

REA-Semantic Teaching of integrated Enterprise Systems (iES)

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Abstract:

Currently there is a substantial gap between the concepts underlying Enterprise Information Systems (EIS), Accounting Information Systems (AIS) and Enterprise Resource Planning Systems (ERP-Systems). Due to this mismatch of the guiding concepts the teaching of ERP-Systems is unsatisfactory. On the one side the accounting infrastructure is essential which is addressed in AIS and on the other side the process support infrastructure is needed which is addressed in EIS. In this paper the integration problem is solved by defining an integrated Enterprise System (iES) as a combination of EIS and AIS and teaching it in line with the REA-semantic teaching system.

INTRODUCTION

A PLAN FOR TEACHING ACCOUNTING INFORMATION SYSTEMS WITH REA MODELING –
A Personal Note on Teaching AIS: *When I started teaching an AIS course in Spring 1978 at MSU, I had no integrated plan, and it did not occur to me that I needed one. ... I was dead wrong, and it took me only one term to discover that a potpourri course without any unifying theme was a dreadful experience for both teacher and student. Combining an accounting mindset with the latest technology du jour was a mistake I made, and I believe it is a mistake repeated often by AIS teachers, often at the innocent behest of department-wide curriculum committees. Historically, AIS has not had a unifying theme ..., although there have certainly been some group efforts aimed at producing an AIS teaching charter. Long laundry lists of technical topics make neither a good course nor a sound curriculum. From my biased viewpoint, semantic modeling of accounting phenomena in general and REA modeling in particular provided that unifying theme.* (McCarthy, 2003, p. 436).
This personal note on teaching AIS from McCarthy who introduced in his seminal article (McCarthy, 1982) the REA-Accounting Model, where REA stands for Resource-Event-Agent, is still valid today. Although the original REA Accounting Model was – as can be seen by its name – closely connected to the accounting domain, the REA semantic information system research deviated successively more and more from its original accounting roots into a business modeling framework. The *REA semantic modeling technique* initiated by McCarthy heavily influenced the teaching of Enterprise Information Systems (EIS). *A semantic orientation also precludes the use of artificial constructs such as debits, credits, and accounts as base objects in the enterprise system. Chapters 8 through 13 demonstrated the derivation of many accounting numbers using queries, with no debits, credits, or accounts in the REA-based system. Most ERP software preserves the use of debits, credits, and accounts to satisfy accounting information needs rather than generating the accounting numbers from the underlying economic events and relationships. One probable reason for the preservation of accounting artifacts as base objects in ERP software is marked demand; another related reason is lack of education about how to generate accounting numbers procedurally on demand rather than storing them in accounts.* (Dunn et al., 2005, p. 478).

By building an EIS without referring to accounting artifacts of *debit* and *credit* actually divorces EIS from Accounting Information Systems (AIS). Consequently the connection to the accounting domain is removed from the EIS and is moved to the Enterprise Resource Planning (ERP) domain. According to this shift it is not understandable when it is argued on the other side: *In this edition the authors will show how a well-designed REA-based Accounting Information System is the Enterprise Information System.* (Dunn et al., 2005). Furthermore it is interesting that in the traditional AIS teaching the REA-accounting model is not really influential. In Romney et al. (Romney, Steinbart, Mula, McNamara, & Tonkin, 2012) it is covered in one chapter, but this chapter is quite isolated from the rest of the book. Finally the ERP community has a strong practical and informational focus which often goes to the expense of rigorously defined concepts. Exemplarily this is shown with the following statement where there is a somehow vague distinction between different types of resources: *The bill of materials (BOM) then describes the structure of a finished (or semi-finished) item by specifying the components (materials, or lower-level semi-finished items). Resources (machines or human resources) are another basic element, providing capacity for manufacturing. Routes and operations, which describe the necessary activities to manufacture an item, determine the required resources. Products, BOMs, resources, and routes are master data, only occasionally updated after initially creating the individual records. In the course of production order processing, planned and actual production orders (transaction data) receive default values from these master data, which you can override in the transaction – for example selecting a non-standard bill of materials in a particular production order.* (Luszczak, 2016, p. 183).

Problems: 1) Definition and 2) Teaching of integrated Enterprise Systems (iES)

In this AIS/EIS/ERP divorced situation two main problems can be identified which show up when a course on a ‘well-designed REA-based Accounting and Enterprise Information System with applications in an ERP-System’ has to be taught. In this article such a course will be called an ‘integrated Enterprise System’ (iES) course. Such a course is e.g. taught by the authors of this article at the TU Wien in the *Business Informatics* Bachelor study program.

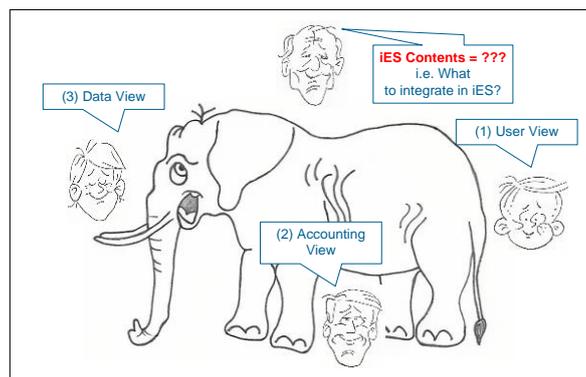


Figure 1: Meta-Perspective upon iES-Contents – What to integrate in iES? (Metaphor: “The Blind Men and the Elephant”)

The 1st problem relates to the contents of an iES-course. In order to answer this question a meta-perspective in the sense of the king perspective in the “The Blind Men and the Elephant” metaphor is taken. This perspective can be seen on top of Figure 1. Furthermore the Figure also suggests the solution to this question in form of the three perspectives, i.e. the user view, the accounting view and the data view. These views are essential for not only using ERP-Systems but also understanding their functioning.

After the idea of solving the 1st problem is given the 2nd problem arises: How to teach such an iES-course? The answer to the second question lies in the development and application of an adequate iES-Teaching system. How such a teaching system is structured comes next.

Solution: Development and Application of a REA-semantic iES-Teaching System

In order to structure an adequate iES-Teaching system a meta-perspective is taken again as this top-view (comprehensive) perspective oversees the constituent (partial) perspectives. Figure 2 specifies the basic construction of the proposed iES-Teaching system in the left panel. The system covers three components: The usage of a REA-semantic language, the usage of a running example/consecutive case study and the application of constructive alignment and spiral curriculum considerations. More to this setup of the iES-Teaching system comes soon.

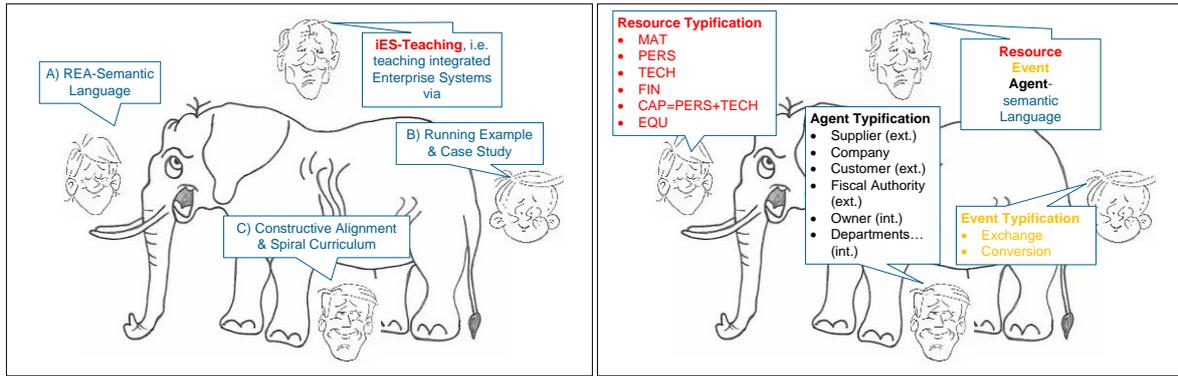


Figure 2: iES-Teching Contents and REA-Typifications
(Metaphor: “The Blind Men and the Elephant”)

The right panel in the Figure gives an overview upon the important REA-types that are used in the REA-semantic language. The proposed semantic approach closely relates to McCarthy’s view: *By contrast, the top-down or semantic approach to design—first pioneered fully by Chen (1976)—started with an analysis of the reality being modeled for its various types of objects (like people, things, activities in time, and concepts), and it then proceeded by representing those identified entities along with their named links or relationships in tabular form ... A semantic database designer would always produce an entity-relationship diagram ... before he or she would proceed with the table design ... It is in this arena of top-down modeling where the REA accounting model provides its greatest teaching advantage.* (McCarthy, 2003, p. 429).

“We need a language to express our thinking”: The complete specification of the REA-semantic language is given in Figure 3. This specification is heavily based on the extended REA model introduced by Geerts/McCarthy (Geerts & McCarthy, 2006) where a policy infrastructure that contains among others typifications of the REA constituents is added to the accounting infrastructure. The inclusion of the *balanced duality* assures the compliance to the debit and credit booking rules and the included REA types broaden the limitations with the account recordings and open the conceptual accounting infrastructure with respect to a business process support infrastructure.

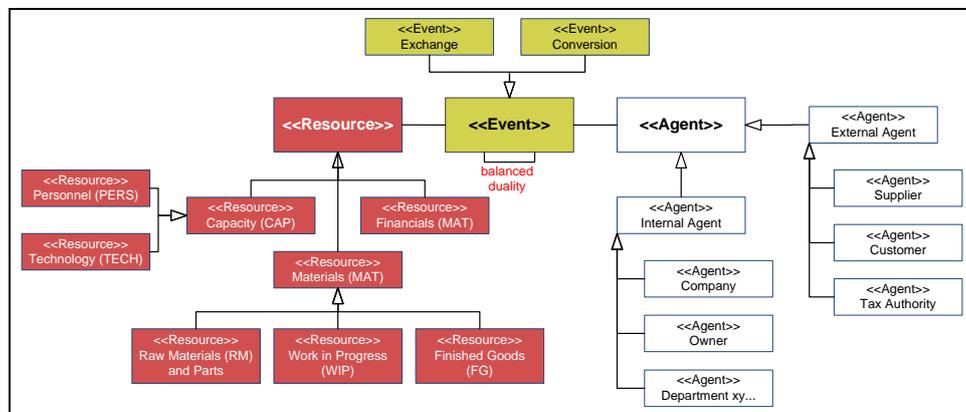


Figure 3: REA-Semantic Language: Vocabulary, Syntax and Meaning

Now all important ingredients for this article were presented so that an overview of the article’s structure can be given. The article consists of three main chapters that address the REA-semantic teaching in the three views, i.e. user, the accounting and the data view. In order to have a REA-semantic unifying theme through the article the three chapters are using REA-semantic tools, i.e. tools that are based on the REA-semantic language presented in Figure 3, to express the contents in each chapter. In the user view *REA-Activity diagrams*, in the accounting view *REA-Doubly entry diagrams* and in the data view *REA-Data diagrams* are used.

