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# WORKING PAPER

# User Comprehension of Accounting Information Structures:

# An Empirical Test of the REA Model

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# User Comprehension of Accounting Information Structures: An Empirical Test of the REA Model

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**Abstract.** This paper presents a laboratory experiment that evaluates the REA approach for modelling enterprise-wide accounting information systems. REA is a pattern-driven conceptual modelling approach that is based on the Resource-Event-Agent semantic model of a company's accountability infrastructure. Using a between-subjects experiment with business students we investigated whether Entity-Relationship (ER) diagrams that show a REA pattern occurrence are better understood than informationally equivalent ER diagrams that do not show a REA pattern occurrence. The results of our experiment indicate that students develop a more accurate understanding of the business processes and policies modelled when they recognize the REA structure of accounting information in ER diagrams. Students also perceive such diagrams to be easier to use when performing model comprehension and validation tasks. The experiment further showed that the number of information systems courses taken by students has a significant effect on task performance. The number of accounting courses completed before the experiment did not affect the understanding of business process models. The paper concludes by discussing some implications for Accounting Information Systems (AIS) education.

**Keywords.** REA accounting model, enterprise information architecture, model evaluation, experimentation, AIS education

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# 1. Introduction

Accounting Information Systems (AIS) education concerns teaching business students how to model, design, use, control, and audit accounting systems using information technologies. Throughout the years the concept of accounting information system has evolved from the traditional accounting software package (used primarily for bookkeeping and financial reporting) to the contemporary enterprise information system supporting organization-wide transaction processing and managerial information provision. This change in views is not unrelated to the proliferation of Enterprise Resource Planning (ERP) systems, which are a major way of implementing the company's accounting information system (Vaassens, 2002).

AIS education has responded to the trend by including topics related to ERP implementation, use, and audit. The successful adoption of an ERP solution by a company depends, amongst others, on the understanding of the company's value chain of business processes and its associated information needs for managerial decision making and management control. AIS courses should therefore contain subjects such as the conceptual modelling of business processes and the integration of these models into an enterprise information architecture (Jones and Lancaster, 2001). To teach these subjects, AIS teachers have relied on common conceptual modelling grammars, methods, and notations such as the Entity-Relationship (ER) model, flowcharting, and the Unified Modelling Language (UML).

The use of these conceptual modelling techniques and formalisms has, however, not always led to the desired result, as they are domain-neutral and do not offer specific guidance for modelling and designing accounting information systems. Furthermore, this approach does not really allow distinguishing the AIS course from the Management Information Systems (MIS) course. Combining an accounting mindset with common MIS technology is a repeated mistake by AIS teachers because a unifying and central theme is missing (McCarthy, 2003). Such a theme may come along in the form of the Resource-Event-Agent (REA) model (McCarthy, 1982). The REA model provides a framework for the semantic modelling of accounting phenomena and for the design of an accounting system based on this conceptual model.

## 1.1. The REA Model

The conceptual core of the REA model is shown in Figure 1. It is a reusable pattern of relationships between three kinds of objects that can be identified in any economic exchange or conversion process: economic resources, economic events, and economic agents. Figure 2 shows, for instance, how the basic REA pattern is applied for modelling the acquisition process in a retail company. Each economic resource (e.g. inventory, cash) is linked by a stock-flow relationship with an economic event (e.g. purchase, cash disbursement) that causes its inflow or outflow. The pattern further shows that each event that results in a resource inflow (e.g. a purchase) must be paired by an event that results in a resource outflow (e.g. a cash disbursement), and vice versa. The dual nature of the economic events involved in a business process is represented as a duality relationship between these events. Participation relationships associate economic events with their participating economic agents, which can be inside parties (e.g. purchase agent, cashier) or outside parties (e.g. vendor) to the economic exchange or conversion.

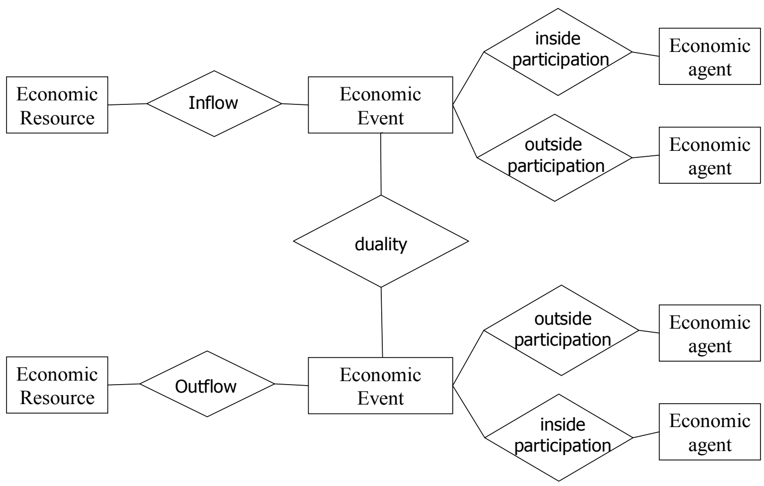


**Figure 1.** The basic REA pattern (based on McCarthy (2003))

The basic REA pattern shown in Figure 1 is derived from McCarthy's original REA model (McCarthy, 1982). Over the years, many 'design science' efforts have resulted in extensions to the basic REA model (David et al., 2002). These include the modelling of accounting phenomena at different levels of abstraction (value chain, process, and task) (Geerts and McCarthy, 1997) and additional ontological primitives and axioms (commitment events, type images) (Geerts and McCarthy, 2002). These extensions have created a comprehensive modelling framework that was specifically developed to design the enterprise information architecture of a company's accountability and policy infrastructure.

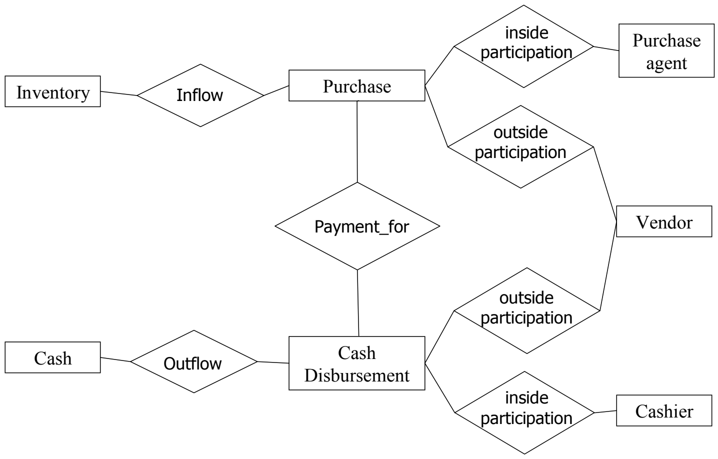


**Figure 2.** The acquisition process in a retail company

What sets REA modelling apart from other conceptual modelling techniques and formalisms, is its normative character. Unlike its underlying modelling formalisms, which are purely descriptive in nature, this pattern-driven modelling approach prescribes exactly how to model an enterprise information system. According to Dunn and McCarthy (1997, p. 40) the REA framework is “a semantic theory of how an information system that tracks economic phenomena should be structured in a shared use environment without regard for ever changing technology platforms.”

## 1.2. Evaluating the REA Model

In several AIS research reviews, the REA model is praised as being the most significant and influential proposal for the semantic modelling of accounting information systems (Daigle and Arnold, 2000; Poston and Grabski, 2000; Samuels and Steinbart, 2002). The treatment of REA modelling as the foundation for designing accounting information systems in textbooks such as Hollander et al. (2000) and Romney and Steinbart (2003), has helped its diffusion in AIS education (McCarthy, 1999). The REA model has even found its way into some elementary accounting and database courses (McCarthy, 2003).

