Bridging the Educational Gap between Requirements Holders and Requirements Engineers

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Abstract

Requirements engineering is still hindered by misunderstandings between requirements holders and requirements engineers. The mutual understanding can be improved by providing common cognitive basis for both professional groups. Higher priority of Business Modelling module in curricula of potential requirements holders and potential requirements engineers can form a cognitive background for better communication between both partners in requirements engineering. The module should consist of several business modelling methodologies that provide understanding of relationships between business and computer systems in different contexts; illustrate a wide scope of issues in business modelling and relationships between them; as well as provide insight in cognitive frameworks exploited by requirements engineers and requirements holders.

Keywords: business modelling, requirements engineering, education

1. Introduction

In a very general sense requirements may be defined as "anything that somebody has got to do to provide a product or service" [1]. Thus requirements engineering in that context may be defined as a scope of activities that produce correct, unambiguous, complete, consistent, ranked for importance and/or stability, verifiable, modifiable and traceable system of requirements. In the area of Software Engineering this system of requirements is reflected in the document that is titled Software Requirements Specification [2] and Software Requirements Engineering has been defined as one of the main knowledge areas of the field [3].

Despite considerable achievements in the area of Requirements Engineering many problems concerning requirements still exist. This paper addresses one of these problems, namely, *misunderstandings between customers and those developing the systems requirements* [4]. There may be several reasons for such misunderstandings, e.g., different backgrounds, different purposes and goals etc. Here we will discuss *the lack of common cognitive basis* (conceptual schema and way of thinking about particular things) *for both parties* as a reason for misunderstandings between requirements holders and requirements engineers. Professional usage of business modelling methods during requirements engineering is proposed as a means of minimising misunderstandings in requirements engineering.

Business modelling includes a range of activities aimed at the development of a business model. The business model is a system of interrelated submodels that represent the enterprise under the consideration from different perspectives [5]. Business models differ in their architecture and contents of submodels. The issues represented in the business model can range from just business and information processes to knowledge of business goals, values and mission [6].

Benefits of comprehensive business modelling methods have been well understood. This understanding is witnessed by recent publications [7] as well as the fact that there are many systems development tools that include business modelling components, e.g., such as ORACLE Designer 2000, ARIS, GRADE, etc. [8]. However, in many cases neither business managers nor software requirements engineers are ready to use business modelling approaches in situations of requirements engineering [9]. It is claimed here that one of the potential reasons of non-utilisation of power of

business modelling in requirements engineering is *lack of proper education* of both parties involved (business managers and software (requirements) engineers) in business modelling.

The role of Business Modelling module in current curricula is addressed in Section 2. The educational gap between requirements holders and requirements engineers is discussed in Section 3. Business Modelling as an educational bridge is proposed in Section 4. In Section 5 the Business Modelling module is discussed in detail. Some lessons learnt in practical application of the module are reported in Section 6. Section 7 consists of brief conclusions.

2. Role of Business Modelling in current curricula

The role of Business Modelling in current curricula has been assessed on the basis of analysis of curricula available in the Internet, course books, and discussions with lecturers of courses on (or related to) Information Systems and Requirements Engineering. In the remainder, of the text courses at the disposal of potential requirements holders will be referred as *Business Management* and courses offered to potential requirements engineers - as *Software Engineering*.

Two knowledge sources are taken here as representatives of common trends in the area:

1) for Business Management; - the book "Introduction to Information Systems: A Management Perspective" 3rd ed. by Alter S., 1999 [10]
2) for Software Engineering; - the document "Software Requirements Knowledge Area Description" by Sawyer P. and Kotonya G., 1999 [3]

The first knowledge source exemplifies trends in Business Management curricula with respect to Information Systems Development. Information Systems have been chosen here because they are the most common computer systems that business managers are dealing with.

The second knowledge source can be considered as one of the working standards in Software Engineering since it is a part of the Software Engineering Body of Knowledge (SWEBOK) approved by the Industrial Advisory Board [11].

