cases from industry	Usefulness, completeness, alignment with business

5.1 EVAL 1: Research Justification

The validity of the research approach (research question, research gap, and approach) could be demonstrated, as already described in the introduction and in the course of studying the relevant literature: Further support in understanding and navigating the complexities surrounding ERP systems is required.

5.2 EVAL 2: Formal Analysis of Structural Integrity

For the problem-oriented research approach, requirements are derived in two iterations addressed by the artifact. The EGPS contains extensive specifications of all object types used, their detailed assignments in the EGPS framework, their relations to each other, the model types formed from them and the possible horizontal or vertical navigation between them, which is recorded in a convention manual.

By using formal methods, the design specification of the Enterprise GPS could be verified mathematically and essentially confirmed view-specifically (Polovina et al., 2016). A subsequent specification of the underlying ontology, semantics, and relations within the information models used led to further improvements. In particular, this was implemented by a continuous process-oriented hierarchy across all layers in a further adaptation.

5.3 EVAL 3: Prototypical Implementation

For the instantiation of EGPS, the choice of the modeling tool was initially essential. Four tools were compared: ARIS Architect & Design, Enterprise Plus (E+), Microsoft Visio and SAP Solution Manager. Important criteria were the ability to map the EGPS standard and the automated exchange of information models and objects with SAP Solution Manager for comparison with SAP ERP. Since a variety of models had to be developed for the EGPS content, ARIS Architect & Design and E+ (MS Visio interface) was chosen as shown in Figure 4.

The recent prototypes comprise the first six layers (Value - Data) and all four levels of the EGPS framework. The EGPS Navigator supports horizontal and vertical navigation. The current position can be displayed in the EGPS Map (requirement B4). EGPS instantiation also uses the SAP Solution Manager for model synchronization. This allows parts of the models or objects defined in ARIS to be transferred to SAP ERP or S/4 HANA and SAP HANA in the context of the EGPS content, making it easier to implement business process changes. The prototype can be reached via the EGPS Navigator at the following address in German: http://t1p.de/3tfe.

5.4 EVAL 4: Validation in Academic and Industrial Context

EGPS was validated in an academic context, among university students and educators as well as in an industrial context with two company cases.

	Modelling languages											
Tools	Event Process Chain (EPC)	Extended BPMN	Business Process Modeling Notation	Unified Modeling Language	Value Chain Diagram	Entity Relationship Model (ERM)	Balanced Scorecard (BSC)	Organizational Chart	Star scheme	Mask Diagramm	Integration with SAP Solution Manager	Compatible with Enterprise GPS
Software AG ARIS Architect & Design (Version 10)	X		X	X	X	X	X	X	X	X	X	X
LEADing Practice Enterprise Plus (E+)	X	X	X	X	X	X	X	X	X	X	(X)	X
Microsoft VISIO	X		X	X	X	X	X	X	X	X		
SAP Solution Manager 7.2	(X)		X		X	(X)		(X)			-	

Legend: X = supported, (X) = limited support

Figure 4: Comparison of modeling languages.

5.4.1 Academic Context

Besides SAP ERP, Microsoft Navision is most widely used in ERP-based teaching at German universities as we learned in a survey, which was conducted with 489 lecturers at German universities, universities of applied sciences and vocational academies in 2016 (Sicorello, 2013; Müller, 2016). Within the SAP University Alliance, the SAP University Competence Center Magdeburg provides more than 3000 educational institutions worldwide with teaching and learning environments. These consist mainly of the GBI or IDES model company and various SAP software solutions. In addition to the teaching materials provided, Enterprise GPS could be made available as a supplementary artifact via the EGPS Navigator to the teachers or students interactively. The models from the EGPS content could be made available within the framework of the case studies. The EGPS Navigator has been widely used for two years. Since June 2016, more than 11,000 hits have been recorded worldwide, especially from America (e.g. Silicon Valley and Colombia), Europe and Asia.