Until recently the adoption in practice has been limited, mainly by technological constraints of storing and processing massive amounts of accounting and operational data at the transaction level (McCarthy, 1999). Nowadays the REA framework has been integrated with newer information technologies. The REA framework has, for instance, been applied in the UN/CEFACT Modelling Methodology (UMM) for business process modelling (Bergholtz et al., 2003). UMM is used in the context of ebXML, which is an XML-based transaction standard for e-commerce. REA modelling has also been integrated in the OMG's Model-Driven Architecture (MDA), allowing the creation of efficient and flexible accounting system generators (Ellegaard Borch et al., 2003). Furthermore, the use of REA modelling has been accelerated by the advent of ERP systems, with which the REA framework shares the process-oriented foundation of integrated enterprise value chains (McCarthy, 2003). According to O'Leary (2004), the REA model can be used to establish a theoretical basis for SAP and other ERP models. Moreover, the commercial importance of ERP systems provides a clear incentive for the study of the REA framework in AIS education (O'Leary, 2004).

Despite these observations, only few research studies have examined the quality of the REA framework as a conceptual modelling approach. Although the REA model is the only accounting model that imposes a normative accounting information structure, Dunn and McCarthy (1997) admit that the benefits of REA pattern-driven modelling are only hypothesized. They further remark that the study of individual users' behavior as a means to validate accounting models is scarce in AIS research.

Recently, some empirical tests of the claimed benefits of the REA model have been conducted. Dunn and Grabski (2001) showed that the structuring orientation of the REA model resulted in better user performance in information retrieval tasks, as compared to a system based on the traditional Debit-Credit-Account (DCA) accounting model. In another study, Dunn and Grabski (2000) demonstrated experimentally that users perceive an accounting system based on the REA model as more semantically expressive than a DCA-based system. They also showed that higher perceived semantic expressiveness is associated with higher task accuracy in information retrieval. It should be noted that the participants in Dunn and Grabski's experiments were not only given conceptual models (ER diagrams for REA and chart of accounts for DCA), but also proxy accounting system implementations (a relational logical database model for REA and sample journals and ledger accounts for DCA). Also, to answer some of the information retrieval questions in the experiment of Dunn and Grabski (2000), the use of source documents (e.g. sales invoices, purchase orders) turned out to be necessary (Summers, 2000). Hence, the REA and DCA accounting models were not compared at the conceptual modelling level.

A number of other experimental studies on the REA model were conducted at the conceptual modelling level, but are intragrammar (Wand and Weber, 2002) as they concern underlying modelling formalisms and not the basic REA pattern. Dunn and Gerard (2001), for instance, observed greater efficiency in information retrieval tasks when REA modelling employs a diagrammatic representation (ER diagram) instead of a linguistic representation (Backus-Naur form). Dunn et al. (2003) further showed that the accuracy of cardinality error identification increases when users are presented a set of binary ER diagrams (i.e. showing only a single relationship between two entities) instead of one comprehensive ER diagram.

To the best of our knowledge, only two empirical studies have evaluated the quality of the REA framework as a conceptual modelling approach for accounting systems. Akoka and Commyn-Wattiau (2004) compared the REA model against DREAM, an object-oriented model for developing multidimensional accounting information systems. They showed that the semantic expressiveness of the DREAM model is higher, whereas the REA model is less complex. They did, however, not investigate the impact of these differences on the performance of model users or builders. Poels et al. (2004) presented a controlled experiment that compared the participants' comprehension of an ER diagram showing an occurrence of the basic REA pattern and an informationally equivalent ER diagram hiding this pattern. The results of this experiment indicate that the correctness of answering comprehension questions about the business process modelled is higher if a diagram that instantiates the basic REA pattern is used.

In the light of this lack of empirical evidence, we respond to the call for more 'natural science' type of research to theorize and justify the claimed benefits of REA modelling (Dunn and McCarthy, 1997; McCarthy, 1999; David et al., 1999). This paper reports upon a laboratory experiment that aimed at evaluating the value of the REA framework as a conceptual modelling approach for accounting information systems. We approached our study from the perspective of AIS education and looked for demonstrable benefits of teaching business students the domain-specific and prescriptive REA approach to modelling enterprise information systems as compared to the use of domain-neutral and purely descriptive conceptual modelling techniques and formalisms.

The next section of this paper elaborates our research question further. This is followed by a description of the research method and the results of the statistical tests. Finally, we discuss some implications of our findings and outline directions for further research.

## 2. Research Question

The experimental evaluation of conceptual modelling techniques (i.e. methods, tools, …) and formalisms (i.e. grammars, notations, …) can be approached from different angles, each having its own requirements for proper study. The evaluation space is defined by dimensions such as (i) intergrammer versus intragrammar versus multigrammar studies; (ii) model creation versus model interpretation tasks; (iii) efficiency versus effectiveness measures; and (iv) novice modellers/users versus modelling/domain experts (Kim and March, 1995; Siau et al., 1997; Wand and Weber, 2002; Gemino and Wand, 2003; Parsons and Cole, 2003). A basic assumption underlying the evaluation is that the conceptual modelling technique or formalism is evaluated according to the purpose it serves (Parsons and Cole, 2003).

Given our focus on AIS education, we evaluate REA modelling from the point of view of the business student that, as a future accounting professional, learns to understand conceptual models of a company's accountability infrastructure. We reckon that most of the students that take an AIS course will find themselves later in the role of accounting information system user or auditor rather than information systems analyst or developer. As a user, the accounting professional must be able to express his accounting information requirements to the analyst and validate the models that are the formal representation of the requirements elicitation. The ability to understand conceptual models of enterprise information systems is especially relevant for students that seek auditor positions. As part of the assurance services they provide, auditors are expected to evaluate information systems and hence must understand the system's documentation (Dunn and Gerard, 2001). Hence, for our purposes, performance on model interpretation tasks seems to be the more appropriate evaluation criterion.

Second, after choosing type of subjects and tasks, we must clearly distinguish what is being compared. In a cognitive evaluation approach it is better to evaluate conceptual modelling techniques in relation to other techniques, as there are no absolute evaluation scales (Gemino and Wand, 2003). Here we wish to assess the value of the pattern-driven REA modelling approach for AIS education. To decide against which to compare this approach we opt for the same solution as in Poels et al. (2004), where the prescriptive REA approach was compared against the descriptive Entity-Relationship (ER) approach (Chen, 1976). Although the use of the REA model for the semantic modelling of accounting systems is not tied to a particular modelling formalism (Dunn and McCarthy, 1997), the ER model is the preferred and most often used format for the REA model (Dunn and Gerard, 2001; Dunn and Grabski, 2001). Conceptual models of accounting information systems developed using the REA approach are therefore often presented as ER diagrams (as in Figures 1 and 2). Given the AIS teacher confronted with the basic choice of using a general-purpose modelling formalism such as the ER model or using a AIS-specific formalism such as the REA model (on top of the ER model), we formulate our research question as:

*Are ER diagrams of accounting information systems better understood by business students if the REA approach is used to develop these diagrams?*

## 3. Research Method

### 3.1. Hypothesis Development and Research Model

Although our study is largely exploratory, there is reason to believe that the REA approach to accounting systems modelling is beneficial to students' understanding of models. What distinguishes REA from other (semantic) modelling approaches is its structuring orientation (Dunn and McCarthy, 1997). The REA pattern is an easily recognizable fixed structure. Regardless of the type of company and business process modelled, students familiar to the basic REA pattern may expect what information to find in which place of the diagram. Knowledge of the normative structure imposed by the REA framework may also facilitate navigating through the diagram as well as interpreting the presented information. The specific semantics attached to the REA constructs (e.g. the economic duality expressed by a relationship between a pair of 'give-and-take' economic events) might even result in a more accurate understanding (i.e. interpreting the modelled reality as it was intended by the modeller).

The structuredness of ER diagrams developed using the REA approach is further enhanced by the implicit presence of an indexing mechanism in the basic REA pattern (Dunn and Gerard, 2001). This indexing mechanism is formed by a diagram layout where the entities representing economic resources, economic events, and economic agents are placed in respectively a left, middle, and right column of the diagram. Additionally, the top-down ordering of the entities that represent events (including commitment events) may reflect temporal relationships between event occurrences.