2.1 Knowledge about Information Systems acquired by Business Management students

Fig. 1 shows the contents of the book "Introduction to Information Systems: A Management Perspective" 3rd ed. by Alter S., 1999. Business Modelling here is discussed as Data Flow diagramming, and usage of Flowcharts and Structured English.

In Fig. 1 the issues related to business modelling are placed under the sub-sub-heading Process Modelling: Documenting Business Process Architecture. Such location is a common trend in text books for managers (e.g., also in the book "Business and Information Systems" [12] business modelling issues are located under the sub-sub-heading, namely, Systems Development Tools, that, in turn, are under the sub-heading Information Systems Development).

2.2 Knowledge about business modelling offered to Software Engineering students

The role of Business Modelling in the Software Requirements Knowledge Area Description is shown in Fig. 2. The concept of Business Modelling does not appear explicitly here. However, topics close to Business Modelling are concentrated under the sub-sub-topic Conceptual Modelling, - except of Scenario Analysis (not shown in Fig. 2) that is located under the sub-heading Requirements Elicitation. There are several books on Requirements Engineering, where more attention is paid to the modelling issues than in the SWEBOK document, i.e., modelling issues are put on the sub-topic level of their contents (e.g., books by Sommerville and Sawyer, 1997 [4] and Wieringa, 1996 [13], etc.). However, even in those cases methods described in the books can hardly be called Business Modelling. But it has to be mentioned here that books on Requirements related topics, that describe Business Modelling issues more properly do exist (e.g., the one written by Flynn, 1992 [14], etc.).