According to the survey (Müller, 2016), ARIS and Visio are used in almost equal proportions at German universities. Other modeling tools are far behind, 18% of respondents use Enterprise GPS with GBI. 62% of them consider horizontal and vertical navigation to be useful. This resulted in different usage frequencies of the individual model types in the different cells (83% for the EPCs of the application layer on level 3, 67% for the BPMN diagrams of the process layer on level 1-3, 56% for the ERM of the data layer on level 3 and only 8% for the mask diagrams of the application layer on level 4).

5.4.2 Industrial Context

Our current projects also show the applicability of Enterprise GPS for two cases from industry (see Table 3).

Case A: Over a period of a total of two years, the project participants were able to improve parts of the strategic and operational sales process within the framework of two projects at an internationally positioned medium-sized company in the area of electronical motor construction.

In the initial phase of the *first project*, the company wanted to migrate its existing big data structure (Data layer) to a new database system. Further specification and especially the implementation of the project made it clear to all participants that integration with the management processes to be supported (Process Layer) and with the application used by the management for weekly determination of the break-even point (Application Layer) was necessary. Using EGPS, this integration could create transparency for all participants as well as constitute a continuous structure from the company level down to the media breaks at the workplace (3) and document level (4). Figure 6 collects all assignments of the structural / completeness evaluation.

Figure 5 illustrates the usage of EGPS in Case A's first project. Starting at the company level, the distribution of the management process to five different plants was presented in BPMN (P1). A detailed examination of the third plant at the department level (P2) shows the release of the management report in the highest swimlane located there. In the two lower swimlanes, the sales data (see the second project) must first be aggregated plant-

Table 3: Evaluation cases for EVAL 4.

	Case A	Case B
Case business model	The industry-leading midsized company in the area of electro motors construction	Leading consultancy company that implements and migrates SAP solutions for its worldwide customers
Case's application software usage	SAP & custom software used for logistics and strategic management on different databases SAP Solution Manager only used for IT service management; Quality management spread over process modeling tool & document management	SAP Solution Manager used for SAP implementation based on SAP Activate; SAP best practice models synchronized with ARIS and other process modeling tools like E+ and aeneis
Contribution to validity by EGPS	Project 1: Improvement of Management Processes: Usefulness, completeness, alignment with business Project 2: Integration of quality mgmt. f. order processing: Usefulness, completeness, align. w. business	Usefulness, completeness, alignment with business: Improvement of Quality of SAP Best Practice models for "Order to cash"