It should be noted that this particular placement of entities on an ER diagram is a diagrammatic convention, not a mandatory rule of REA modelling. However, AIS textbooks like Hollander et al. (2000) and Romney and Steinbart (2003) recommend these placement conventions. They were also used in the AIS course from which the experiment participants were drawn. We therefore consider these readability guidelines as an integral part of the practice of REA modelling.

Previous (theoretical) studies on conceptual modelling offer some support for structuredness as a quality-carrying property. Lindland et al. (1994) mention structure as a model property leading to a better understanding. Kesh (1995) postulates a causal relationship between suitability of structure, i.e. how well the structure of the diagram reflects the structure of the problem domain, and usability. The Guidelines of Modelling (GoM) of Schütte and Rotthowe (1998) consider layout design as an element supporting the lucidity, and hence comprehensibility of a schema. Finally, Wand and Weber (2002) state that the physical rearrangement of the entities and relationships on an ER diagram affects user comprehension.

These findings allow us to operationalize the research question into a number of testable hypotheses. Given that the use of the REA approach results in ER diagrams (hereafter called *REA diagrams*) with a fixed structure that is easily recognizable and readable by students familiar to the basic REA pattern, we hypothesize that such diagrams are 'better' understood than informationally equivalent ER diagrams that were not obtained using the REA approach (hereafter called *non-REA diagrams*). Information equivalence of diagrams means that the information contained in one diagram is inferable from the other and vice versa (Gemino and Wand, 2003).

In experimental comparisons of conceptual modelling techniques, 'better' model understanding can mean two things: the understanding is more efficient (i.e. requiring less effort) or it is more effective (i.e. more accurate). Recognizing the pattern occurrence in a REA diagram may speed up model understanding. The structure present in a REA diagram may also create a more correct perception in the mind of the model user (Gemino and Wand, 2003). Using task completion time (i.e. time taken to complete a comprehension task) and task accuracy (i.e. number of correctly answered comprehension questions) as measures of respectively efficiency and effectiveness (Bodart et al., 2001; Shoval et al., 2002; Parsons, 2003), the following operational hypotheses are formulated:

> *$H_1$: For a same comprehension task, the task completion time with a REA diagram is less than with an informationally equivalent non-REA diagram.*

> *$H_2$: For a same comprehension task, the task accuracy with a REA diagram is higher than with an informationally equivalent non-REA diagram.*

As far as we know, the only study testing these two hypotheses is that of Poels et al. (2004). But apart from performance-based measures of model comprehension, previous empirical REA-related research has also employed perception-based variables such as perceived ease of use and user satisfaction (Dunn and Gerard, 2001; Dunn and Grabski, 2001). If it takes less time to retrieve the required information to answer the comprehension questions when using the REA diagram, then students would likely perceive the REA diagram as easier to use. Given that the same comprehension task is used on informationally equivalent REA and non-REA diagrams, a higher perception of ease of use with REA diagrams would be another indication of efficient model understanding. Furthermore, a higher perceived ease of use would leave the student more satisfied about the diagram used. User satisfaction is, however, also determined by perceptions of usefulness. So if the REA diagram better supports the information needs of students performing the comprehension task (e.g. allowing an unambiguous interpretation of business rules modelled), then user satisfaction would likely be higher than with the non-REA diagram. Again, given the same comprehension task and information equivalence, a higher user satisfaction when using the REA diagram would be another indication of 'better' model understanding.

*$H_3$: For a same comprehension task, perceived ease of use is higher with a REA diagram than with an informationally equivalent non-REA diagram.*

*$H_4$: For a same comprehension task, user satisfaction is higher with a REA diagram than with an informationally equivalent non-REA diagram.*

As in Dunn and Grabski (2001) and Dunn and Gerard (2001), perceived ease of use (PEOU) is measured using five 7-point Likert scale questions adapted from Davis (1989). The reliability of the PEOU instrument in our study (Cronbach's alpha 0.86) compares well to previous studies (0.84 in Dunn and Grabski (2001), 0.90 in Dunn and Gerard (2001), 0.89 in Burton-Jones and Weber (1999), who used a slightly different variant of Davis' instrument (perceived ease-of-understanding) in the context of ER diagram comprehension). Our PEOU instrument is:

1. I found the conceptual schema cumbersome (confusing) to use.
2. Using the conceptual schema required a lot of mental effort.
3. The conceptual schema was clear and understandable to me.
4. Using the conceptual schema was frustrating.
5. Overall, I found the conceptual schema easy to use.

The measurement instrument for user satisfaction (US) was adapted from Seddon and Yip (1992), as in Dunn and Grabski (2001) and Dunn and Gerard (2001) who reported Cronbach alphas of 0.92 and 0.94. The reliability obtained in our study was lower (0.81), but still above the value of 0.70 which is usually required for measurement instruments to be deemed reliable (Nunally, 1978). Our US measure is composed of the following items:

1. How adequately do you believe the conceptual schema meets the information needs that you were asked to support?
2. How efficient is the conceptual schema for providing the information you needed?
3. How effective is the conceptual schema for providing the information you needed?
4. Overall how satisfied are you with the conceptual schema for providing the information you needed?

The research model for this experiment is summarized in Figure 3. The independent variable is the modelling approach taken to develop the diagrams. Its treatments are 'using the REA approach' and 'not using the REA approach'. Depending on the treatment, the diagram will have another structure, either showing a REA pattern occurrence (a *REA diagram*) or not (a *non-REA diagram*). According to the hypotheses, structure impacts model understanding. The dependent variables are performance-based and perception-based dimensions of model understanding: efficiency of model comprehension, effectiveness of model comprehension, perceived ease of use, and user satisfaction. They are measured respectively by comprehension task completion time, task accuracy, PEOU and US.

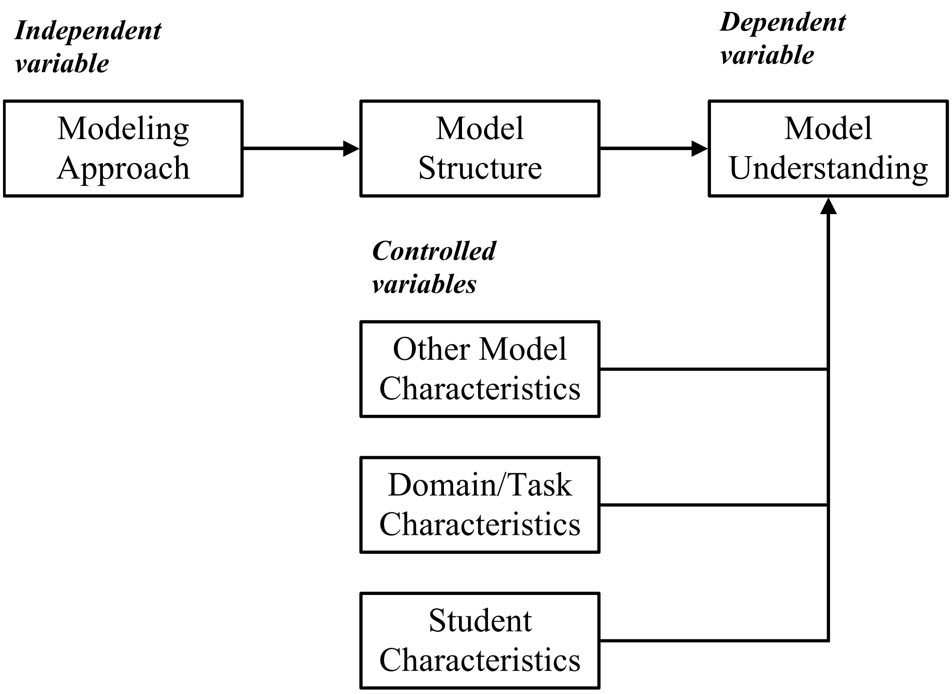


**Figure 3.** Research model

The research model also shows a number of other variables that might impact model comprehension and thus confound the main effect of modelling approach. These variables will be controlled in the experiment. They include student characteristics (e.g. modelling knowledge, accounting knowledge, information systems knowledge, working experience, age, gender, nationality), domain characteristics (e.g. domain complexity, domain familiarity), task characteristics (e.g. task difficulty, nature of the task), and other model characteristics (e.g. size and complexity of the diagram, diagram aesthetics).