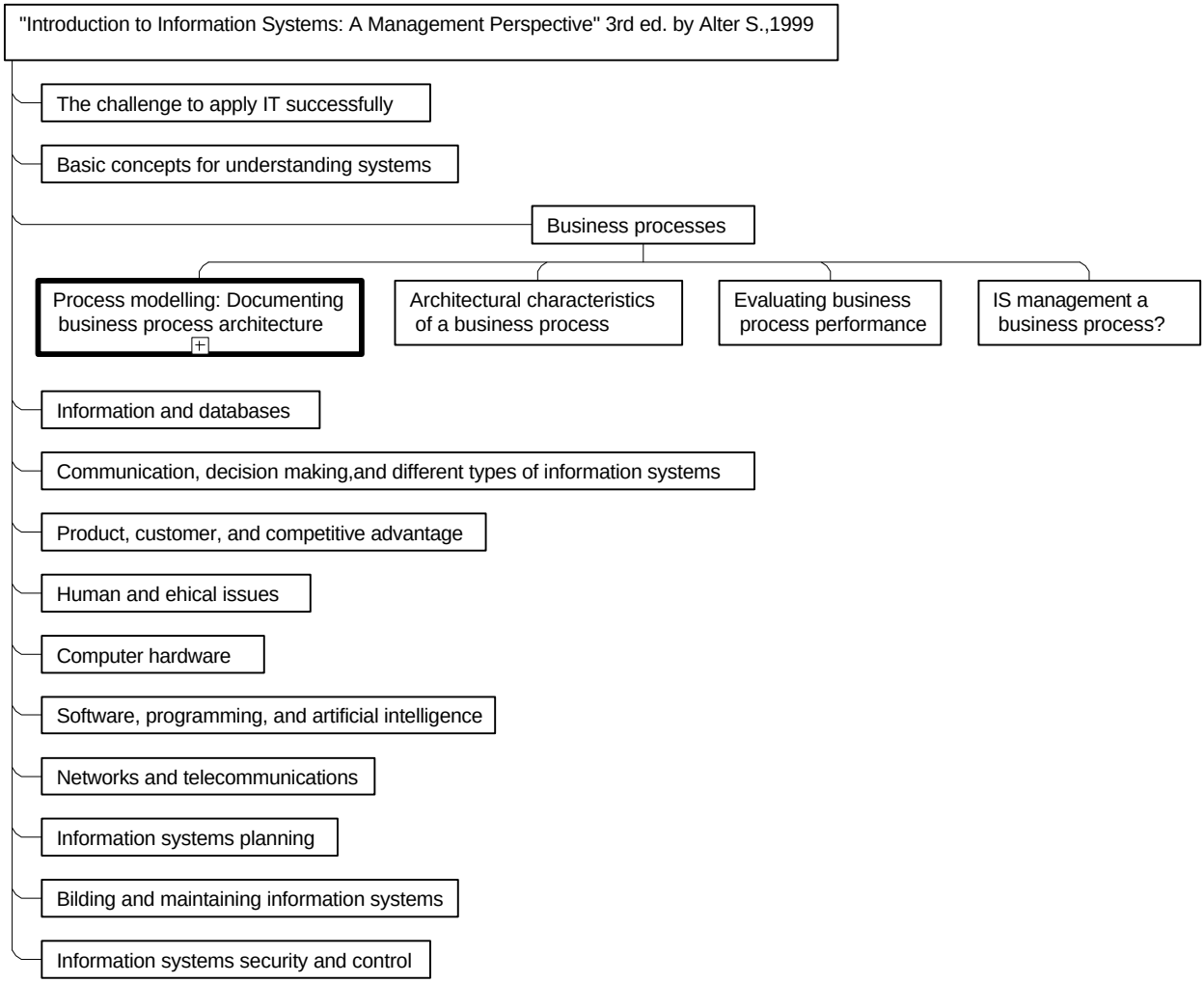

Figure 1. Role of Business Modelling in contents of “Introduction to Information Systems: A Management Perspective” 3rd ed. by Alter S., 1999

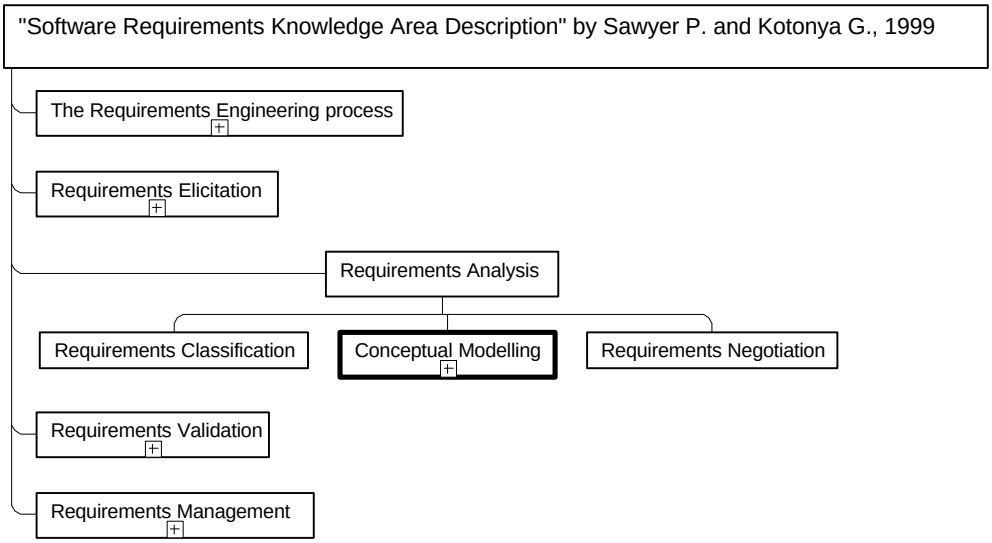

Figure 2. Conceptual structure of the Software Requirements Knowledge Area Description (SWEBOK)

3. Educational gap between business managers and requirements engineers

As shown in Fig. 1 Business Management students can receive profound knowledge about information systems, starting with the systems' place in the enterprise, the benefits one can gain from different kinds of information systems, as well as knowledge on hardware, software, information systems development and security aspects. This knowledge, of course, is very helpful in understanding what information system is and how the organisation can benefit from it. However, when it comes to defining requirements for information systems, it is not easy for business people to relate their domain knowledge with their knowledge in information systems. More over, besides facing the problem of requirements definition they also have a problem of requirements validation. According to author's experience many notations used in requirements specifications that could *add to* understandability of the document, e.g., Data Flow Diagrams and large Object Models, in many cases business managers perceive as uncommon and *non*-understandable. Such perception is natural because they have never used those notations *in practice* themselves. The lack of managers' experiences in particular modelling techniques therefore can be regarded as one reason of problems in requirements engineering.