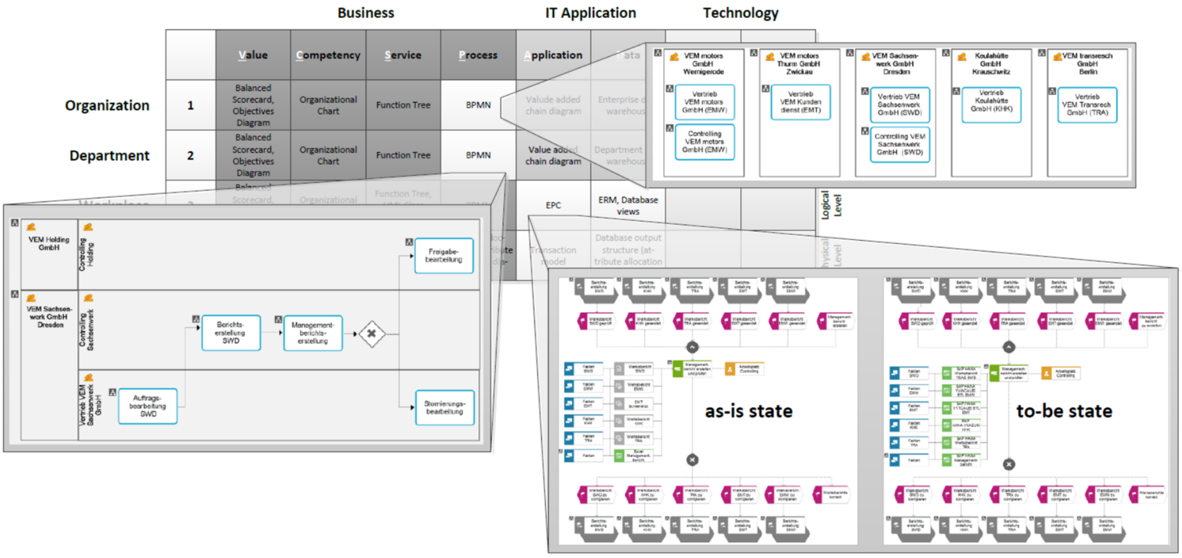

Figure 5: Usage of EGPS in Case A.

Table 4: Benefit of EGPS for Case B.

Position in the EGPS Map	*The benefit of EGPS for Company*
V1, V2, V3 & V4	Adaptable integration of a cascaded sustainability balanced scorecard over three levels with the exemplary assignment of key performance indicators
C3	Adaptable role concept for the process-oriented organizational structure
P3 & A3	Parallel display as BPMN and EPC on customers demand
P3	Representation of SAP document flow and adaptable customers documents
P2 & P3	Process selection matrix for transparent differentiation of existing company scenarios
A3	System organizational unit types as configurable SAP layer models
P3	Extensible business vocabularies and business rules
D3 & D4	Adaptable and extensible SAP data models e.g. for visualizing extensions of S/4 HANA data model e.g. regarding integration of business partner and customer
D1, D2, D3 & D4	Future integration of HANA views into S/4 HANA
A4	200 mask attributes for a structured comparison of ERP masks, S/4 HANA masks and FIORI apps & for the layout of new Fiori apps
{V|C|S|P|A|D}4	Adaptable definitions of compliance and performance indicators for all layers at level 4
All positions	Automated generation of process and sustainability/environment documentations
A3	Improved usage of SAP Solution Manager for model-based customizing
S123	Hierarchical selection from all End-to-End, baseline and support services offered by SAP
A3 & A4	Support of SAP Activate Prototyping by content of 6 SAP ERP modules (e.g., sales)

specifically and then merged for all five plants in the company controlling department located there before release processing or cancellation processing can take place, which is frequently required in practice. At work center level (A3), the improvements found compared to the as-is state can be recognized on the basis of newly created SAP Big Data applications as to-be state. These applications are compared to the media breaks that existed previously in the as-is state due to a non-integrated use of Excel depicted as an EPC. These applications are fed by entity types, which are first arranged on the same level as star schema ERM (D3) and then enriched with controlling-specific evaluation dimensions specified by companies as (foreign) key attributes on the document level (D4) in the new database management. Finally, the new application can be recognized as A4, which could now provide the management with the required break-even point every Monday morning faster and more reliably.

In a *second project*, the actual state of the process was already determined in the context of the EGPS, whereby all documents provided by the company were assigned a layer/level in the EGPS Map. The description of the developed company-specific EGPS content as a prototype also follows the layer/level assignment of the EGPS map in the respective final report (see also Figure 6).

While the project participants were able to map the value layer with sustainability balanced scorecards at the organization (V1) and department (V2) level, BPMN diagrams down to workplace level were used in the process layer. The application layer contains the SAP S/4 HANA systems to be examined as well as SAP ERP systems. On level 4 (A4), the project participants presented the (foreign) key relationships between SAP Fiori masks and the input/output documents of the process layer involved as well as the quality problems resulting from the not yet digitized media breaks. As the most important result, case A plans to convert its worldwide quality management to EGPS. This will be used for automatically creating quality and sustainability certifications that have to be provided on a regular basis.

Case B: The case used for evaluation is a leading consultancy company that implements SAP software solutions for its worldwide customers. Their "Best Practice" process templates are provided by SAP and can be imported into SAP Solution Manager. The resulting BPMN models can be assigned to levels 1-3 of the application layer. In an investigation of structural properties with regard to consistency and completeness, about 169 end-to-end, baseline and support processes (level 2) could be examined and about ten different structural breaks could be identified and typified on levels 1-4:

Among other things, levels were swapped, BPMN conventions were not observed, assignments were located incorrectly, different languages were mixed, process descriptions were assigned syntactically incorrectly or with incomplete content. The process description ID was also partially missing.