### 3.2. Participants

The participants were 42 graduate business students enrolled in an AIS course. During the course, students were trained in the use of the REA accounting model. First they were taught the constructs and grammatical rules of the ER model. They were introduced to the UML notation for ER diagrams and learned to read ER diagrams of various domains (e.g. university personnel management, hospital operations), that were used as business models (showing business rules) and data models (showing conceptual data structures). Then they studied the principles of REA modelling. Students learned to instantiate the basic REA pattern and use commitment and type images.

After becoming familiar with the REA framework, the focus of the course was directed towards the understanding of the company's value chain. For this part of the course, ER diagrams of various kinds of transaction-oriented business processes were analyzed by solving comprehension questions similar to the ones used in the experiment afterwards. These questions were chosen to mimic real-life situations where accountants, auditors, and (future) accounting information system users are confronted with tasks requiring a thorough understanding of the models. It must be stressed that not all of the studied diagrams fully adhered to the basic REA pattern (extended with commitment and type images). Especially those diagrams representing economic conversion processes (e.g. production) departed from some of the REA axioms.

At the beginning of the course the students completed a questionnaire to assess their background (Table 1). There were considerable differences in prior educational accounting and MIS exposure (with an average of six accounting and two MIS courses completed). Most students had no working experience (74%) and were completely unfamiliar with the ER model (62%) and the REA framework (93%). Two-thirds of the students were female and age ranged between 21 and 27 years, with most of the students falling in the 21-23 range (76%). Because of the international character of the course, students came from seven countries.

**Table 1.** Demographic data participants

| | Mean | Median | Std. Deviation | Minimum | Maximum |
|---|---|---|---|---|---|
| Age | 22.93 | 22 | 1.455 | 21 | 27 |
| Years of working experience | 0.4226 | 0 | 0.9081 | 0 | 4 |
| MIS courses completed | 2.67 | 2 | 2.032 | 0 | 6 |
| Accounting courses completed | 6.4 | 6 | 3.021 | 1 | 15 |
| Familiarity ER modelling[1] | 1.69 | 1 | 1.024 | 1 | 4 |
| Familiarity REA modelling[1] | 1.095 | 1 | 0.3702 | 1 | 3 |

*([1] measured by a student's self-assessment of familiarity on a 7-point Likert scale ranging from no familiarity (1) to absolute familiarity (7))*

### 3.3. Experimental Design

To test the hypotheses, a between-subjects experimental design was chosen (Table 2). The students in Group A and B were given a same comprehension task which they needed to perform under the same circumstances. The Group A participants were required to solve the comprehension questions using a non-REA diagram, whereas the students in Group B could use a REA diagram. In each group were 21 students.

**Table 2.** Experimental design

| **Treatment** | *non-REA diagram* | *REA diagram* |
|---|---|---|
| **Group** | Group A | Group B |

Given the individual differences between the students and the relatively small sample size, a random allocation of the students to the two experimental groups could have introduced considerable error variance. Therefore, to control for differences in student characteristics case-by-case matching was applied. The use of this technique involves identifying extraneous variables that possibly confound the experimental results, measuring the students on these variables, and then pairing the students that are most similar to each other with respect to the amount or type of the variables measured. The pairing of students was based on the data collected by the questionnaire distributed at the beginning of the course. Next, we randomly picked one student out of each pair to compose a first experimental group. The remaining students form the other group.

This matched pairs random allocation schema eliminates to the best extent possible any differential influence of variables like gender, age, years of working experience, familiarity with ER and REA modelling, and the number of accounting and information system courses completed. Prior experimental research on the REA framework and other conceptual modelling techniques and formalisms has shown that some of these variables have an impact on task performance (e.g. accounting knowledge in Dunn and Grabski (2000), experience and gender in Dunn and Grabski (2001), data modelling experience in Parsons (2003), familiarity with modelling formalisms in Kim and March (1995)).

### 3.4. Instrumentation

The non-REA diagram and the REA diagram used by respectively Group A and B, are shown in Appendix A. Both diagrams are representations of the same business process (i.e. a consulting services acquisition process), allowing us to control the possible confounding effects of domain complexity and familiarity. The effect of domain familiarity on model understanding has, for instance, been demonstrated by Burton-Jones and Weber (1999) in a study where the impact of ontological clarity in ER diagrams on user comprehension was less pronounced when diagrams of a familiar domain were used. Therefore the importance of using a model of a same domain in both treatments.

The consulting services acquisition process shares characteristics with both the materials acquisition and human resources transaction cycles studied in the course. The experiment participants had, however, not looked at this particular business process during the course. The diagrams used in the experiment were new to them. As they were the only information source the students could use to answer the comprehension questions, they were 'forced' to understand the diagrams.

Another requirement for the experimental objects is that they are informationally equivalent. Otherwise, differences in information content may confound attempts to measure the impact of the independent variable on the dependent variable (Parsons and Cole, 2003).

To ensure the information equivalence of the REA diagram and the non-REA diagram, a same approach as in Poels et al. (2004) was taken, where the non-REA diagram was derived from the REA diagram by means of two information-preserving transformations:

- Reification of many-to-many relationships between entities. A many-to-many relationship between entities A and B can be replaced by a new entity C, a one-to-many relationship between A and C, and a one-to-many relationship between B and C.
- The physical repositioning of the entities and relationships on the diagram.

The first transformation was applied to the *PaysFor* economic duality relationship between the *Get Consulting Services* and *Pay Consulting Services* entities, thereby replacing this relationship and its association class by a new entity *Consulting Services Paid*. It was also applied to the *Orders* relationship between the *Order Consulting Services* and *Consulting Services Type* entities, in so doing replacing it by the *Ordered Consulting Services* entity. The UML class definitions of these new entities on the non-REA diagram contained the attributes that were found in the replaced association classes of the REA diagram. They also showed the new entity's primary key as a composition of the primary keys of the originally related entities.

It was decided not to reify other relationships of the REA diagram, although in principle reification of one-to-many relationships is allowed. We felt that reifying the stock-flow, participation, and other relationships of the basic REA pattern and its ontological extensions would result in a non-REA diagram that is of considerably different complexity (i.e. more relationships as the first transformation replaces one relationship in the REA diagram by two others in the non-REA diagram). Previous empirical research by Genero et al. (2002) has shown that the size and complexity of ER diagrams (basically in terms of number of entities and number of relationships) negatively affects their understandability. So in order to control the confounding effect of differential diagram complexity, reification was only applied to the economic duality relationship (which is according to Dunn and McCarthy (1997) an essential structuring idea of the basic REA pattern) and to the commitment image contained in the REA diagram (which is an ontological extension of the basic REA pattern (Geerts and McCarthy, 2002)).

When applying the second transformation we strived for a layout design of the non-REA diagram that is not aesthetically inferior to that of the REA diagram. In the experiment of Poels et al. (2004), the non-REA diagrams 'looked worse' than the REA diagrams since diagram elements were not placed in a logical way. In the non-REA diagram that we used, the sequence of event occurrences is still observable, though it is now mainly organized in a left-to-right fashion (instead of the usual top-down ordering of the basic REA pattern). Moreover, related entities are placed close to each other on the non-REA diagram (though no longer in the usual three-column arrangement of the basic REA pattern). Neither did we clutter the diagram layout by crossing lines to purposely diminish its aesthetic value.

We are aware that the modifications applied seem minor and that the non-REA diagram still showed some REA characteristics (e.g. every economic event is related to an economic resource and to both an internal and external economic agent). The transformations applied were, however, constrained by the requirement of information equivalence. We therefore believe that starting from the REA diagram to obtain the non-REA diagram was the only feasible alternative, as independently developing both diagrams (one using the REA approach, the other without) would probably not result in provable informationally equivalent diagrams. Moreover, the idea of the transformations was to hide the REA pattern occurrence (and to some extent also the commitment and type images) in the non-REA diagram. The transformations aimed at creating a diagram in which the normative REA accounting information structure was no longer easily and quickly recognizable to the model user. An informal meeting with some of the students of Group A (the non-REA treatment) after the experiment, confirmed that they were not aware being given a transformed REA diagram.