On the other hand, requirements engineers who *theoretically* know that a computer system must match vision, mission, goals and processes of the business organisation, actually, are not always able to apply this knowledge in practice [9]. Instead of matching the requirements to the organisational objectives, processes and structures they try to match them to integrity of separate wishes of particular requirements holders [4, 15]. In this way requirements engineering process is seriously hindered by the following two well known problems:

1) very often requirements holders do not know what *exactly* they wish
2) there is no visual or formal means of assuring the explicit systemic fitness between requirements, proposed computer systems, and business organisation

The first problem can be resolved by applying the most expensive requirements engineering approach - eliciting requirements by prototyping [16]. However, even this approach does not solve the second problem. Business Modelling has a particular role in Requirements Engineering, because it deals with the second problem and helps to solve the first one too [5].

4. Business Modelling as an educational bridge

There are several reasons for viewing the business modelling as an educational bridge between requirements holders (called business managers in the context of this paper) and requirements engineers. The reasons are the following:

1) Business Modelling has been recognised as useful knowledge in Business Management as well as Software Engineering.
   - Business modelling is a necessary constituent of business process reengineering that has become a well-known option of organisational development [17].
   - Business modelling has been recognised as a tool for change management [17]. Introduction of new computer system always more or less changes the business organisation and therefore generates the need to manage these changes.
   - The business model can be used as a basis for stating right requirements [18].
2) Considerable experience in business modelling has been acquired and reported [7].
3) Many business modelling tools exist, that can support teaching on Business Modelling [8].
4) In fairly many universities particular business modelling methods are already included in different courses as larger or smaller parts of them (e.g., University of Colorado, Stockholm University, etc.).

The scope of business modelling methods, methodologies and approaches is quite large. The choice of the ones for teaching usually depends on three following criteria or reasons:

1) overall popularity of the methodology, method or approach
2) popularity of methods (and/or availability of tools) in a particular university or country
3) availability of teaching materials

The first reason can be illustrated by the fact that Entity-Relationship Diagrams and Data Flow Diagrams are included in almost every book meant for educating business managers in Information or Computer Systems and are a necessary part of study programs in Software Engineering too. The second reason can be illustrated by the Enterprise Knowledge Development (EKD) methodology [18, 19] that being an excellent educational tool is delivered in quite limited number of universities. The third reason can be illustrated by Soft Systems Methodology [20] that is most popular in England and Scandinavian countries, but due to very good teaching materials is adopted also, e.g., in USA and Baltic countries.

The present state of affairs in requirements engineering discussed in the introduction of the paper shows that the present teaching on Business Modelling is not sufficient for bridging the educational gap between business and software engineering professionals. One argument that is usually omitted while choosing contents and approach for teaching in Business Modelling is *cognitive implications* of dealing with particular business modelling methodologies, methods and approaches. To be able to communicate successfully requirements holders and requirements engineers should have a common cognitive background, i.e., familiar systems of concepts and a common way of thinking. Yet, due to time limits for education and rapid developments in business and software areas it is not realistic to expect that business managers will think like software engineers, and software engineers - like business managers, and both will have similar conceptual backgrounds in general. However, the situation can be improved if more attention is paid to the business modelling in education of both, - potential requirements holders and potential requirements engineers, i.e., the Business Modelling is placed on the sub-heading level in the contents of knowledge module on Information Systems for Managers and knowledge module on Requirements Engineering for software engineers (Fig. 3, compare with Fig. 1 and Fig. 2).