SAP Solution Manager maps only about 50% of the required object types and even only 30% of the required model types (Scheruhn et al., 2013). The current version 7.2 has also changed little about that. The authors see considerable potential for improvement here. A project's content (objects and models) can be synchronized with an external modeling tool such as ARIS or E+ (next version) via an interface of the SAP Solution Manager. By extending the application layer of the modelling tools by five additional layers of EGPS with the simultaneous complete integration of the additional layers on all 4 levels, usability, comprehensibility and, above all, acceptance by all participants should be considerably improved (see Table 4).

A subsequent investigation on the part of the company and its customers should clarify to what extent the improvements make business sense and are adaptable or scalable to the respective customer.

Figure 6summarizes the above described four different validation tasks in the academic environment and for the two cases. It compares these regarding the structural completeness in the context of EGPS. Not surprisingly the mostly used structural parts of EGPS are the "classic" P1-P3, A3-A4 and D3-D4 selections, followed by the value and competency layers on all levels. Due to the didactical structure of the teaching case studies (e.g. only used as a clicking guideline) used by German universities, only the three uppermost levels are accessed.

The next section summarizes this paper, shows limitations and draws a conclusion.

Layers/Levels	Value	Competency	Service	Process	Application	Data
(1) Organisation				P1		
(2) Department				P2		
(3) Workplace					A3	D3
(4) Document					A4	D4

Case A, project 1

Layers/Levels	Value	Competency	Service	Process	Application	Data
(1) Organisation	V1	C1		P1		
(2) Department	V2	C2		P2		
(3) Workplace		C3		P3	A3	D3
(4) Document					A4	D4

Case A, project 2

Layers/Levels	Value	Competency	Service	Process	Application	Data
(1) Organisation	V1	C123	S123	P1	A1	D1
(2) Department	V2			P2	A2	D2
(3) Workplace	V3			P3	A3	D3
(4) Document	V4	C4	S4	P4	A4	D4

Case B

Layers/Levels	Value	Competency	Service	Process	Application	Data
(1) Organisation				P1		
(2) Department				P2		
(3) Workplace				P3	A3	D3
(4) Document						

German Universities

Legend: C123 crosses level 1 to 3, but is positioned in level 1 (same goes for C123)

Figure 6: Eval 4: Summary of EGPS application comparing their structure/completeness.

6 DISCUSSION AND CONTRIBUTION

The problem addressed in the paper was identified as the lack of clarity and the limited and non-integrated selection of views and levels of detail in the execution of case studies in typical teaching and learning environments with ERP case studies.

These limitations make it difficult to understand important ERP information objects from case study documents and their interrelationships when teaching or learning.

As a solution, an integration of all required views at user selectable levels of detail was implemented through the development of the Enterprise GPS. The Enterprise GPS Framework builds on recognized enterprise architecture frameworks such as LEADing Practice and process frameworks such as SCOR and APQC's PCF. When applied by lecturers or students, new difficulties due to additional complexity should be avoided.

Enterprise GPS EAF was instantiated as Enterprise GPS Navigator and Enterprise GPS for SAP Content using ARIS Architect & Designer and E+, SAP Solution Manager and SAP ERP or SAP S/4 HANA. For easy orientation of the user, each individual model is graphically located in a view and on one or more levels. The authors call this part of the framework EGPS Map because of its analogy to a navigation system.

A subsequent online demonstration of the Enterprise GPS Navigator and EGPS Map based on the EGPS Content for SAP was made available to teachers and students of SAP UA via the SAP Learning Hub and ARIS Business Publisher.