### 3.5. Experimental Task

The experimental task required answering 16 comprehension questions (included in Appendix B) about the process as modeled in the diagrams. The information equivalence of the diagrams ensured that exactly the same questions could be used for both treatments. This way we control for task characteristics such as task difficulty, which has been identified by Dunn and Gerard (2001) as another possibly confounding effect on task performance when studying conceptual modelling representations.

The first eight questions were of the information retrieval – inference kind, meaning that to answer the questions, interaction between model comprehension and previously acquired knowledge is required (Dunn and Gerard, 2001). This can be knowledge about how the ER formalism represents certain facts about reality, such as business rules (an example of a question used was "*Can the company make partial payments for consulting services that are registered on a same time card?"*) or accounting knowledge (e.g. "*Does the conceptual schema allow calculating at any time the balance of the accounts payable to consulting firms?*"). These questions were chosen to be representative of problems that auditors have to deal with, like understanding a company's accounting policies, assuring information relevance and reliability, and identifying system-related risks.

The other eight questions required checking the conformity of the diagrams with respect to scenarios describing specific business policies. They are typical for the validation type of tasks that confront future system users (as part of their interaction with analysts during systems development) as well as system auditors (when the diagrams are part of the system's documentation (Dunn and Gerard, 2001)). Example questions of this category are "*Can the conceptual schema be used by a company that wants to issue a single payment check to pay for consulting services related to more than one order?*" and "*Can the conceptual schema be* *used by a company that wishes to pay for consulting services that are ordered but not yet delivered?*".

All but two questions were binary questions requiring a "YES" or "NO" answer. For the other two questions (i.e. "*What type of business process is modelled in the diagram?*" and "*List the entity types that represent economic resources (i.e. valuable assets) that are affected by the transactions modelled in the diagram.*") an unambiguous grading schema was used.

### 3.6. Operational Procedures

The experiment was organized as an individual class room exercise. Students were motivated to participate as course credits could be earned. They were stimulated to solve the tasks as accurately as possible, but were told that the time spent on the tasks was also important. There was, however, no specific time limit in order to avoid a possible ceiling effect.

Before the participants entered class, 42 addressed envelops were distributed in a controlled manner so that neighbours belonged to different treatment groups. They contained a REA diagram or a non-REA diagram, four pages with each four comprehension questions, and a post-experiment questionnaire with the PEOU and US items.

Students were instructed to answer the questions in the order as they come (which was the same for each participant). Before and after solving a series of four questions, students had to write down the correct time, which was projected on a screen in front of the class room. By separately collecting every page (with four questions) after completion, we could exercise more control over the experiment's execution and alleviate the danger of measurement errors. After finishing all four pages, participants completed the post-experiment questionnaire.

This experiment was an exercise for the students, so after correction we provided them with feedback. Afterwards students were also informed that the exercise was part of a research study and consent was obtained to include them as experimental subjects.

## 4. Data Analysis and Results

### 4.1. Descriptive Statistics and Measurement Instrument Validity

Table 3 presents descriptive statistics of the data collected in the experiment (included in Appendix C). For each dependent variable, treatment means and standard deviations are shown. As can be seen, all differences in treatment means are in the expected direction.

**Table 3.** Treatment means (standard deviations) for dependent variables

| | non-REA diagram (Group A; n = 21) | REA diagram (Group B; n = 21) |
|---|---|---|
| Task completion time *(hours:minutes:seconds)* | 0:19:12 (0:05:01) | 0:17:35 (0:04:31) |
| Task accuracy | 9.59 (2.42) | 11.30 (2.10) |
| Perceived ease of use (higher = easier) | 3.04 (0.81) | 3.81 (1.27) |
| User satisfaction (lower = more satisfied) | 3.67 (0.80) | 3.44 (1.22) |

Before testing the hypotheses, we evaluated the construct validity of the PEOU and US measurement instruments. Given the small sample size, an inter-item correlation analysis was carried out to evaluate construct validity. The results are shown in Table 4 for all items used in the questionnaire.

**Table 4.** Inter-item correlations for PEOU and US

| | PEOU | | | | | US | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Q1 | Q2 | Q3 | Q4 | Q5 | Q1 | Q2 | Q3 | Q4 | CV[1] | DV[2] | VALID?[3] |
| PEOU Q1 | 1 | 0.44 | 0.61 | 0.65 | 0.71 | 0.37 | 0.59 | 0.43 | 0.17 | 0.61 | 0.39 | YES |
| PEOU Q2 | 0.44 | 1 | 0.4 | 0.47 | 0.54 | 0.35 | 0.35 | 0.23 | 0.18 | 0.46 | 0.28 | YES |
| PEOU Q3 | 0.61 | 0.4 | 1 | 0.61 | 0.61 | 0.34 | 0.46 | 0.33 | 0.29 | 0.56 | 0.36 | YES |
| PEOU Q4 | 0.65 | 0.47 | 0.61 | 1 | 0.65 | 0.51 | 0.6 | 0.52 | 0.34 | 0.6 | 0.49 | YES |
| PEOU Q5 | 0.71 | 0.54 | 0.61 | 0.65 | 1 | 0.52 | 0.56 | 0.48 | 0.22 | 0.63 | 0.44 | YES |
| US Q1 | 0.37 | 0.35 | 0.34 | 0.51 | 0.52 | 1 | 0.64 | 0.74 | 0.29 | 0.56 | 0.42 | YES |
| US Q2 | 0.59 | 0.35 | 0.46 | 0.6 | 0.56 | 0.64 | 1 | 0.65 | 0.35 | 0.55 | 0.51 | YES |
| US Q3 | 0.43 | 0.23 | 0.33 | 0.52 | 0.48 | 0.74 | 0.65 | 1 | 0.45 | 0.61 | 0.4 | YES |
| US Q4 | 0.17 | 0.18 | 0.29 | 0.34 | 0.22 | 0.29 | 0.35 | 0.45 | 1 | 0.36 | 0.24 | YES |

*([1] Convergent validity; [2] Divergent validity; [3] YES if CV > DV)*

An item is considered valid if the convergent validity is higher than the divergent validity (Campbell and Fiske, 1959). This requirement is satisfied for all items of the PEOU and US measurement instruments. Note that the second US item has the highest correlation with the PEOU items (divergent validity of 0.51). This item is used to assess the perceived efficiency of a diagram in providing the required information, hence its high correlation with the PEOU items.

### 4.2. Hypothesis Testing

As the Kolmogorov-Smirnov test did not demonstrate deviations from the normal data distribution, parametric t-tests were used to test the hypotheses. The results of the statistical tests are summarized in Table 5.

**Table 5.** Results of the hypothesis testing

| Dependent variable | t | Significance (one-tailed) | Conclusion |
|---|---|---|---|
| Task completion time | 1.097 | 0.139 | $H_1$ not supported |
| Task accuracy | -2.448 | 0.009 | $H_2$ supported |
| Perceived ease of use | -2.329 | 0.012 | $H_3$ supported |
| User satisfaction | 0.742 | 0.231 | $H_4$ not supported |

Regarding the performance-based variables of model understanding, the results indicate that the time required to complete the comprehension task is not significantly lower with the REA diagram than with the non-REA diagram (one-tailed p value of 0.139). Hence, hypothesis $H_1$ is not supported. On the other hand, the students that used the REA diagram gave significantly better answers than those that used the non-REA diagram ($p < 0.01$). Thus, hypothesis $H_2$ stating that comprehension task accuracy is higher with the REA diagram, is supported.

As far as the perception-based variables of model understanding is concerned, hypothesis $H_3$ is supported, but hypothesis $H_4$ is not. According to students' perceptions, solving the comprehension task was easier with the REA diagram ($p < 0.05$). On the other hand, the user satisfaction in the REA group was not significantly higher than in the non-REA group (one-tailed p-value of 0.231).