Before the main chapters start, a short overview on the REA-semantic iES-Teaching system is given.

REA-semantic iES-Teaching: Setup of the Teaching System

The teaching system is based upon different concepts that provide an overarching economic perspective in the integrated enterprise system context and cover this perspective in a constructive aligned way.

The setup of the REA-semantic iES-teaching system is based upon the following concepts:

- REA-Semantic language (McCarthy, 2003) – Providing the overarching economic perspective defined via the three constituents of the REA Accounting model (McCarthy, 1982) in form of resource, event and agent as well as their typifications (see Figure 3).
- Running example demonstration (Guizzardi, Almeida, Guarino, & Carvalho, 2015) – Allowing consecutive extensions to more complex settings: The concept of a *running example* is widely used in conceptual modeling literature to exemplify complex settings (Guizzardi et al., 2015; Rybola & Pergl, 2016). The *running example* provides a teaching case study so it also aims to *demonstrate the application of theoretical concepts* and *encourages active learning* (Davis & Wilcock, 2005). Throughout this paper, one running case study example is conducted, on which three different views, i.e. the user view, the accounting view and the data view are applied upon.
- Teaching case study methodology (Davis & Wilcock, 2005) – Enabling presentation of theoretical concepts in a practical context: The running case study example links the conceptual model with the practical implementation in Microsoft Dynamics 365 for Operations.
- Constructive alignment (Biggs, 2003) – Seeing that *students construct meaning through relevant learning activities* and setting up a *learning environment that supports the learning activities appropriate to achieving the desired learning outcomes* by aligning tasks, learning outcomes, assignments and evaluation criteria: ‘*Constructive alignment*’ has two aspects. The ‘*constructive*’ aspect refers to the idea that students construct meaning through relevant learning activities. That is, meaning is not something imparted or transmitted from teacher to learner, but is something learners have to create for themselves. ... The ‘*alignment*’ aspect refers to what the teacher does, which is to set up a learning environment that supports the learning activities appropriate to achieving the desired learning outcomes. The key is that the components in the teaching system, especially the teaching methods used and the assessment tasks, are aligned with the learning activities assumed in the intended outcomes. (Biggs, 2003)
- Spiral curriculum structure (Bruner, 1960) – Allowing spiral progression of theoretical considerations by applying them in successively more complex contexts: *The need instead is for something approximating a spiral curriculum, in which ideas are presented in homologue form, returned to later with more precision and power, and further developed and expanded until, in the end, the student has a sense of mastery over at least some body of knowledge.* (Bruner, 1960)

For achieving a balanced mix of presentations, conceptual and practical tasks and assignments one business process, i.e. the procurement process is demonstrated according to the user, the accounting and the data view during the classroom learning phase. The other two business processes, i.e. the production and the sales process are also considered according to the three views, but they are designated as homework assignment. By repeating the three views to the production process (conversion process) and the sales process (profit generation) the idea of a spiral curriculum with spiral progression is followed due to the iterated application of the same REA semantic considerations in contexts with successively increased complexities. Furthermore the constructive alignment is implemented by setting tasks and learning outcomes in the user, the accounting and the data view that support the students’ constructive learning activities.

REA-semantic iES-Teaching: Running Example

At the core of the running example is the production of 80 units of a slot-car which is a powered miniature vehicle often used as toy. Possible due to its similarity to a “Ferrari” the slot-car is called *FER-01* (FER-01-slot car).

In order to produce 1 unit of the FER-01-slot-car different types of resources are needed:

1. *Capacity resources, i.e. PERS-resources and TECH-resources:* The production of one unit of slot-car is organized in an assembly line. The capacity resources of the assembly line consist of
 - a personnel resource (PERS-resources) in form of a skilled *Employee* and
 - an equipment (technology) resource (TECH-resources) in form of a *Workbench*.
 These capacity resources, i.e. PERS- and TECH-resources are documented in a *working plan* called *Route* (in Dynamics 365 for Operations) and they are specified as follows
 - 5 minutes of *Employee* PERS-resource, rate EUR 5.01 (hourly rate EUR 60/h)
 - 5 minutes of *Workbench* TECH-resource, rate EUR 1.67 (hourly rate EUR 20/h)
2. *Materials, i.e. MAT-resources:* Next to the capacity resources materials (MAT resources) are needed for producing the FER-01-slot-car. Specifically two materials which are documented in the *Bill-Of-Materials (BOM)* are needed, i.e.
 - 1 x *Chassis* (Karosserie) with item number BGR-01, which can be bought at a price of EUR 6.00 + EUR 1.20 VAT

- 1 x *Assembly-kit* (Baugruppen-Set) with item number ZUT-01, which can be bought at a price of EUR 10.00 + EUR 2.00 VAT

The produced slot-car can be sold in the market at a price of EUR 27.00 + EUR 5.40 VAT.

In the running example 80 units of the FER-01-slot car will be produced and sold. In order to cover the whole value chain in the running example three business processes are considered:

1. procurement process where the MAT-resources are bought,
2. production process where the slot-cars are produced by using the capacity resources, i.e. the PERS- and TECH-resources and
3. sales process where the produced FER-01-slot-cars are sold.

This simple setup of the value chain business processes provides a clear orientation for the successive discussions of the three different views characterizing the REA-semantic iES-Teaching by just looking at the cost and revenue associated with the 80 slot-cars. The cost per unit of the FER-01-slot-car is EUR 22.68 what is the sum of

- EUR 6 for the *Chassis* raw material (MAT-resource),
- EUR 10 for the *Assembly-kit* part (MAT-resource),
- EUR 5,01 for the *Employee* (PERS-resource) and
- EUR 1,67 for the *Workbench* (TECH-resource).

- a) **Overall production cost:** Multiplying this unit cost with 80 gives the overall production cost for the 80 FER-01-slot-cars amounting to **EUR 1,814.40**.
- b) **Total revenue:** Multiplying the sales price of EUR 27 per slot-car with the quantity of 80 gives the overall revenue of **EUR 2,160**. Adding EUR 423.00 VAT gives in total **EUR 2,592.00**.
- c) **Total materials cost:** Multiplying the materials cost of *Chassis* and *Assembly-kit* summing up to EUR 16 with 80 gives total materials cost of **EUR 1,280.00**. Adding EUR 256.00 VAT gives in total **EUR 1,536.00**.

These numbers often appear in the subsequent sections so that they provide a good orientation on the one side and demonstrate the validity of the calculations and corresponding information processing on the other side.

REA-SEMANTIC TEACHING: USER VIEW

The teaching of Enterprise Systems is often focused on the user view. For this view there is plenty of literature (Luszczak, 2016) and commercial courses (on- and offline) available. The user-view is defined as the focus upon the interaction of the end-user with the Enterprise System. It represents tasks performed by users on a daily basis in their various roles, e.g. as purchaser, accountant, production employee or sales representative. Teaching the user view in this course setting gets the students familiar with the system's look and feel, its peculiarities of the graphical user interface and most important – with the special technical terms of the system. While teaching the user view is not the priority for *Business Informatics* students in the presented curriculum it is inevitable in order to establish an initial connection and understanding of integrated Enterprise System.

In Table 1 the three business processes along the value chain are used for structuring the activities in Dynamics 365 for Operations. These activities are named in the middle column of the table. They are of special importance in the user view because they constitute the activities which are supported by the Dynamics enterprise software. In the right column of the table the REA semantics in form increments and decrements of the three generic resource types, i.e. MAT-, PERS- and TECH-resources are inserted. They are used in the REA-Activity diagram (see e.g. Figure 4) as stereotypes in order to indicate the meaning of the involved activities (modeled in the UML-language as rounded rectangles) as well as objects (modeled as rectangles).

Table 1: Business processes and related activities in Dynamics 365 for Operations

	Business Process	Activity in Dynamics 365 for Operations	REA-Semantics
Value Chain	Procurement	Procurement of Materials (MAT)	Raw materials (MAT) Increment Cash Decrement
		Production	Commissioning Materials (MAT)
	Working Time Registration (PERS/TECH)		WIP (PERS/TECH) Increment Labor and Machine (PERS/TECH) Usage
	Completion Confirmation (FG)		Finished Goods (MAT) Increment WIP Decrement
	Sales	Invoicing Sales Order (FG)	Receivable Increment Finished Goods (MAT) Decrement
		Payment of Sales Order	Cash Increment Receivable Decrement

Constructive Alignment in the User View: Supporting Constructive Learning Activities

In order to achieve the constructive alignment in the user view the following business process related tasks as well as intended learning outcomes are specified. The intended learning outcomes give the students an orientation about the knowledge, skills and competences which they are expected to have after finishing the user view session in the REA-semantic iES-Teaching system. The tasks are specific problems that have to be solved and they are part of the students' constructive learning activities.

Task

- Conceptual modeling of business processes (i.e. procurement, production and sales) with REA-Activity diagrams
- Execution of real-world business processes in Microsoft Dynamics 365 for Operations

Intended Learning Outcomes

- Recognize a three-tier-architecture in given, specific ERP-architecture diagram (Knowledge, level 1)
- Illustrate real-world business processes using REA activity diagrams (Comprehension, level 2)
- Recall programming languages used for parametrizing ERP-systems (Knowledge, level 1)

Procurement in the User View – Conceptual Modeling and Practical Implementation

The procurement process constitutes the first business process in the value chain. Table 1 indicates in the last column that the procurement process is an exchange process in the REA semantics which is characterized by an increment of a MAT-resource and a decrement of a financial/FIN-resource (e.g. cash). In Dynamics 365 for Operations the procurement process is supported by the activity *Procurement of Materials*.