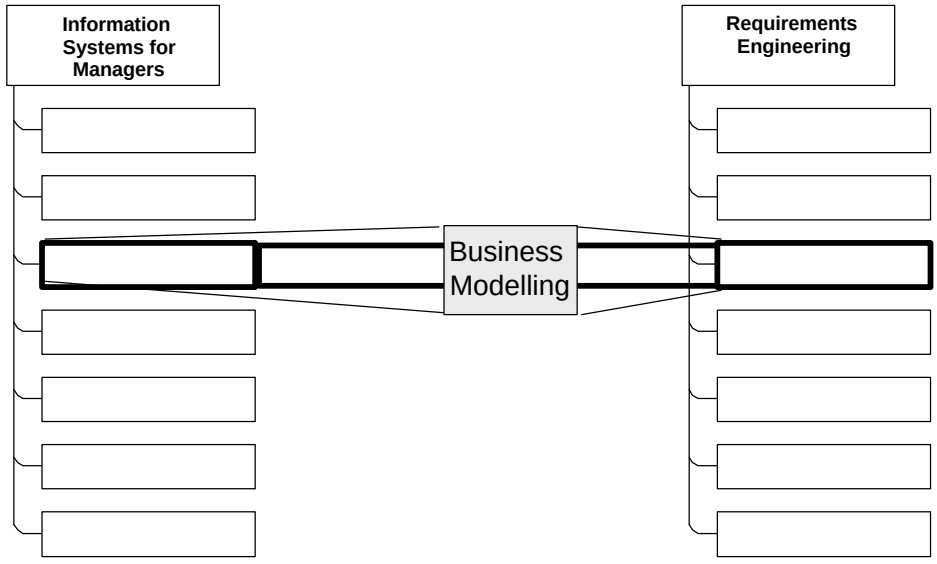

Figure 3. Bridging the educational gap by Business Modelling

The way of thinking required by business modelling approaches discussed in the next section is perceived as common neither by Business Management nor by Software Engineering students. But it is important, that this way of thinking is *almost equally accessible* to both parties. The truthfulness of the last two statements has been proved by three years teaching experience at Riga Technical University and the Marine Academy of Latvia. The scope of business modelling methods, methodologies and approaches used and criteria for choice of contents of Business Modelling will be discussed in the next section. It has to be mentioned here, that curricula of both groups of students, in general are the same as corresponding curricula in Western universities.

5. Knowledge module for Business Modelling

The choice of the Business Modelling contents and teaching methods has to be based on the analysis of cognitive implications of Business Modelling module rather than on the criteria of choice mentioned in Section 4. Computer System has to support Business System and becomes an integrated part of it. Therefore relationship between Business System and Computer System to be developed has to be properly understood for stating right requirements. This implies that those who are involved in requirements engineering process, i.e., requirements holders as well as requirements engineers, must be able to reason about relationships between business system and information system. In turn, to be able to reason about them they need knowledge about *both of them* and *how they are related*. As was illustrated in Section 4, current education supports theoretical knowledge of business managers in Information (Computer) Systems. On the other hand Software Engineering curricula usually include theoretical courses on Business Systems (the issue is not discussed in this paper). However, practice shows that this knowledge is not sufficient for successful requirements engineering [9]. It is not sufficient also theoretically, at least, from the point of view of Cognitive Psychology.

According to research in Cognitive Psychology there are two important sources where understanding comes from [21], namely:

1) seeing the thing in different contexts
2) practical experience

In requirements engineering one of the main things to be understood is the *relationship between business system and computer system*. This issue is insufficiently dealt with in current curricula. Therefore it is suggested here to pay main attention to this issue in Business Modelling. This can be achieved, by teaching *several* different business modelling methodologies that illustrate that relationship from different perspectives.

The knowledge coming from practical experience can partly be gained when *students themselves develop business models* (not just look at or repeat models developed by somebody else). In the remainder of this section one possible set of business methodologies to be provided in Business Modelling and cognitive implications of each methodology will be discussed.