### 4.3. Discussion

Our experiment confirms the conclusion of Poels et al. (2004) that ER diagrams showing an occurrence of the basic REA pattern result in more effective user comprehension. The experiment in Poels et al. (2004) can be criticized, however, for confounding the effect of REA's structuring orientation with graph aesthetics, whereas we compared diagrams of a same aesthetic quality. Moreover, Poels et al. (2004) investigated only the impact on user understanding of the basic REA pattern.[1] In our experiment, commitment and type images were included on the diagrams, resulting in a more complete representation of the business process modelled. Students that were given a REA diagram developed a more accurate understanding of the business process as modelled in the diagram. Their interpretation of the business rules and accounting information modelled was closer to what was intended, as compared to the non-REA diagram group. The students in the REA diagram group could also

[1] Other differences are the use of (i) perception-based variables of model understanding, (ii) a between-subjects experiment involving only one business process, (iii) a conceptual data model, (iv) the UML notation, and (v) a task focusing on passive model user roles, as compared to the use of (i) only performance-based variables (ii) a within-subjects experiment involving two different business processes, (iii) a business model, (iv) a non-standard ER notation, and (v) a task focusing on passive and active user roles (e.g. comprehension questions related to the subsequent transformation into a relational database design) in Poels et al. (2004).

better identify discrepancies between the diagram and textual descriptions of specific business policies.

Similar to Poels et al. (2004) no effect was found for the efficiency of user comprehension. Although the mean time to complete the comprehension task was lower in the REA diagram group, the difference was not significant. This is contrary to our expectations. We anticipated that students would need less time to retrieve the information they needed to solve the comprehension questions if they were shown a diagram structured according to the REA principles. However, we agree with Bodart et al. (2001) that in situations where both accuracy and time are used to measure task performance, participants make trade-offs. It might be that the students in the REA diagram group have consumed the comprehension time they would otherwise save, to develop a deeper understanding of the reality modelled.

As in Bodart et al. (2001) we also analyzed our data using the normalized accuracy measure, which is defined as a participant's accuracy score divided by its time score (Table 6). This analysis shows that at least some effect on efficiency of model understanding may be assumed. The difference in mean normalized accuracy score is not only highly significant (one-tailed p value of 0.006); it is even more significant than the difference in mean accuracy scores. Although the difference in comprehension task completion time was in the expected direction, the failure to demonstrate statistical significance may reflect a problem of low statistical power (Burton-Jones and Weber, 1999).

**Table 6.** Analysis of normalized accuracy scores

| | non-REA diagram (Group A; n = 21) | REA diagram (Group B; n = 21) | **t-test for equality of means** | |
|---|---|---|---|---|
| | | | **t** | **Significance (one-tailed)** |
| Normalized task accuracy mean (standard deviation) | 0.52 (0.17) | 0.68 (0.21) | -2.618 | 0.006 |

A moderate effect on the efficiency of understanding may also be assumed because of the support we found for hypothesis $H_3$. The students perceived the diagram in which the REA structure was visibly present, as easier to use. But again, contrary to our expectations, the better performance with the REA diagram and its higher perceived ease of use did not translate into a significantly higher user satisfaction. One reason may be that the students in the REA diagram group were not aware that they performed better than the students in the non-REA diagram group. A lack of results for perception-based variables has been observed before in experiments with conceptual modelling techniques and formalisms, and is attributed to the existence of ‘thresholds’ that determine when differences are noticed (Burton-Jones and Weber, 2003). Given the low accuracy scores observed in both groups (mean scores of 9.59 (non-REA) and 11.30 (REA) out of a total score of 16), it is plausible that many students experienced difficulties in understanding and validating the diagram. Hence, neither group was particularly satisfied with the diagrams, making it harder to detect any difference (if it does exist) caused by the treatments.

It remains an open question whether the difference in user satisfaction would turn out to be significant if a less complex diagram or more familiar domain or less difficult comprehension task had been used. These variables were controlled in the experiment (i.e. they were fixed at a single level).

Other possibly confounding variables related to student characteristics were also controlled, through matching and randomization. Some of these characteristics, in particular the number of accounting and MIS courses taken prior to the AIS course, showed sufficient variability to investigate their impact on model understanding. As Dunn and Grabski (2000) demonstrated, accounting knowledge has an impact on task performance with accounting information system (models). We therefore decided to include the number of accounting courses completed as a covariate in our study. Also the number of prior MIS courses was included as a covariate.

We ran five regression analyses (Table 7) in which each of the dependent variables (i.e. task completion time, task accuracy, normalized task accuracy, perceived ease of use (PEOU), user satisfaction (US)) was regressed against the independent variable (REA vs non-REA), the number of accounting courses taken (accounting knowledge), and the number of MIS courses taken (MIS knowledge). Conform the parametric t-tests, the regression equations for task accuracy, normalized task accuracy, and perceived ease of use were significant. The only effect of covariates found was on task accuracy and normalized task accuracy, where the regression coefficients for MIS knowledge were significant (respective p-values of 0.021 and 0.024).

If we approximate a business student’s accounting knowledge by the number of accounting courses completed, then no effect on ‘real’ and perceived model understanding could be demonstrated. Student’s knowledge of information systems, as acquired during MIS courses, seems to be a better predictor of how well a student can interpret a conceptual model of business reality.

**Table 7.** Regression Analyses

| Task completion time = a + b REA vs non-REA + c accounting knowledge + d MIS knowledge + error | | | | | |
|---|---|---|---|---|---|
| Adjusted $R^2$: | 0.030 | F-statistic: | 1.415 | p-value: | 0.254 |
| | Unst. Coeff. | Std Error | Std Coeff | t | Significance |
| Constant | 21.444 | 1.842 | | 11.643 | 0.000 |
| REA vs non-REA[1] | -0.817 | 1.476 | -0.088 | -0.554 | 0.583 |
| Accounting knowledge[2] | -0.245 | 0.256 | -0.158 | -0.957 | 0.345 |
| MIS knowledge[3] | -0.462 | 0.384 | -0.200 | -1.203 | 0.237 |

| Task accuracy = a + b REA vs non-REA + c accounting knowledge + d MIS knowledge + error | | | | | |
|---|---|---|---|---|---|
| Adjusted $R^2$: | 0.282 | F-statistic: | 6.233 | p-value: | 0.002 |
| | Unst. Coeff. | Std Error | Std Coeff | t | Significance |
| Constant | 7.617 | 0.817 | | 9.327 | 0.000 |
| REA vs non-REA[1] | 1.396 | 0.654 | 0.291 | 2.133 | 0.040 |
| Accounting knowledge[2] | 0.160 | 0.114 | 0.200 | 1.406 | 0.168 |
| MIS knowledge[3] | 0.409 | 0.170 | 0.344 | 2.406 | 0.021 |

| Normalized task accuracy = a + b REA vs non-REA + c accounting knowledge+ d MIS knowledge + error | | | | | |
|---|---|---|---|---|---|
| Adjusted $R^2$: | 0.272 | F-statistic: | 5.978 | p-value: | 0.002 |
| | Unst. Coeff. | Std Error | Std Coeff | t | Significance |
| Constant | 0.375 | 0.070 | | 5.327 | 0.000 |
| REA vs non-REA[1] | 0.119 | 0.056 | 0.290 | 2.117 | 0.041 |
| Accounting knowledge[2] | 0.013 | 0.010 | 0.192 | 1.341 | 0.188 |
| MIS knowledge[3] | 0.035 | 0.015 | 0.341 | 2.362 | 0.024 |

| PEOU = a + b REA vs non-REA + c accounting knowledge+ d MIS knowledge + error | | | | | |
|---|---|---|---|---|---|
| Adjusted $R^2$: | 0.195 | F-statistic: | 2.978 | p-value: | 0.044 |
| | Unst. Coeff. | Std Error | Std Coeff | t | Significance |
| Constant | 3.320 | 0.420 | | 7.899 | 0.000 |
| REA vs non-REA[1] | 0.821 | 0.337 | 0.365 | 2.437 | 0.020 |
| Accounting knowledge[2] | -0.091 | 0.058 | -0.243 | -1.550 | 0.130 |
| MIS knowledge[3] | 0.099 | 0.088 | 0.179 | 1.133 | 0.264 |

| US = a + b REA vs non-REA + c accounting knowledge+ d MIS knowledge + error | | | | | |
|---|---|---|---|---|---|
| Adjusted $R^2$: | -0.034 | F-statistic: | 0.556 | p-value: | 0.648 |
| | Unst. Coeff. | Std Error | Std Coeff | t | Significance |
| Constant | 3.698 | 0.406 | | 9.118 | 0.000 |
| REA vs non-REA[1] | -.325 | 0.325 | -0.163 | -0.999 | 0.324 |
| Accounting knowledge[2] | 0.033 | 0.056 | 0.101 | 0.589 | 0.560 |
| MIS knowledge[3] | -0.054 | 0.084 | -0.109 | -0.637 | 0.528 |