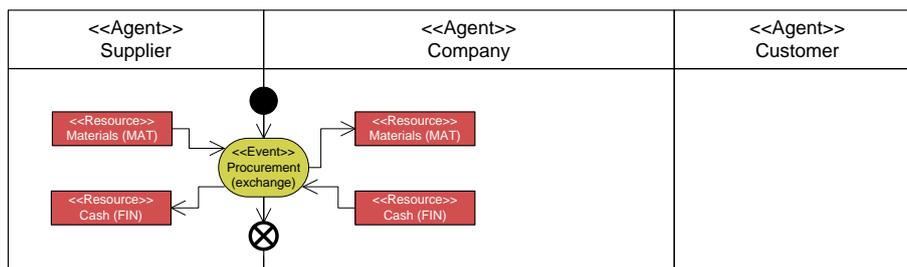


Figure 4: Procurement process – REA-Activity Diagram

The REA-Activity diagram in Figure 4 conceptualizes the procurement process according to the three REA constituents. The procurement includes the two dual events, i.e. the flow of the *Materials* MAT-resource form the *Supplier* agent to the *Company* agent and the flow of the *Cash* FIN-resource into the opposite direction.

In Dynamics 365 for Operations the procurement process is directly connected to the *purchase order*. Related to the running example it is assumed that the materials needed for the production of the 80 FER-01-slot-cars are not available on stock. Consequently a purchase order has to be given to the *Rohstoff GmbH* supplier agent for buying:

- 80 units of *Chassis* MAT-resource (ZUT-01), price EUR 6.00 + EUR 1.20 VAT

- 80 units of *Assembly-kit* MAT-resource (BGR-01), price EUR 10.00 + EUR 2.00 VAT

For the specification of the purchase order for materials that are needed for the 80 FER-01-slot-car the following instructions have to be followed. According to the REA semantics it can be seen that for the purchase event the connected agents and resources are selected, i.e. in the 3rd step the supplier agent and in the 6th and 7th step the materials (ZUT-01 and BGR-01) are selected.

1. Navigate to *Procurement and sourcing* > *Purchase orders* > *All purchase orders*
2. *New Purchase order*
3. Select an appropriate *Supplier account* (30001 – *Rohstoff GmbH*) > *OK*
4. Select an appropriate *Delivery date*
5. Navigate to *Purchase order lines*
6. *Add line* > *Item number* (ZUT-01) > *Quantity* (80)
7. *Add line* > *Item number* (BGR-01) > *Quantity* (80)
8. *Save*
9. *Navigate to PURCHASE* > *ACTIONS* > *Confirm*
10. *Navigate to RECEIVE* > *GENERATE* > *Product receipts* > *Enter Product receipt number* > *OK*
11. *Navigate to INVOICE* > *GENERATE* > *Invoice* > *Enter Invoice number* > *OK*

After following these instructions the purchase order shown in Figure 5 is specified. The purchase order relates to the purchase event and it shows the ordered materials (resources) and the supplying agent (Rohstoff GmbH).

Line number	Item number	Product name	Pr...	Varian...	CW...	CW unit	Quantity	Unit	Unit price	Adjusted unit pr...	Discount	Disc...	Net amount	Adjuste
1	BGR-01	Baugruppen-Set					80.00	Stk	10.00	0.00000			800.00	
2	ZUT-01	Karosserie					80.00	Stk	6.00	0.00000			480.00	

Figure 5: Procurement process – Specified purchase order

Production in the User View – Conceptual Modeling and Practical Implementation

The production process constitutes the second business process in the value chain. Table 1 indicates in the middle column that this process is quite complex compared to the procurement process as it decomposes into three different Dynamics 365 for Operations activities, i.e. *Commissioning Materials (MAT)*, *Working Time Registration (PERS/TECH)* and *Completion Confirmation (FG)*. The abbreviations in the parenthesis indicate the different resource types that are “flowing” in the three activities. In the first and third activities these are MAT-resources (including finished goods) and in the second activity the capacity resources in form of PERS- and TECH-resources are used. The last column of Table 1 that contains the REA semantics gives additional insights by showing that in the first two activities the *Work in Progress (WIP)* MAT-resource is increased and in the third activity it is decreased. Consequently the *WIP* MAT-resource can be seen as a container variable that stores the during the production process successively increasing maturity levels of the produced and finally finished goods. At the end of the production process the finished goods are increased which can be seen in the *Completion Confirmation* activity. During the production raw materials (MAT) are consumed in the production process and labor/personnel (PERS) as well as machine/technology (TECH) resources are used.

The REA-Activity diagram in Figure 6 conceptualizes the production process according to the three REA constituents. It is helpful to consider the production process in a 2-step approach:

- The first step covers the conversion of the input resources. This relates to the *Materials* MAT-resources, i.e. the *Chassis* raw material and the *Assembly-kit* part which are consumed and converted into the *WIP* MAT-resource. This conversion is supported in the *Commissioning Materials* activity. In addition to that the production process also uses capacity resources in form of *Employee* PERS- und *Workbench* TECH-resources. This conversion is supported in the *Working Time Registration* activity. In the case of multi-level

production processes there is a loop with respect to the *WIP*-resource (*WIP*-looping) that is explicitly shown in Figure 6 as well.

- The second step relates to the *Completion Confirmation* activity where the *WIP* MAT-resource, which was produced in the first step, is exchanged against the finally produced finished good.

In the REA-Activity diagram this 2-step approach can be seen by the two combinations of different decrementing and incrementing resources, i.e. *Materials* and *WIP* as well as *WIP* and *FG*. Furthermore it is interesting to note that in the case of the production process the *balanced duality* restriction relates to in- and outflows in the process context within the company so that there is no external agent. Finally, the diagram also contains the *Bill-of-Materials* (BOM) and the *Route* which specify the production process concerning the materials consumptions and the capacity resource usages.

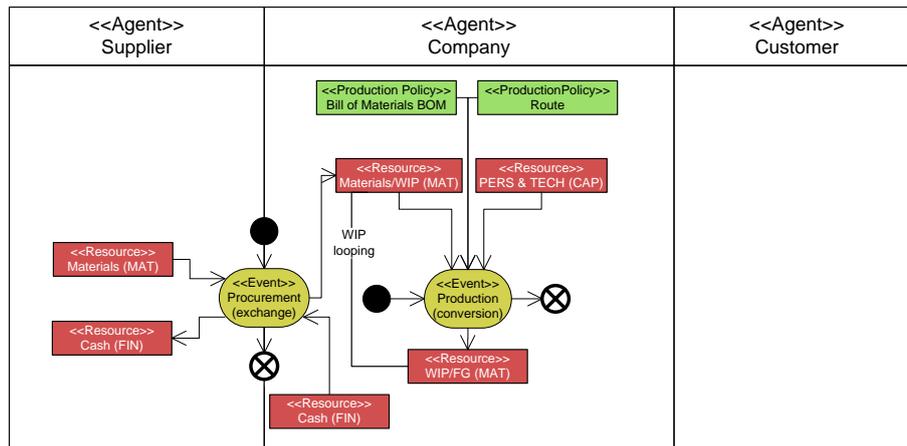


Figure 6: Production process – REA-Activity Diagram

In Dynamics 365 for Operations the production process is directly connected to the *work order*. Related to the running example it is assumed that the slot-car assembly process not only consumes a certain amount of materials, but it also uses a defined amount of capacity resources. For the FER-01-slot-car the usage is defined as the follows:

- 5 minutes of *Employee* PERS-resource, rate EUR 5.00 (hourly rate EUR 60/h)
- 5 minutes of *Workbench* TECH-resource, rate EUR 1.67 (hourly rate EUR 20/h)

For the specification of the work order for the production of the 80 FER-01-slot-car the following instructions have to be followed. According to the REA semantics it can be seen that for the work (production) event only the output resource (FER-01-slot-car) and the targeted production volume (*Quantity*) has to be specified in the 3rd step. All other information related to the required materials and capacity resources are accessible via the BOM and Route.

1. Navigate to *Production control > Work orders > All work orders*
2. *New works order (!)*
3. Select in *Item number* the slot-car (FER-01) with a *Quantity* of 80 units
4. OK
5. Navigate to *WORKS ORDER > PROCESS > Start > OK* in order to start the production process
6. Navigate to *VIEW > JOURNALS > JOB CARD > enter duration of job in hours* (standard time is 6,67hours for 80 slot-cars)
7. Navigate to *WORKS ORDER > PROCESS > Report as Finished > OK* in order to finish the production process

The instructions also include in the 5th step the starting and in the 6th step the duration of the production process. With this information the actual production times are determined and stored in Dynamics 365 for Operations. After executing all instructions the work order shown in Figure 8 is posted, i.e. initialized and recorded at actual starting times and durations.

Production	Item number	CW ...	CW...	Quantity	Report remaine...	Delivery	Status	Remain status	Reference type	Pool
PA-000003	FER-01			80.00		4/27/2017	Reported as finished	Ended	Sales order	
PA-000002	FER-01			80.00		4/7/2017	Ended	Ended	Sales order	

Figure 7: Production process – Initialized and executed work orders

Figure 8 gives a cost overview that contains the estimated cost amounts (totaling to **EUR 1814.40**) for the type *Production* as well as the realized cost amounts (totaling to **EUR 1814.40**) for the consumed materials (ZUT-01 and BGR-01), which are called *Item*, and the used capacity resources (MON-MAS and MON-PERS), which are called *Process*. The comparison of these costs shows no difference. The reason lies in the duration inserted into the work order execution which exactly matches with the budgeted process duration. In this case the actual quantity equals the budgeted quantity. Furthermore in the underlying standard costing setup the standard price (rate) is equated to the budgeted price (rate).

Type	Number	Level	Item/Resource	Dimen...	Calcul...	Unit	Estimated con...	Realised consu...	Estimated cost amount	Realised cost amount	Cost group
Production	PA-000002	0	FER-01	W/10	STD	Stk	80.00	80.00	1,814.40	1,814.40	FER
Item	PA-000002	1	ZUT-01	W/10	STD	Stk	80.00	80.00	480.00	480.00	ZUT
Item	PA-000002	1	BGR-01	W/10	STD	Stk	80.00	80.00	800.00	800.00	BGR
Process	PA-000002	1	MON-MAS			Hours	6.68	6.68	133.60	133.60	MON
Process	PA-000002	1	MON-PERS			Hours	6.68	6.68	400.80	400.80	MON

Figure 8: Production process – Cost constituents for ended work order PA-...02

Sales in the User View – Conceptual Modeling and Practical Implementation

The sales process constitutes the third business process in the value chain. This process is again an exchange process like the procurement process. But in contrast to that the sales process is decomposed into two supporting Dynamics 365 for Operations activities as can be seen in the middle column of Table 1. The splitting into two activities, i.e. *Invoicing Sales Order* and *Payment of Sales Order* allows the separation of invoicing a sales order and its payment at a later point in time. In the first activity a FIN-resource (e.g. receivable) is increased and a *Finished Good (FG)* MAT-resource is decreased. In the second activity the FIN-resource is decreased and hence converted into an increased Cash resource.