A module of Business Modelling is shown in Table 1. This (main) module is suggested for Business Management *and* Software Engineering students. There are some other methodologies that could be delivered additionally only to Software Engineering Students. They are reflected in Table 2. Some sources of teaching materials for each component of the modules are amalgamated in Table 3.

The main module consists of four components. Each of them requires different thinking patterns, lets to see different objects and relationships in business organisations and computer systems. In other words they are different contexts of requirements acquisition and determination. *Enterprise Knowledge Development* methodology has richer conceptual framework than other components of the module. Therefore it is suggested as the first component. By working with this methodology students can get an intuitive understanding what business modelling is, and can understand large scope of issues to be considered and a variety of relationships between them. Thus

this methodology prepares the cognitive grounds for other methodologies. *Entity-Relationship, Data Flow and State Transition Diagrams* [13, 22] usually are already known to students in Software Engineering. Therefore those diagrams can be excluded from their Business Modelling contents. For Business Managers this component brings insight in details of model development and lets to understand what computer systems developers particularly are interested in when they seek for systems requirements. They also show the means of finding information subsystem in the business system by examining information flows. The Entity-Relationship Diagram can be taught in a way that it makes easy for the student to switch to simple Class Diagrams [23, 24]. It is essential that business management students develop these diagrams themselves. Knowledge in EKD then lets them see how these diagrams fit in the overall business modelling framework. S*oft Systems Methodology* [20] helps to think about the core of particular business and learn how to put knowledge about systems into systemic terms. For Software Engineering students it an additional exercise that facilitates them to think about business system in terms of rich picture not just in terms of boxes and arrows between them. *I* - method* [25, 26] reflects organisation as a set of actors and strategic relationships among them. It requires thinking how changes in one particular actor will affect changes in other actors. When a computer system here is considered as an actor the impact of the computer system on the other actors can be demonstrated. When students come to this methodology they are already used to thinking about relationships between actors in terms of information sender and receiver. *I* - method* requires much richer scene in thinking about the relationships and therefore helps to avoid narrow-mindedness that can be developed by extensive dealing with Data Flow and Entity-Relationship or Class Diagrams.

Table 1. Contents of Business Modelling and their cognitive implications (main module)

Method or methodology	*Cognitive implications*
Enterprise Knowledge Development (EKD)	Understanding of large scope and variety of mutual relationships between different aspects and elements of the enterprise, such as organisational structures, actors, processes, concepts, objectives, etc.
Entity-Relationship, Data Flow and State Transition Diagrams	For requirements holders: Trying “shoes” of software engineers. For requirements engineers: practical experience by modelling.
Soft Systems Methodology	Understanding of how to find the essence of the system, Understanding the relationship between the process and structure. Understanding the difference between system in natural and system in systemic terms Additionally for requirements engineers: trying “shoes” of business managers.
I*- method	Understanding how differently systems actors can be subjected each to other. When a computer system is taken as an actor: how changes in computer systems change relationships and task decomposition and task alternatives for other actors.

In the additional module (Table 2) *OMNIS approach* [14] requires detailed thinking about the relationship between the functional system and information system in terms of objects, processes and interfaces. *TEMPORA methodology* [27] introduces time issue in business and information systems modelling. This modelling approach also lets to analyse impact of rules on the systems in detail (EKD lets to do it at higher level of abstraction). TEMPORA methodology requires to define information system on the basis of business systems model, so it directly addressees the issue of relationships between business and computer systems. *Use Cases* [15, 28] are suggested to be included as an example of methods that do not address the relationship between business system and computer system explicitly, but still are useful in requirements acquisition. This method requires to imagine the business system and the computer system on the basis of services and properties of

computer system stated by requirements holders. *Multiview approach* [4] adds to understanding of similarities, differences, and relationships between possible viewpoints.