*([1] REA vs non-REA = 1 for REA treatment group, = 0 for non-REA treatment group;*
*[2] Accounting knowledge = number of accounting courses taken before experiment;*
*[3] MIS knowledge = number of MIS courses taken before experiment)*

## 5. Implications and Future Research

The main conclusion that can be drawn from the experiment is that the use of the REA accounting information structure in conceptual models of transaction-oriented business processes leads to better model understanding by business students. We showed that students developed a more accurate understanding of the accountability infrastructure modelled. They can, for instance, produce a more correct interpretation of the business policies that govern a process. They can also better check a model against reality. Model comprehension and discrepancy checking are the two aspects of model validation (Kim and March, 1995). The correct 'reading' of transaction cycle models is not only important to verify whether a required system will adequately support accounting information needs. A thorough understanding of the components that make up a company's integrated value chain is also crucial when a company considers adopting an ERP solution to satisfy its transaction processing and information needs. Activities like business process reengineering and ERP module evaluation and implementation require adequate conceptual modelling support. Our experiment strengthens the thesis of other researchers (e.g. McCarthy (2003), O'Leary (2004)) that the REA framework may offer such support.

We are aware that the results of our experiment cannot be generalized outside its specific educational setting. The students were trained in using the REA framework. So we cannot make inferences upon how model users in industry unfamiliar with the basic REA pattern and its ontological extensions, would perform with models that clearly show the REA accounting information structure. Neither can we conclude that students without proper training would develop a better model understanding when given a model developed using the REA approach. Our study does show, however, that the use of this approach in AIS education leads to demonstrable benefits in terms of improved understanding of models that are used to represent transaction-oriented business processes.

Another result of our study is that a student's model understanding is not affected by the number of accounting courses previously completed. It seems that accounting education other than AIS does not specifically deal with the type of tasks used in the experiment. On the other hand, the number of MIS courses taken does matter. Although in our sample, there were no students that claimed to be familiar with ER modelling (even not amongst those that had five or six MIS courses before), it is possible that MIS courses promote ways of thinking (e.g. abstraction) that enhance model understanding. Given that students have acquired sufficient background MIS knowledge (also with respect to conceptual modelling techniques and formalisms), the AIS course can focus on domain-specific approaches (in particular REA) to develop a deep understanding of business processes and their associated information needs and how these should be supported by the enterprise information system.

The question arises what would have happened if the experiment was carried out before the students received REA teaching. Our experimental hypotheses were strongly based on the assumption of a phenomenon that can be described as 'pattern recognition'. But does the use of REA modelling lead to better model understanding if such a fixed pattern, both semantically (due to ontological definitions of the pattern elements) and visually (due to a conventional relative positioning of the pattern elements), is not present in model users' memory? We believe this is a relevant research question that, if answered positively, could increase the external validity of our current study, and more importantly, further validate the REA framework. To investigate this question, we need not only conduct more experiments, but also base the experimental hypotheses on theoretical foundations (e.g. using theories of cognition like in Dunn and Grabski (2000; 2001), Dunn and Gerard (2001), and Dunn et al. (2003)). Apart from demonstrating the benefits of the REA approach, such type of research would also seek to explain the observed benefits.

As future research we also plan to evaluate the REA approach using model construction and integration tasks. Such research would investigate REA's claim of semantic expressiveness (McCarthy and Dunn, 1997) and test whether it leads to more faithful representations of business reality than not using (or using other) pattern-driven modelling approaches. Experimental comparisons that employ model creation tasks would also eliminate the requirement of information equivalence, which we experienced as a constraint when designing this study.

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# Appendix A: Experimental objects