The REA-Activity diagram in Figure 9 conceptualizes the sales process according to the three REA constituents. The sales process includes the two dual events, i.e. the flow of the *Finished Good (FG)* MAT-resource from the *Company* agent to the *Customer* agent and the flow of the *Cash* FIN-resource into the opposite direction.

In Dynamics 365 for Operations the sales process is directly connected to the *sales order*. Related to the running example it is assumed that by selling the FER-01-slot-car a revenue can be generated, i.e.

- Revenue per one unit of slot-car: EUR 27.00 + EUR 5.40 VAT

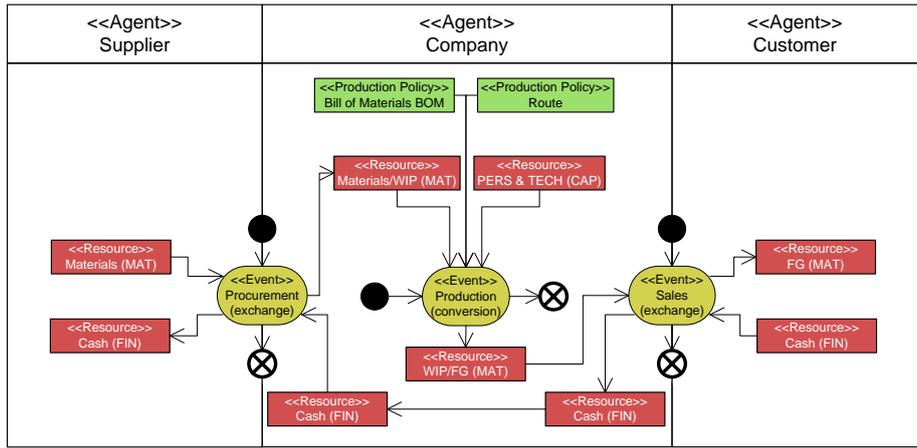


Figure 9: Sales process – REA-Activity Diagram

For the specification of the sales order related to 80 FER-01-slot-car the following instructions have to be followed. According to the REA semantics it can be seen that for the sales event the *Customer* agent (Slotcar Handelsgesellschaft AG) as well as the deliverable resource (FER-01-slot-car) and the sales volume (*Quantity*) have to be specified in the 3rd and 4th step.

1. Navigate to *Sales and marketing > Sales orders > All sales orders*
2. *New*
3. Select an appropriate *Customer account (20001 – Slotcar Handelsgesellschaft AG) > OK*
4. Navigate to *Sales order lines > Item number > select (FER-01) for slot-car with a Quantity of 80 units*
5. *Save*
6. Navigate to *SELL > GENERATE > Confirm sales order > OK*
7. Navigate to *PICK AND PACK > GENERATE > Generate picking list > OK*
8. Navigate to *INVOICE > GENERATE > Generate invoice > OK*

The instructions also include in the 6th to the 8th step the sales order confirmation, the command to generate the pickling list and to generate the invoice. After executing all instructions the sales order shown in Figure 10 is posted, i.e. initialized and recorded.

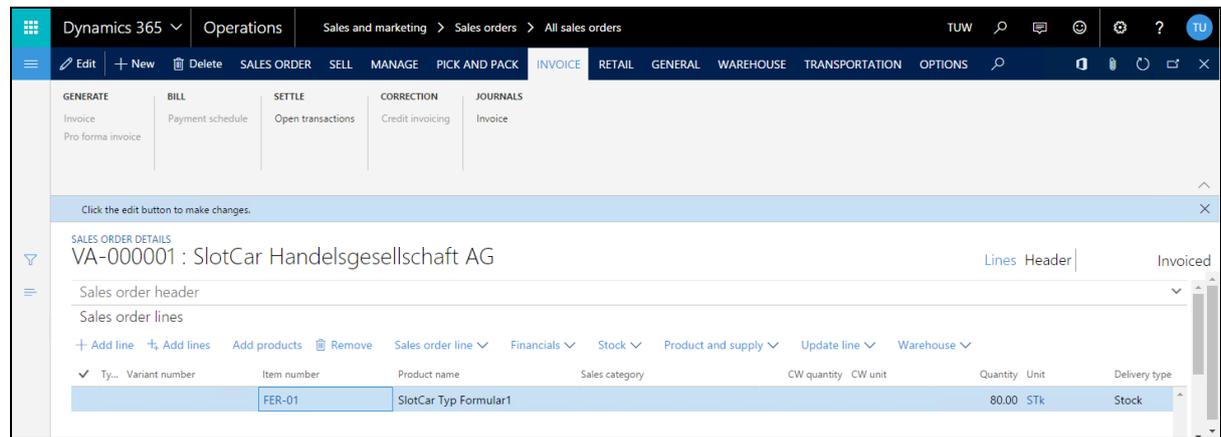


Figure 10: Sales process – Initializing and executed sales orders

REA-SEMANTIC TEACHING: ACCOUNTING VIEW

The teaching of an integrated Enterprise Systems (iES) cannot be limited to the user view which was presented in the last chapter. Otherwise the students could not understand how the legally required financial reports as well as internally required management reports would be generated. For being able to understand such reporting systems the students have to understand the double-entry bookkeeping system that underlies the accounting infrastructure of an integrated Enterprise System. The traditional starting point for understand the iES accounting infrastructure is the chart of accounts. Table 2 shows the chart of accounts based on the Austrian

uniform scheme in a condensed form which is selected in order to allow the recording of all business processes in the running example.

Table 2: Chart of Accounts on basis of the Austrian uniform scheme of accounts

Account category	Ledger Account	Account name
Asset	040	Equipment (Anlagen und Maschinen)
	110	Raw materials (Bezogene Ressourcen)
	120	Parts (Bezogene Teile)
	149	Work in progress (WIP)
	150	Finished goods (Fertige Erzeugnisse)
	200	Receivables (Lieferforderungen)
	250	Input VAT (Vorsteuer)
	270	Cash (Kassa)
Liability	280	Bank (Bank)
	330	Liabilities (Lieferverbindlichkeiten)
	339	Incoming goods without receipt (Wareneingang)
	350	VAT (Umsatzsteuer)
Revenue	352	Tax payable (Zahllast)
	400	Revenue account (Umsatzerlöse)
Expense	450	Inventory variation (Bestandsveränderung)
	510	Consumption Raw materials (Materialaufwand)
	520	Consumption Parts (Materialaufwand)
	591	Production cost (Herstellungskosten)
	699	Discharge PERS (Personalaufwand)
	700	Depreciation (Abschreibung)
Equity	709	Discharge TECH (Betriebsaufwand)
	900	Equity (Eigenkapital)
	980	Opening balance sheet (Eröffnungsbilanzkonto)
	985	Closing balance sheet (Schlussbilanzkonto)

This chart of accounts contains the ledger accounts (including their names) for all asset, liability and equity related accounts. For recording the equity changes that are reported in the income statement the corresponding revenue and expense accounts are specified as well.

Table 3 extends Table 1 by adding an additional column which contains the general ledger transactions. These transactions are specified by the debit (Dr.) and credit (Cr.) entries in the corresponding ledger accounts. In contrast to the previous investigations now also value added tax (VAT) considerations are included. For a full understanding of the general ledger transactions the previously used REA-Activity diagram is not sufficient any more. Instead of this diagram the *REA-Double Entry Diagram* (see e.g. Figure 11) will be introduced and used.

Table 3: Business processes and related General Ledger Transactions

Business Process	Activity in Dynamics 365 for Operations	REA-Semantics	General Ledger Transaction (Simplified)
Procurement	Procurement of Materials (MAT)	Raw materials (MAT) Increment	Dr. 110 EUR 480.00
		Cash Decrement	Dr. 250 EUR 96.00
			Dr. 120 EUR 800.00
			Dr. 250 EUR 160.00
			Cr. 280 EUR 1536.00
Production	Commissioning Materials (MAT)	WIP (MAT) Increment	Dr. 510 EUR 480.00
		Raw materials (MAT) Consumption	Cr. 110 EUR 480.00
			Dr. 520 EUR 800.00
			Cr. 120 EUR 800.00
	Working Time Registration (PERS/TECH)	WIP (PERS/TECH) Increment	Dr. 591 EUR 400.80
		Labor and Machine (PERS/TECH) Usage	Cr. 699 EUR 400.80
			Dr. 591 EUR 133.60
	Cr. 709 EUR 133.60		
Completion Confirmation (FG)	Finished Goods (MAT) Increment	Dr. 150 EUR 1814.40	
	WIP Decrement	Cr. 450 EUR 1814.40	
Sales	Invoicing Sales Order (FG)	Receivable Increment	Dr. 450 EUR 1814.40
		Finished Goods (MAT) Decrement	Cr. 150 EUR 1814.40
			Dr. 200 EUR 2592.00
			Cr. 400 EUR 2160.00
	Payment of Sales Order	Cash Increment	Cr. 350 EUR 432.00
		Dr. 280 EUR 2592.00	

		Receivable Decrement	Cr. 200	EUR 2592.00
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Constructive Alignment in the Accounting View: Supporting Constructive Learning Activities

In order to achieve the constructive alignment in the accounting view the following double entry related tasks as well as intended learning outcomes are specified. The indented learning outcomes give the students an orientation about the knowledge, skills and competences which they are expected to have after finishing the accounting view session in the REA-semantic iES-Teaching system. The tasks are specific problems that have to be solved and they are part of the students' constructive learning activities.

Tasks

- Posting accounting records of real-world business processes
- Reproduce those accounting records through classic T-accounts

Intended Learning Outcomes

- Create an export-view of all created accounting-records from the general ledger (Synthesis, level 5)
- Match accounting-records and ERP-business processes (Knowledge, level 1)
- Explain the accounting-record according to REA-Double entry diagrams (Comprehension, level 2)
- Reconstruct the accounting-record by means of classic T-accounts (Synthesis, level 5)
- Recall the peculiarities of IT-aided accounting (Knowledge, level 1)
- Apply a pivot-mapping of documents with respect to business-processes and their actual balances (Application, level 3)

Procurement in the Accounting View – Conceptual Modeling and Practical Implementation

The double-entry bookkeeping methodology implements the *balanced duality* requirement. In the REA-Double entry diagram shown in Figure 11 this requirement corresponds to the equality of the amounts connected to the *Debit Events* on the left sight and the amounts connected to the *Credit Events* on the right sight. The diagram illustrates the procurement process of the running example where the company receives the

- 80 units of *Chassis* MAT-resource (ZUT-01), price EUR 6.00 + EUR 1.20 VAT
 - 80 units of *Assembly-kit* MAT-resource (BGR-01), price EUR 10.00 + EUR 2.00 VAT
- amounting to EUR 480.00 for the *Chassis* and EUR 800.00 for the *Assembly-kit*. The related VAT for the two acquired MAT-resources amounts to EUR 96.00 as well as EUR 160.00. The VAT is a claim of the company against the fiscal authority.