An online evaluation showed that EGPS still has limited prominence amongst teachers. The portion of teachers who are already working with the models rates the horizontal and vertical navigation in the EGPS as “useful”. This seems to be limited to three out of six layers and three out of four levels. Both BPMN diagrams and EPCs are often shared by the instructors, which is very well supported by different layers of Enterprise GPS that are integrated at different hierarchy levels.

Compared to the academic scenario, the industry cases show a significantly extended structural use of the EGPS layers and levels to support knowledge transfer among all participants. In addition, both companies rate the usefulness of the EGPS, its structural completeness and its compliance with business management challenges as high.

No car driver today wants to do without a GPS navigation system. Many companies still believe that they can navigate through their company without a GPS. Like a conventional GPS, Enterprise GPS supports several vertical "zoom factors" from the company level to the departments and workplaces to the documents located there. EGPS thus provides an overview factor as demanded in the literature (Weronek, 2012; Robert et al., 2013). In contrast to a normal GPS, Enterprise GPS also combines various maps that are required to successfully manage a company. As an analogy to GPS for motorways, it also combines (horizontally) e.g. train, airplane, ship and rail connections at exactly the same (vertical) level of detail, e.g. continent, country, road, house. In Enterprise GPS these different maps are called Value, Competency, Service, Process, Application, Data, Platforms, and Infrastructure. They are mapped as perspectives in an information model. One challenge was to find a complete and consistent zoom factor for a typical company across all these perspectives, which had to be easy to understand and range from the company level to the workplace documents.

First evaluations in the university and company context show that well-defined parts of the EGPS are used up to a complete use. An important part of this success can be the complete integration of a leading IT service management software (SAP Solution Manager) or its enhancement by extending the application layer by five additional layers of the EGPS. Consequently, benefits of EGPS go well beyond knowledge transfer and can be used, for example, for the automated generation of quality and sustainability certificates (Case A) or for an improved model-based implementation of ERP systems, as could be demonstrated by the example of the SAP systems used by case B.

7 LIMITATIONS AND RESEARCH OUTLOOK

The authors have made considerable simplifications in the arrangement of various existing EAFs. In particular, the arrangement of the underlying LEADing Practice Framework was rotated by 90 degrees. Reasons for this are the complete integration of the SAP Solution Manager as well as a division of the object relations into horizontal and vertical. The vertical relations, in turn, are regarded as process-oriented decomposition similar to SCOR and APQC PCF. However, this is only possible due to the limited selection of 38 (out of 78) existing LEADing Practice objects. The associated model types are typically displayed horizontally within a layer, such as a

BPMN model on level 1, 2 or 3 (e.g. predecessor/successor relationship). Model types such as organigrams, on the other hand, are vertically hierarchized over several levels within a layer. This concept could also be considered for almost all other model types. Exceptions are the event-driven process chain (Figure 5), which is typically displayed from top to bottom, and even more clearly the Balanced Scorecard. The last example makes it very clear that the process views of the Balanced Scorecard are hierarchized vertically in a process-oriented way on levels 1, 2 and 3. However, the strategic goals of the customer or success perspective and the associated strategy or vision and mission are superior in each case. At this point, the process-oriented overlaps with a "natural" hierarchy or order of the objects of the real world, which can only be represented to a limited extent in EGPS. The authors expect a similar overlap in the representation of the technical layer, which can typically be hierarchized component/object-oriented.

In the future, the EGPS for SAP content will be enhanced to fully cover the Technology layer, which it currently does not. This should allow a better mapping of domains such as Industry 4.0 or technical information of SAP Solution Manager. Furthermore, further SAP best practice models are to be localized by EGPS in order to further increase their usability. An adaptability and scalability check has to be made at the customers. Furthermore, the EGPS for SAP Content is to be further developed in Technology Layer in the context of Industry 4.0 and its usability is to be evaluated not only in teaching at universities but also in the industrial sector.

By the continuous use of formal methods on the EGPS framework, the authors want to extend the user-friendliness (e.g. for schools) of the EGPS Navigator with new tools appearing on the market like E+ from Leading Practice and AENEIS from Intellior continuously.

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