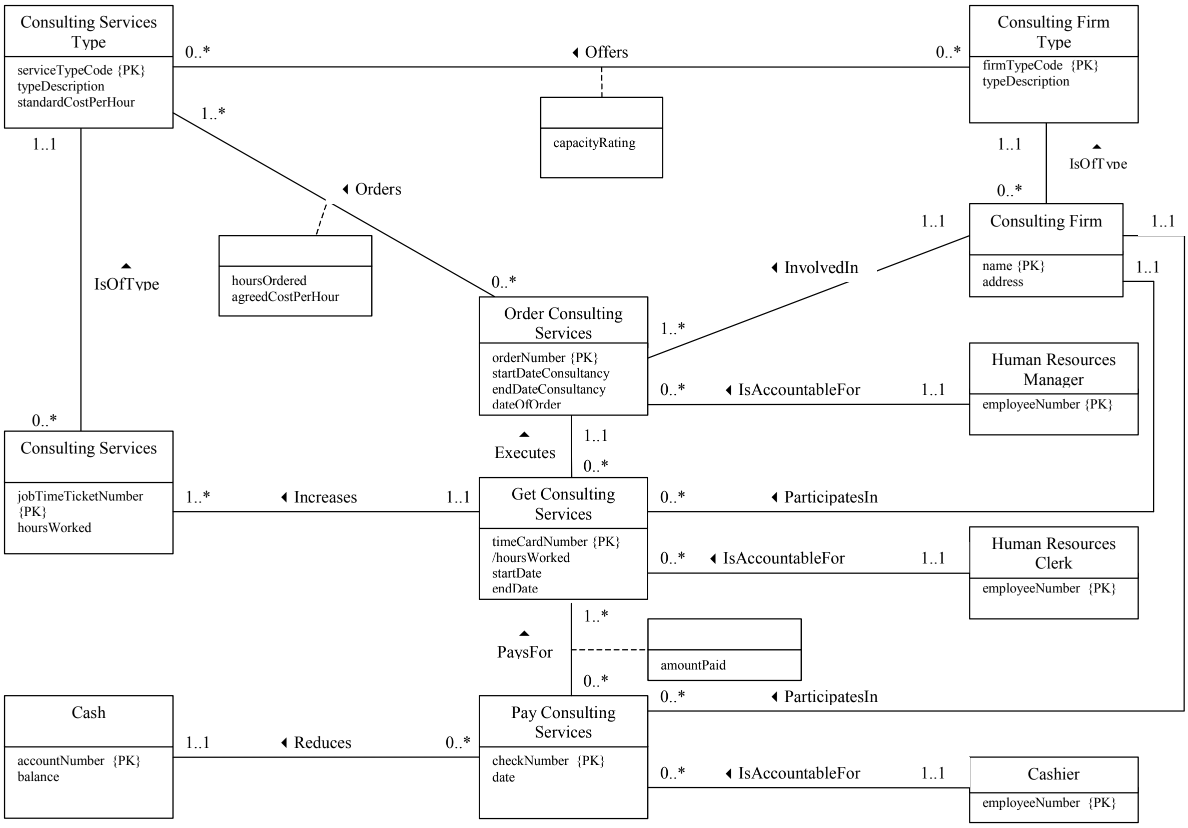


**Figure A-1.** REA diagram

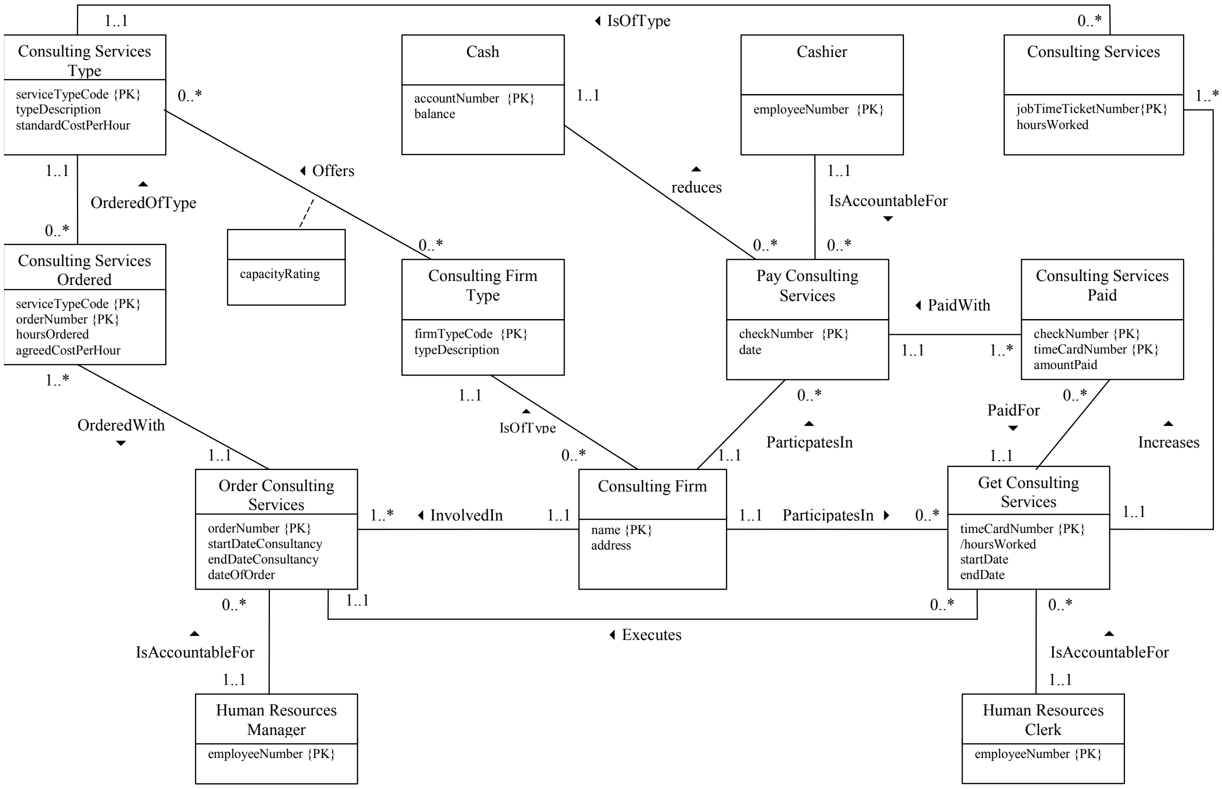


**Figure A-2.** non-REA diagram

## Appendix B: Comprehension questions

1. Can a capacityRating apply to a consulting firm if the company has never ordered consulting services with that consulting firm ?
2. Can the hours worked that are registered for some consulting service on the same job time ticket (identified by its jobTimeTicketNumber) be ordered by more than one human resources manager ?
3. What type of business process is modelled in the diagram ?
4. Does the diagram depict a closed value cycle ?
5. Can the company make partial payments for consulting services that are registered on a same time card ?
6. Must the amounts that are paid to a same consulting firm for consulting services registered on different time cards be drawn from a single cash account ?
7. List the entity types that represent economic resources (i.e. valuable assets) that are affected by the transactions modelled in the diagram.
8. Does the conceptual schema allow calculating at any time the balance of the accounts payable to consulting firms ?
9. Can the conceptual schema be used by a company where several human resources clerks are allowed to register consultancy hours on the same time card (and be held accountable)?
10. Can the conceptual schema be used by a company where every consulting hour registered on a job time ticket must also be registered on a time card ?
11. Can the conceptual schema be used by a company that has human resources managers that never order consulting services ?
12. Can the conceptual schema be used by a company where the human resource clerks are only allowed to process time cards that relate to orders by the same human resources manager?
13. Can the conceptual schema be used by a company where more than one cashier can be hold accountable for paying the consultancy hours that are registered on a same time card?
14. Can the conceptual schema be used by a company that wants to issue a single payment check to pay for consulting services related to more than one order ?
15. Can the conceptual schema be used by a company that allows to register consulting hours related to different consulting service types on the same time card ?
16. Can the conceptual schema be used by a company that wishes to pay for consulting services that are ordered but not yet delivered ?

## Appendix C: Experimental data

| Participant | Treatment | Time | Accuracy | PEOU | US |
|---|---|---|---|---|---|
| 1 | non-REA | 16 | 6 | 4.2 | 4.25 |
| 2 | non-REA | 21.5 | 8.5 | 2.8 | 4 |
| 3 | non-REA | 14 | 11 | 3.2 | 4.5 |
| 4 | non-REA | 15 | 8 | 3.4 | 3.5 |
| 5 | non-REA | 23 | 10 | 4.4 | 3.25 |
| 6 | non-REA | 23.5 | 12 | 2.4 | 3 |
| 7 | non-REA | 15.5 | 9 | 2.2 | 4.5 |
| 8 | non-REA | 15 | 8 | 3.2 | 3.25 |
| 9 | non-REA | 17 | 9 | 3.2 | 2.75 |
| 10 | non-REA | 23 | 6 | 3.4 | 4 |
| 11 | non-REA | 16 | 9.5 | 3.6 | 4 |
| 12 | non-REA | 17 | 11 | 3 | 2.75 |
| 13 | non-REA | 19 | 12 | 2.6 | 3.5 |
| 14 | non-REA | 14.5 | 14 | 3 | 3.75 |
| 15 | non-REA | 26 | 5.5 | 1 | 4.5 |
| 16 | non-REA | 22 | 14 | 3.8 | 3 |
| 17 | non-REA | 24.5 | 10 | 2.4 | 4.5 |
| 18 | non-REA | 17.5 | 9.5 | 3.8 | 3 |
| 19 | non-REA | 9 | 6.5 | 2 | 4.5 |
| 20 | non-REA | 29 | 11 | 2.4 | 5 |
| 21 | non-REA | 25.5 | 11 | 4 | 1.75 |
| 22 | REA | 19 | 13 | 6.2 | 1.75 |
| 23 | REA | 14 | 12 | 4.8 | 3.25 |
| 24 | REA | 18 | 8.5 | 5.2 | 2.25 |
| 25 | REA | 12 | 10 | 3.8 | 4.25 |
| 26 | REA | 11.5 | 10 | 4.4 | 2.75 |
| 27 | REA | 18 | 10 | 3.6 | 4 |
| 28 | REA | 17 | 9.5 | 3.8 | 5.25 |
| 29 | REA | 17 | 12 | 4.6 | 4.5 |
| 30 | REA | 32 | 6.5 | 1.75 | 3 |
| 31 | REA | 20 | 11 | 2.8 | 2.75 |
| 32 | REA | 18 | 12 | 6 | 1.25 |
| 33 | REA | 18 | 10 | 4.2 | 3 |
| 34 | REA | 21 | 12 | 3 | 4.5 |
| 35 | REA | 14 | 15 | 4.4 | 3.25 |
| 36 | REA | 15 | 13.5 | 3.2 | 2.5 |
| 37 | REA | 10.5 | 12 | 1 | 6 |
| 38 | REA | 22 | 14 | 4.8 | 1.5 |
| 39 | REA | 17.5 | 8.5 | 3 | 4 |
| 40 | REA | 20 | 14 | 3 | 4.5 |
| 41 | REA | 19 | 12 | 3.8 | 4 |
| 42 | REA | 16 | 12 | 2.8 | 4 |

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