According to the balanced duality requirement the company has to pay the supplier agent the amount of **EUR 1,536.00** which is exactly equal to the sum of the four entries at the left, i.e. at the debit side. As peculiarity it should be seen that the amount of the credit events is expressed as a negative number. This is in line with the representation of credit events in Dynamics 365 for Operations (see e.g. Figure 13 and Table 4). The advantage of using the sign of the amounts for debit and credit entries is twofold, firstly, a reduction of the space needed for storing the general ledger transactions and secondly, more efficient information processing algorithms.

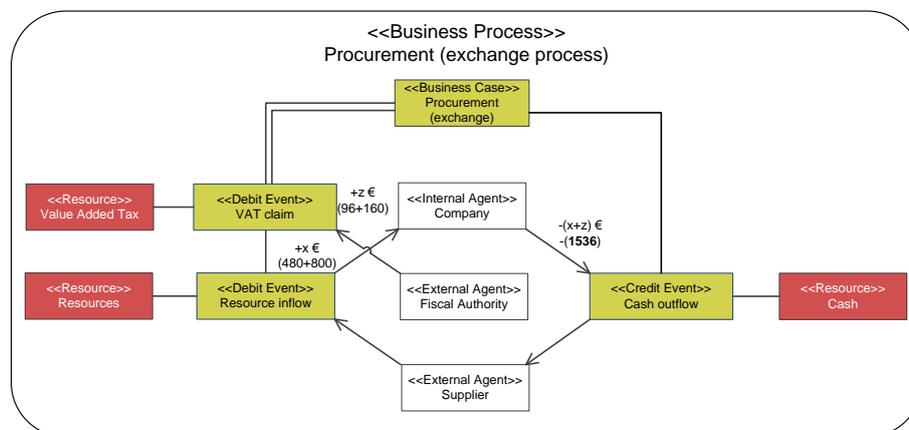


Figure 11: Procurement exchange process – REA-Double Entry Diagram

The traditional way to double-entry bookkeeping consists of using T-accounts. In Figure 12 the procurement process is recorded in T-accounts for *Raw materials*, *Parts*, *Input VAT* and *Cash*. The T-Account recording has “optical” advantages, but compared to the REA-Double entry diagram it misses the REA semantic basement.

110 Raw materials		120 Parts		250 Input VAT		270 Cash	
Debit	Credit	Debit	Credit	Debit	Credit	Debit	Credit
EUR 480.00		EUR 800.00		EUR 96.00			EUR 1536.00
				EUR 160.00			

Figure 12: Procurement process – T-Accounts Transactions

In Dynamics 365 for Operations the transaction records in the general ledger are organized in tabular format. Table 4 presents general ledger for the procurement process. As in the REA-Double entry diagram the debit entry can be seen by a negative value sign. Like the T-Account approach the tabular format does not provide the REA semantic interpretation.

Table 4: Procurement of Materials (MAT) – Transactions generated by Dynamics 365 for Operations

Line No	Business Process	Activity in Dynamics 365 for Operations	Voucher	Ledger Account	Account name	Amount in EUR
4	Procurement	Procurement of Materials (MAT)	ER-000001	3300	Liabilities	-1536
6	Procurement	Procurement of Materials (MAT)	ER-000001	1100	Raw materials	480
8	Procurement	Procurement of Materials (MAT)	ER-000001	1200	Parts	800
12	Procurement	Procurement of Materials (MAT)	ER-000001	2500	Input VAT	256

The recordings of the procurement process in Table 4 distinguish from the REA-Double entry diagram and the T-Account recording in one point: The procurement process is now a *purchase on target* and not a *purchase in cash* anymore. This difference in the payment modality corresponds to a change in the debited account which is now the *Liabilities* account (3300) instead of the *Cash* account (270).

In Dynamics 365 for Operations the content of the procurement process can be accessed not only via the general ledger. In Figure 13 the invoice associated with the procurement process is accessed via the invoice journal. The invoice access shows – like the tabular format – the voucher type which is attached to the invoice. As will be shown in the data view the voucher type plays an essential role in integrated Enterprise Systems (iEW) by connecting the accounting infrastructure with the business process support infrastructure.

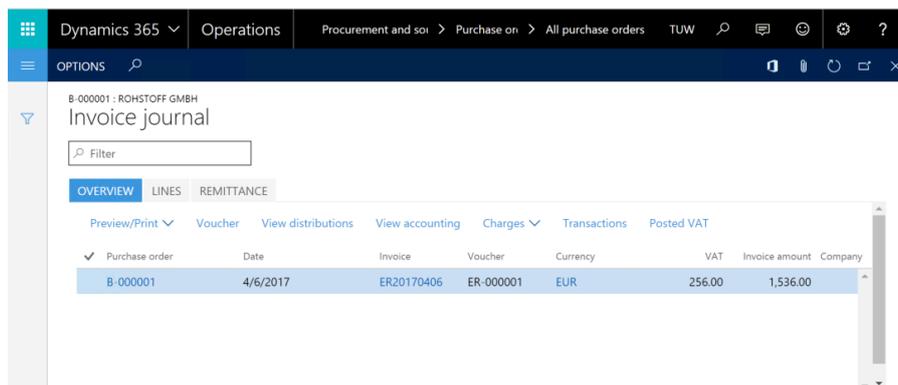


Figure 13: Procurement process – Accessing the invoice

Production in the Accounting View – Conceptual Modeling and Practical Implementation

In Figure 14 the production process of the running example is conceptualized with the REA-Double entry diagram. In contrast to the procurement process the production process is not an exchange process but an internal conversion process. As such it does not have external agents. The involved (internal) agents are

- the *Material Storage Department* that supplies the materials (MAT-resources),
- the *Capacity Resource Provider* that supplies the capacity resources (PERS- and TECH-resources),
- the *Production Department* that is hosting and in charge of the production process and
- the *Finished Good Storage Department* that receives the finished goods.

The overall production cost amounting to **EUR 1,814.40** are composed of the total materials cost for the 80 *Chassis* of EUR 480.00, for the 80 *Assembly-kits* of EUR 800.00, the total capacity cost for the *Employee* of EUR 400.80 and for the *Workbench* of EUR 133.60

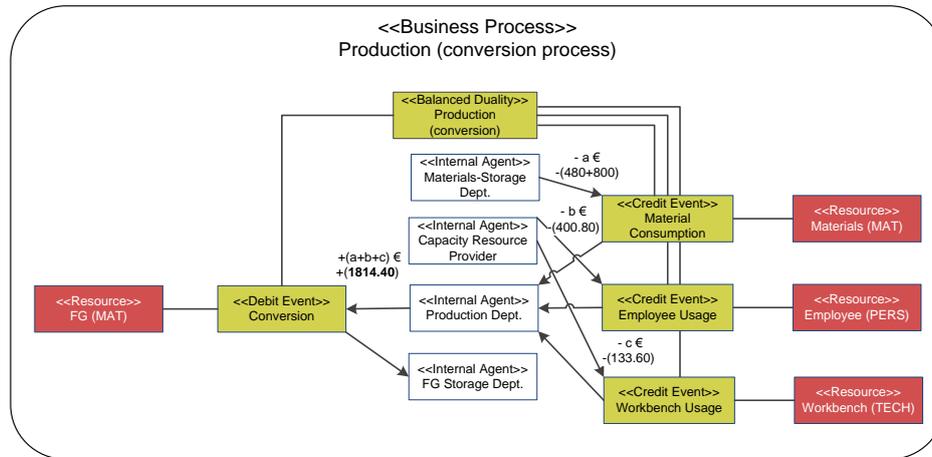


Figure 14: Production conversion process – REA-Double Entry Diagram

The REA-Double entry diagram expresses the economic rational underlying the production process in REA semantic terms. As such it delivers a solid economic understanding. But for a solid accounting understanding additional considerations concerning the *WIP* looping (see Figure 6) have to be added. The following arguments are based – like in the process-oriented user view – upon the 2-step approach. In the first step the successive maturity progression of the produced good is collected in the *Work in Progress/WIP*-resource. In the running example the consumed materials and the used capacity resources deliver value increasing inputs. The consumed materials (MAT-resources) are the 80 *Chassis* and the 80 *Assembly-kits*. In Dynamics 365 for Operations the input of MAT-resources is supported by the *Commissioning Materials* activity. In Figure 15 the consumption of the *Chassis* raw material and the *Assembly-kit* part is credited and the increase is debited in the WIP account. Again, the T-Account recording is intuitive and understandable, but it does not express the REA semantic interpretation.

149 WIP		110 Raw materials		120 Parts	
Debit	Credit	Debit	Credit	Debit	Credit
EUR 1280.00			EUR 480.00		EUR 800.00

Figure 15: Commissioning Materials (MAT) – T-Account transactions for production

In Table 5 the same information is recorded in the tabular format underlying Dynamics 365 for Operations. The recording is similar to the T-Account recording and it has the same disadvantage by not promoting the REA semantic understanding.

Table 5: Commissioning Materials (MAT) – Transactions generated by Dynamics 365 for Operations

Line No	Business Process	Activity in Dynamics 365 for Operations	Voucher	Ledger Account	Account name	Amount in EUR
13	Production	Commissioning Materials (MAT)	KL-000000001	1200	Parts	-800
14	Production	Commissioning Materials (MAT)	KL-000000001	1490	Work in progress	1280
15	Production	Commissioning Materials (MAT)	KL-000000001	1100	Raw materials	-480

In Figure 16 the production costs collected at the *WIP* account are given for the consumed materials (MAT-resources) amounting to **EUR 1,280.00**. Interesting is the *posting type* that shows *estimated cost of materials*. This means that according to the *standard costing* the budgeted materials input quantities and the budgeted materials input prices (rates) are used for calculating these costs.

Date	Ye...	Ledger account	Account name	Desc...	Currency	Amount in trans...	Amount	Amount in repor...	Posting type
4/6/2017		1490	WIP		EUR	1,280.00	1,280.00	0.00	Estimated cost of materials
4/6/2017		1200	Bezogene Teile		EUR	-800.00	800.00	0.00	Estimated cost of materials
4/6/2017		1100	Rohstoffe		EUR	-480.00	480.00	0.00	Estimated cost of materials

Figure 16: Commissioning Materials (MAT) – Voucher Transactions

In the 2nd part of the 1st step also capacity resource costs are collected to the *WIP* account. In Dynamics 365 for Operations this assignment is supported in the *Working Time Registration* activity. Figure 17 show that the accounts “belonging” to the capacity resource provider, i.e. *699 Discharge PERS* and *709 Discharge TECH* are credited so that their incurred costs are neutralized and the *WIP* account is debited so that its value is according to the maturity level enhancement increased.

149 WIP		699 Discharge PERS		709 Discharge TECH	
Debit	Credit	Debit	Credit	Debit	Credit
EUR 534.40			EUR 400.80		EUR 133.60

Figure 17: Working Time Registration (PERS/MAT) – T-Account Transactions for Production

Table 6 contains the same information in tabular format underlying Dynamics 365 for Operations.

Table 6: Working Time Registration (PERS/TECH) – Transactions generated by Dynamics 365 for Operations

Line No	Business Process	Activity in Dynamics 365 for Operations	Voucher	Ledger Account	Account name	Amount in EUR
16	Production	Working Time Registration (PERS/TECH)	EV-000000001	6990	Discharge PERS	-400.8
17	Production	Working Time Registration (PERS/TECH)	EV-000000001	7090	Discharge TECH	-133.6
18	Production	Working Time Registration (PERS/TECH)	EV-000000001	1490	Work in progress	534.4

The 2nd step in the 2-step approach occurs after the production process is finished. In Dynamics 365 for Operations the *Completion Confirmation* activity triggers this situation.

149 WIP		150 Finished goods	
Debit	Credit	Debit	Credit
	EUR 1814.40	EUR 1814.40	

Figure 18: Completion Confirmation (FG) – T-Account Transactions for Production

Figure 1 and Table 7 contain the same information. In both cases the balance of the *WIP* account is transferred to the *Finished goods (FG)* account by crediting the *WIP* account and debiting the *FG* account.

Table 7: Completion Confirmation (FG) – Transactions generated by Dynamics 365 for Operations

Line No	Business Process	Activity in Dynamics 365 for Operations	Voucher	Ledger Account	Account name	Amount in EUR
19	Production	Completion Confirmation (FG)	FM-000000001	1490	Work in progress	-1814.40
20	Production	Completion Confirmation (FG)	FM-000000001	1500	Finished goods	1814.40

Figure 19 delivers the production posting that summarizes the production cost associated with work order PA-...02 (see also Figure 8).

Date	Type	Good quantity	Error quantity	IIP/WIP amount	Cost accounted ...
4/6/2017	Material consumption			1,280.00	
4/6/2017	Route consumption			534.40	
4/6/2017	Report as finished	80.00		1,814.40	
4/6/2017	Costing	80.00			1,814.40

Figure 19: Production process – Overall production cost

Sales in the Accounting View – Conceptual Modeling and Practical Implementation

In Figure 20 the sales process of the running example is conceptualized with the REA-Double entry diagram. This process is an exchange process like the procurement process. The four involved agents are:

- the *Company* (internal) that delivers the finished goods (MAT-resources),
- the *Owner* (internal) that receives the profit (EQU-resources),
- the *Fiscal Authority* (external) that is the claim holder of the company’s VAT liability and
- the *Customer* (external) that receives the finished goods and pays the company the sales price.

The overall revenue amounting to **EUR 2,592.00** is composed of the production cost of the 80 FER-01-slot-cars of **EUR 1,814.40**, the VAT liability of EUR 432.00 and the profit of EUR 345.60. The difference between the revenue on the net-basis, i.e. revenue minus the VAT EUR 432.00, amounting to **EUR 2,160.00** and the overall production costs of **EUR 1,814.40** gives the profit of **EUR 345.60**. This profit is the balance in the income statement and it increases the equity which belongs to the owner of the company.

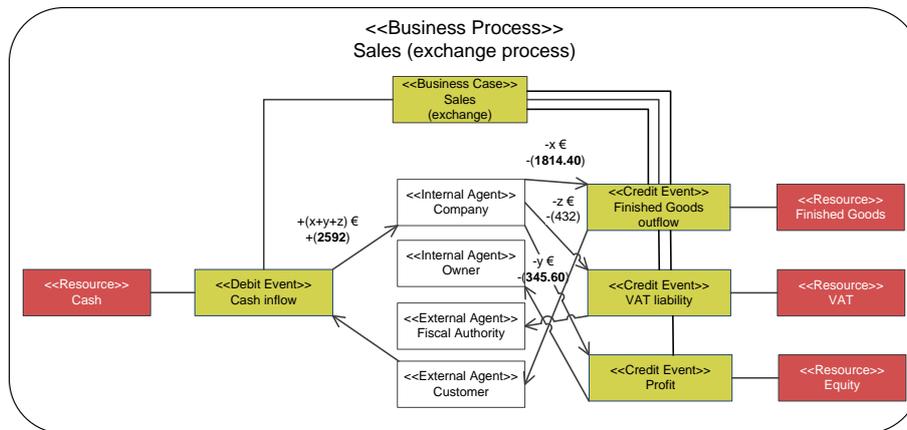


Figure 20: Sales exchange process – REA-Double Entry Diagram

In Figure 21 the overall revenue from selling the 80 FER-01-slot-cars is debited in the *Receivable* account. The revenue net amount is credited in the *Revenue* account and the VAT is credited in the *VAT* account. The reduction of the FER-01-slot-car inventory is recorded by crediting the *Finished Goods* account and the corresponding expense is recorded by debiting the *Inventory variation* account. The difference between the balances in the *Revenue* account and the *Inventory variation* account amounts to **EUR 345.60** which is the profit earned over the value chain.

450 Inventory variation		150 Finished Goods FG		200 Receivables		400 Revenue account		350 VAT	
Debit	Credit	Debit	Credit	Debit	Credit	Debit	Credit	Debit	Credit
EUR 1814.40			EUR 1814.40	EUR 2592.00			EUR 2160.00		EUR 432.00

Figure 21: Invoicing Sales Order (FG) – T-Account Transactions for Sales

The sales process specific recordings in Dynamics 365 for Operations are shown in Table 8. These recordings are generated by executing the *Invoicing Sales Order* activity. The profit generated over the value chain can be seen by taking the difference between the revenue (on net basis) and the expenses recorded in the *Inventory variation* account.

Table 8: Invoicing Sales Order (FG) – Transactions generated by Dynamics 365 for Operations

Line No	Business Process	Activity in Dynamics 365 for Operations	Voucher	Ledger Account	Account name	Amount in EUR
39	Sales	Invoicing Sales Order	AR-000001	2000	Receivables	2592
40	Sales	Invoicing Sales Order	AR-000001	3500	VAT	-432
41	Sales	Invoicing Sales Order	AR-000001	4000	Revenue	-2160
42	Sales	Invoicing Sales Order (FG)	AR-000001	4500	Inventory variation	1814.4
43	Sales	Invoicing Sales Order (FG)	AR-000001	1500	Finished goods	-1814.4

As in the running example the revenue (inclusive VAT) has not been paid in cash there is a receivable debited in the *Receivables* account. When the customer agent pays its obligation the *Receivables* account is credited so that the account balances to zero. The corresponding debit entry comes into the *Bank* account which means that the received money increases the balance in the *Bank* account.

280 Bank		200 Receivables	
Debit	Credit	Debit	Credit
EUR 2592.00			EUR 2592.00

Figure 22: Payment of Sales Order – T-Account Transactions for Sales

The payment of the receivable is supported in Dynamics 365 for operations by the *Payment of Sales Order* activity. The execution of this activity leads to the postings shown in Table 9.

Table 9: Payment of Sales Order – Transactions generated by Dynamics 365 for Operations

Line No	Business Process	Activity in Dynamics 365 for Operations	Voucher	Ledger Account	Account name	Amount in EUR
44	Bank	Payment of Sales Order	BANK-000000001	2800	Bank	2592
45	Bank	Payment of Sales Order	BANK-000000001	2000	Receivables	-2592

Figure 23 shows the transaction postings that are generated automatically in Dynamics 365 for Operations after performing the sales process related activities, i.e. the *Invoicing Sales Order* and the *Payment of Sales Order* activities. The generated profit can be seen as the difference between the debit entry in the *Revenue* account (number 400) and the credit entry in the *Inventory variation* account (number 450). It is interesting to note that both accounts have a suffix added to their account numbers (see Figure 24). These suffixes indicate the *financial dimension* in form of a *cost and revenue object* (ETR-SLC) and they are implemented to allow object related profit analyses in the management accounting domain.

Journal number	Voucher	Date	Ye...	Ledger account	Account name	Desc...	Currency	Amount in trans...	Amount	Amount in
TUW-000007	AR-000001	4/6/2017		4500--ETR-SLC	Veränderungen des...		EUR	1,814.40	1,814.40	
TUW-000007	AR-000001	4/6/2017		4000--ETR-SLC	Umsatzerlöse fertig...		EUR	-2,160.00	2,160.00	
TUW-000007	AR-000001	4/6/2017		3500	Verbindlichkeiten a...		EUR	-432.00	432.00	
TUW-000007	AR-000001	4/6/2017		2000	Forderungen aus Li...		EUR	2,592.00	2,592.00	
TUW-000007	AR-000001	4/6/2017		1500	Fertige Erzeugnisse		EUR	-1,814.40	1,814.40	

Figure 23: Sales process – Voucher transactions

REA-SEMANTIC TEACHING: DATA-VIEW

Integrated Enterprise Systems are characterized by having an accounting infrastructure that allows the transactional recording of accounting data needed for legally required financial reporting purposes. Figure 24 shows a conceptual model for such an iES accounting infrastructure. In the center are the *General Ledger Accounts* which can be *debited (Dr.)* or *credited (Cr.)*. Each *General Ledger Record* fulfills the *duality* requirement by having at least one debit and at least one credit entry. Furthermore the duality must be *balanced* so that the value of the debit entries is equal to the value of the credit entries. In order to extend the financial accounting infrastructure into the direction of a management accounting infrastructure additional financial dimensions are linked to the ledger account. The figure shows exemplarily *Cost and Revenue Object* as well as *Cost Center* with a responsibility link to the working plans called *Route*.

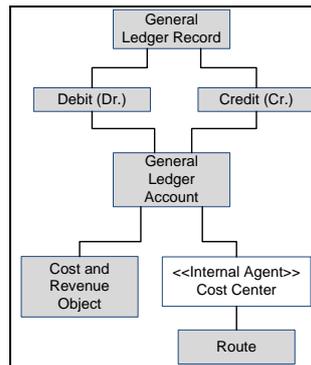


Figure 24: Accounting infrastructure for iES – Conceptual data model

Next to the accounting infrastructure an integrated Enterprise Systems (iES) also has a process support infrastructure which distinguishes the iES from a stand-alone Accounting Information System (AIS). In the data view of the REA-semantic iES Teaching system the connection of the accounting infrastructure and the REA-semantic process support is conceptualized with *REA-Data Diagrams* (see e.g. Figure 28). These diagrams are used in the following to address the link between the accounting and the process support infrastructures. It will be seen that vouchers and their typification play the essential role for establishing the link.

Constructive Alignment in the Data View: Supporting Constructive Learning Activities

In order to achieve the constructive alignment in the data view the following data base related tasks as well as intended learning outcomes are specified. The intended learning outcomes give the students an orientation about the knowledge, skills and competences which they are expected to have after finishing the data view session in the REA-semantic iES-Teaching system. The tasks are specific problems that have to be solved and they are part of the students' constructive learning activities.

Tasks

- Database administration
- Evaluation and analysis of data

Intended Learning Outcomes

- Design of a REA-Data diagram (including classes for accounting-information and financial dimensions) (Synthesis, level 5)
- Identify the REA-Data diagram's underlying tables using Dynamics 365 for Operations documentation (Knowledge, level 1)
- Apply SELECT database queries according to given ERP-datasets (Application, level 3)

Dynamics 365 for Operations: Database ER-Diagrams and Integrated Table Viewer

In ERP multi-tier architectures, the *data access layer* or *persistence layer* is realized by relational database management systems DBMS. In the case of Dynamics 365 for Operations the *data access layer* is implemented by *Microsoft SQL Server 2016* or *Azure SQL*. A deeper understanding requires knowledge about the storage of the data in general and the underlying data-model. For the scope of the lecture it would be illusionary to present the complete data-model which consists of several thousand relational database tables and almost one thousand database views. It is of benefit however that the students get a grasp of how the data is stored and how the tables

are interconnected with each other. This is achieved by studying the ERP system's data-model and retrieving basic datasets from the database.

Microsoft provides database entity relationship ER diagrams for their Dynamics products. They can be retrieved under the URL <https://www.microsoft.com/dynamics/ax/erd/ax2012r2/>. This "AxErd" website hosts entity relationship (ER) diagrams for core tables of the application modules in Microsoft Dynamics AX 2012 R2. You can use the site to quickly list all the foreign key relationships for a table, involving both its child and parent tables. You can also use the site to determine which module a table is in, and which tables are in a module. The Dynamics AX 2012 R2 ER diagrams can be applied to the Dynamics 365 for Operations as well, since both solutions rely on the same data model. Furthermore Dynamics 365 for Operations incorporates an *integrated table viewer* which can be used to retrieve the actual contents of a database table in a user-friendly fashion.

Procurement in the Data View – Practical Implementation and Conceptual Modeling

The retrieving of entity relationship diagrams and the results of the integrated table viewer are now used to demonstrate the practical data search functionalities of Dynamics 365 for Operations in the procurement context. Figure 25 contains an ER diagram that shows several tables of the procurement and sourcing module that are centered around the *PurchaseLine* table. Moreover it reveals the relationship to the table *PurchaseTable* via the foreign key *PurchaseId*. The *PurchaseLine* table therefore stores every single procurement position in one separate line. This makes the *PurchaseLine* table to one of the most central tables in the procurement process.

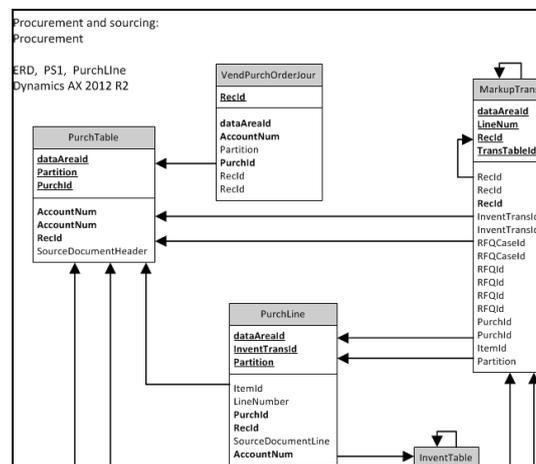


Figure 25: Dynamics 365 for Operations – Database ER-Diagram

In the next step all procurement positions are identified that are triggered by the procurement process (purchase order). After consulting the ER diagrams to get the appropriate table Figure 26 shows the actual contents of the table *PurchLine*. Line one and two represent the line items and thus the necessary positions to build the 80 FER-01-slot-cars of the running example, i.e. *Chassis* (ZUT-01) as well as *Assembly-kit* (BGR-01).

InventRefId	InventRefTransId	InventTransId	IsFinalized	IsPwp	ItemBOMId	ItemId	ItemRefType	ItemRou
PA-000002	TUW-000004	TUW-000005	<input type="checkbox"/>	<input type="checkbox"/>		BGR-01	Production line	
PA-000002	TUW-000003	TUW-000006	<input type="checkbox"/>	<input type="checkbox"/>		ZUT-01	Production line	
		TUW-000025	<input type="checkbox"/>	<input type="checkbox"/>		BGR-01		
		TUW-000026	<input type="checkbox"/>	<input type="checkbox"/>		ZUT-01		

Figure 26: Dynamics 365 for Operations – Table Browser with Table PurchLine

To illuminate the relationship between the accounting infrastructure and the process support infrastructure of an integrated Enterprise System the connections between the general ledger accounts and the different orders, i.e. purchase order, work order and sales order, underlying the procurement, the production and sales process events have to be identified.

Purchase order	Date	Invoice	Voucher	Currency	VAT	Invoice amount	Company	Sales order	Voucher
B-000001	4/6/2017	ER20170406	ER-000001	EUR	256.00	1,536.00			

Figure 27: Procurement process (purchase order) – Invoice journal

Figure 27 contains the *Invoice journal* for the procurement processes. There it can be seen that the purchase orders are connected to the voucher type, i.e. the *Vendor Invoice* (ER-...01). The general ledger accounts are also connected to the corresponding voucher types so that the voucher types provide the connection between the accounting and the process support infrastructure. This relationship is conceptualized in the REA-Data diagram presented in Figure 28. In the diagram it can be seen that the *Vendor invoice* voucher-type provides the link between the general ledger accounts to the right and the process support to the left.

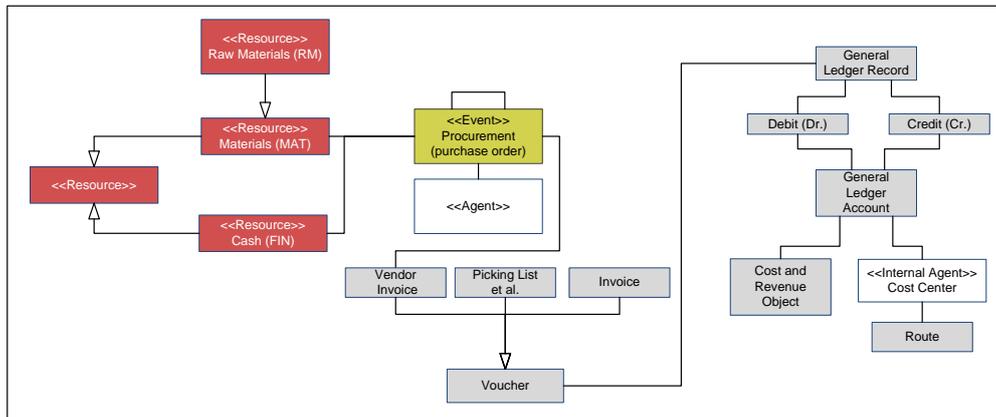


Figure 28: Procurement process (purchase order) – REA-Data Diagram

Production in the Data View – Conceptual Modeling and Practical Demonstrations

The voucher also provides in the production domain the link between the general ledger accounts and the process support. This link is shown in REA-Data diagram in Figure 29. In the production domain different voucher types are used, i.e. *Picking list*, *Product receipt*, *Job card*, *Report as finished* and *Costing* (see Table 10). Furthermore it can be seen that the Bill-of-Materials BOM and the Route are intermediating between the work orders and its resource inputs. The BOM specifies the consumed materials and the Route specifies the used capacity resources. As both are set in the production planning they are termed *Production Policy*.

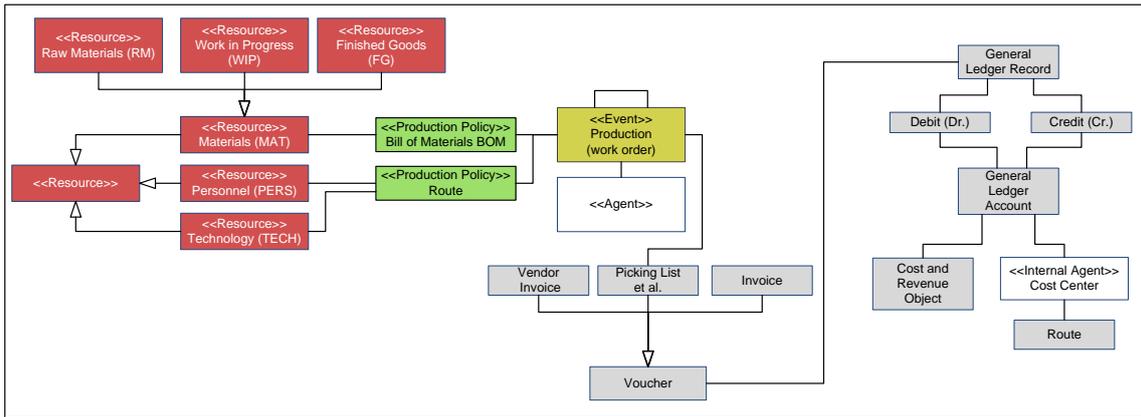


Figure 29: Production process (work order) – REA-Data Diagram

Figure 30 shows the specifications of the production process with respect to the materials resources.

Item number	Product name	Item group							
BGR-01	Baugruppen-Set	BGR							
FER-01	SlotCar Typ Formular1	FER							
BOM									
Name	From quantity	From date	To date	Active	Approved by	Approved			
FER-01	SlotCar Typ Formular1	1.00		Yes	000022	Yes			
Item number	Product name	Item type	Position	Operation number	Quantity	Per series Unit	Formula	Line type	Configuration group
ZUT-01	Karosserie	Item			1.0000	1 Stk	Standard	Item	
BGR-01	Baugruppen-Set	Item			1.0000	1 Stk	Standard	Item	
Item number			Product name			Item group			
ZUT-01	Karosserie					ZUT			

Figure 30: Production process (work order) – Bill of materials BOM

Figure 31 shows the specifications of the production process with respect to the capacity resources.

Route number	Name	Site	From date	To date	From qty.	Activ
TUW-000001	APL zu FER-01	W			0.00	

Oper. No.	Priority	Operation	Run time	Process qty.	Next	Route group	Item code	Route
10	Primary	MON-MAS	5.00	1.00	0	MON	Table	
10	Secondary 2	MON-PER		1.00	0	MON	Table	

Figure 31: Production process (work order) – Route

Sales in the Data View – Conceptual Modeling and Practical Demonstrations

The voucher also provides in the sales domain the link between the general ledger accounts and the process support. This link is shown in the REA-Data diagram Figure 32 where the *Invoice* is the voucher-type.

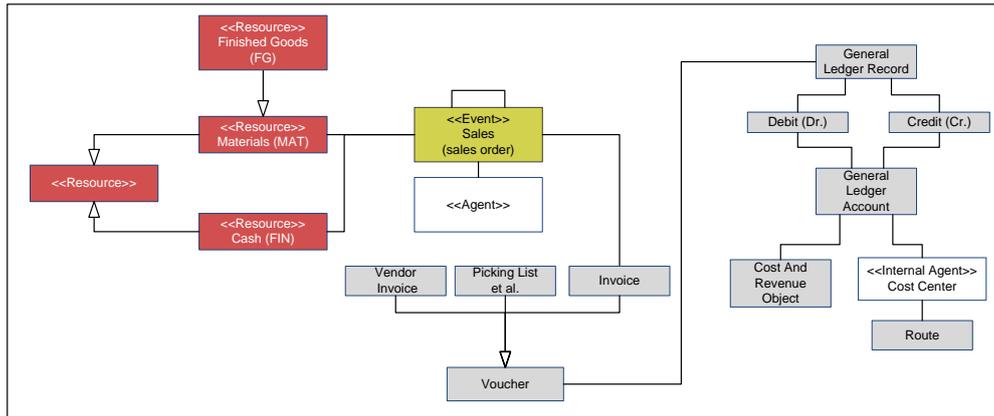


Figure 32: Sales process (sales order) – REA-Data Diagram

Figure 33 contains *Invoice* (AR-...01) as voucher type for the sales orders connected to the sales processes. Consequently also the general ledger accounts are connected via the voucher to the process support.

Invoice	Invoice account	Name	Sales order	Date	Voucher	Currency	Invoice amount	Intercompany c
AR-000001	20001	SlotCar Handelsgesellschaft AG	VA-000001	4/6/2017	AR-000001	EUR	2,592.00	

Figure 33: Sales process (sales order) – Options showing the voucher-type Invoice

STUDENTS' FEEDBACK SURVEY: EVALUATING iES-TEACHING

At TU Wien the 'integrated Enterprise System' (iES) course is part of the core curriculum in the Bachelor study *Business Informatics* where students have a strong background in computer science and business administration. The contents of the course and the teaching system are the ones presented in this article. At the end of the semester a students' feedback survey was performed. There were 23 groups of three students each and each group provided a feedback for the further development of the course. The survey was designed in an open questions fashion and the answers were clustered. The overall feedback was very much on the positive side and it provides the following picture:

- The majority of the groups (22/27) valued the possibility to get in touch with an ERP system.
- Furthermore, it was appreciated to have access to an "ERP playground" and discover the various modules.
- It was mentioned several times, that the running example was quite beneficial in order to understand the accounting logic of the system.
- Moreover, the REA-Activity diagrams and the REA-Double entry diagrams were described as "glue" that holds the whole syllabus together.
- A "hands-on-approach" was mentioned by five groups in a positive way – they liked the way to just get started in a few minutes.
- Some groups however found Dynamics 365 for Operations too slow to work with, another group mentioned the approach to connect through remote-desktop to the sandbox tiresome.
- The average workload was estimated to be around 20 hours per student, which is in scope of the course.
- It was furthermore valued, that instant help was available through e-mail and the e-learning platform.
- One group even called the REA-Double entry diagram to have reactivated their retired interest in accounting!

CONCLUSION

This article addressed a quite complex problem: The contents and the teaching of an integrated Enterprise System (iES). The proposed solutions to these two problems started from the definition of an iES as a ‘well-designed REA-based Accounting and Enterprise Information System with applications in an ERP-System’. In order to fulfill these requirements the contents were concretized with respect to the user, the accounting and the data view. For having a “unifying theme” throughout the argumentations the REA-semantic language and its view specific tools in form of the REA-Activity diagram, the REA-Double entry diagram and the REA-Data diagram were constructed and applied. For the REA-semantic teaching a system was presented and implemented that included next to the REA-semantic tools a running case study example and a constructive aligned, spiral curriculum methodology. The running example was not only used for educational purposes. The key numbers also served to validate the calculations in the theoretical as well as the practical Dynamics 365 for Operations parts.

The usage of the REA-semantic language covers a real gap in the current literature as well as ERP practice. It is really amazing that the very limited number of REA-semantic language concepts shown in Figure 3 is sufficient to handle the accounting and process support specific considerations within the discussed value chain business processes.

The proposed contents of the integrated Enterprise System and the REA-semantic iES-Teaching system were evaluated by a students’ feedback survey. The feedback results were satisfactory so that the contents and the teaching system can be recommended.

For the future it is planned to continue at the TU Wien with the proposed contents and concepts and it is hoped that others – e.g. universities or consulting enterprises – find interest and contribute to the future development as well. To give the students a more sustainable education additional study materials should be prepared and supplied. But the preparation of such study materials is not that easy. The current project has shown that this can only be achieved with a highly motivated, balanced and not-financially motivated team. As team leader I would like to thank all team member for their very valuable contributions and hope that the team will continue and be possibly enlarged in the future!

APPENDIX

Table 10: Running Example – Types of vouchers and abbreviations

Voucher	Abbreviation
Product receipt	PZU (Produktzugang)
Vendor invoice	ER (Eingangsrechnung)
Picking list	KL (Kommissionierliste)
Job card	EV (Einzelvorgangsliste)
Report as finished	FM (Fertigmeldung)
Costing	NK (Nachkalkulation)
Invoice	AR (Ausgangsrechnung)
Bank	BANK (Bank)

Table 11: Running Example – Transactions generated by Dynamics 365 for Operations

Line No	Business Process	Activity in Dynamics 365 for Operations	Voucher	Ledger Account	Account name	Amount in EUR
1	Procurement		PZU-000001	3390	Incoming goods without receipt	-1280
2	Procurement		PZU-000001	1100	Raw materials	480
3	Procurement		PZU-000001	1200	Parts	800
4	Procurement	Procurement of Materials (MAT)	ER-000001	3300	Liabilities	-1536
5	Procurement		ER-000001	3390	Incoming goods without receipt	1280
6	Procurement	Procurement of Materials (MAT)	ER-000001	1100	Raw materials	480
7	Procurement		ER-000001	1100	Raw materials	-480
8	Procurement	Procurement of Materials (MAT)	ER-000001	1200	Parts	800
9	Procurement		ER-000001	1200	Parts	-800
10	Procurement		ER-000001	5100	Consumption raw materials	0
11	Procurement		ER-000001	5200	Consumption parts	0
12	Procurement	Procurement of Materials (MAT)	ER-000001	2500	Input VAT	256
13	Production	Commissioning Materials (MAT)	KL-000000001	1200	Parts	-800
14	Production	Commissioning Materials (MAT)	KL-000000001	1490	Work in progress	1280
15	Production	Commissioning Materials (MAT)	KL-000000001	1100	Raw materials	-480
16	Production	Working Time Registration (PERS/TECH)	EV-000000001	6990	Discharge PERS	-400.8
17	Production	Working Time Registration (PERS/TECH)	EV-000000001	7090	Discharge TECH	-133.6
18	Production	Working Time Registration (PERS/TECH)	EV-000000001	1490	Work in progress	534.4
19	Production	Completion Confirmation (FG)	FM-000000001	1490	Work in progress	-1814.4

20	Production	Completion Confirmation (FG)	FM-00000001	1500	Finished goods	1814.4
21	Production		NK-14000	1490	Work in progress	1814.4
22	Production		NK-14000	1500	Finished goods	-1814.4
23	Production		NK-14000	4500	Inventory variation	-1814.4
24	Production		NK-14000	1500	Finished goods	1814.4
25	Production		NK-14000	6990	Discharge PERS	-400.8
26	Production		NK-14000	5910	Production cost	400.8
27	Production		NK-14000	6990	Discharge PERS	400.8
28	Production		NK-14000	7090	Discharge TECH	-133.6
29	Production		NK-14000	5910	Production cost	133.6
30	Production		NK-14000	7090	Discharge TECH	133.6
31	Production		NK-14000	1490	Work in progress	-534.4
32	Production		NK-14000	5200	Consumption parts	800
33	Production		NK-14000	1200	Parts	-800
34	Production		NK-14000	1200	Parts	800
35	Production		NK-14000	5100	Consumption raw materials	480
36	Production		NK-14000	1100	Raw materials	-480
37	Production		NK-14000	1490	Work in progress	-1280
38	Production		NK-14000	1100	Raw materials	480
39	Sales	Invoicing Sales Order	AR-000001	2000	Receivables	2592
40	Sales	Invoicing Sales Order	AR-000001	3500	VAT	-432
41	Sales	Invoicing Sales Order	AR-000001	4000	Revenue	-2160
42	Sales	Invoicing Sales Order (FG)	AR-000001	4500	Inventory variation	1814.4
43	Sales	Invoicing Sales Order (FG)	AR-000001	1500	Finished goods	-1814.4
44	Bank	Payment of Sales Order	BANK-000000001	2800	Bank	2592
45	Bank	Payment of Sales Order	BANK-000000001	2000	Receivables	-2592
46	Bank		BANK-000000002	2800	Bank	-1536
47	Bank		BANK-000000002	3300	Liabilities	1536

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