Table 2. Contents of Business Modelling and their cognitive implications (additional module)

Method or methodology	*Cognitive implications*
OMNIS approach	Detailed understanding of relationships between functional system and information system.
TEMPORA Methodology	Understanding of the time dimension in business system and information system. Deep understanding of relationships between business level and information systems level models of the system.
Use Case in requirements engineering	Understanding the relationship between individual requirements and business and computer system.
Multiview approach	Understanding of the scope of viewpoints and their mutual relationships.

The combination of methodologies shown in Tables 1 and 2 should not be considered as the only best alternative. Cognitive implications of methodologies are the main thing to be considered when developing curriculum modules for Business Modelling. Each combination of methodologies, methods, and approaches can be viewed as theoretically appropriate if it supports cognitive implications shown in Tables 1 and 2 by the following means:

1) large scope of business modelling issues and relationships between them (e.g., EKD and Soft Systems Methodology in the main module)
2) relationship of business system and computer system in several different contexts (e.g., EKD, I* - method, OMNIS and TEMPORA in the main and the additional modules)
3) consideration of the system from other party's viewpoint (e.g., Entity-Relationship, Data Flow and State Transition diagrams for business managers and Soft Systems Methodology for software engineers)

Table 3. Sources of teaching materials (main and additional modules)

Method or methodology	*References*
Enterprise Knowledge Development (EKD)	[8, 18, 19, 29]
Entity-Relationship, Data Flow and State Transition Diagrams	[13, 22]
Soft Systems Methodology	[20]
I*- method	[25, 26]
OMNIS Methodology	[14]
TEMPORA Methodology	[27]
Use Cases in requirements engineering	[15, 28]
Multiview approach	[4]

6. Lessons learnt

For three years the Business Modelling modules discussed in Section 5 were delivered to Port Management students, the Marine Academy of Latvia, and Computer Systems Development students, Riga Technical University. In both cases students were able to develop the required business models. None of the student classes viewed the course as a simple one. It required from them a considerable cognitive effort to think according to different frameworks of methods and methodologies during relatively short course. The most important result was that it was obvious that each new methodology added to students' overall understanding of how business can be modelled, and how computer system and business system affect each other. It has to be noted here, that Port Management students (using tool GRADE [30, 31, 32]) had to develop a business model of an organisation they are familiar with. The students' knowledge development during the course is

shown in Fig. 4 (only part of newly generated or acquired knowledge is reflected). Students of Riga Technical University had a separate course on Systems Development Tools.

Main lessons learnt are the following:

1) Start with the most complex not simple frameworks. Let students feel the complexity and their lack of knowledge to deal with it, thereafter by explaining simpler things and gradually returning to the complexity let them feel that their knowledge and understanding continuously grow.
2) Do not try to explain everything. Let students' brains work and find answers themselves.
3) Answer questions arising from one methodology by explaining another methodology, then go back and show differences.
4) Be sensitive to students' cognitive needs, vary the sequence of teaching material according to them.
5) Each student (or a small subgroup of students in the case of Software Engineering students) has to work on its own business system when developing the business models (not one system for the whole class).
6) Usage of business modelling tool is essential to Business Management students ability to understand business modelling issues (Fig. 4).
7) Business Management students are more capable to operate the modelling tool if each one of them can receive some individual attention, so the number of students in the class should not exceed teacher's ability to see to everyone's individual needs.

7. Conclusions

One of the reasons of problems in requirements engineering is the lack of common cognitive basis for requirements holders and requirements engineers. Business modelling module if included in the curricula of potential requirements holders and potential requirements engineers can serve as a cognitive bridge between two parties. Thinking in terms of business modelling methodologies is not common for any of the parties, however, for both of them it is equally accessible. When choosing business modelling methodologies for teaching, their cognitive implications have to be considered. The scope of methodologies chosen must provide at least the following cognitive service:

1) illustrate large scope of business modelling issues and relationships between them
2) show relationship of business system and computer system in several different contexts
3) allow to consider the system from another party's viewpoint

To gain at least partial practical knowledge students have to develop individual business models for the organisation that they have chosen. Students must use at least one business modelling tool for the model development.

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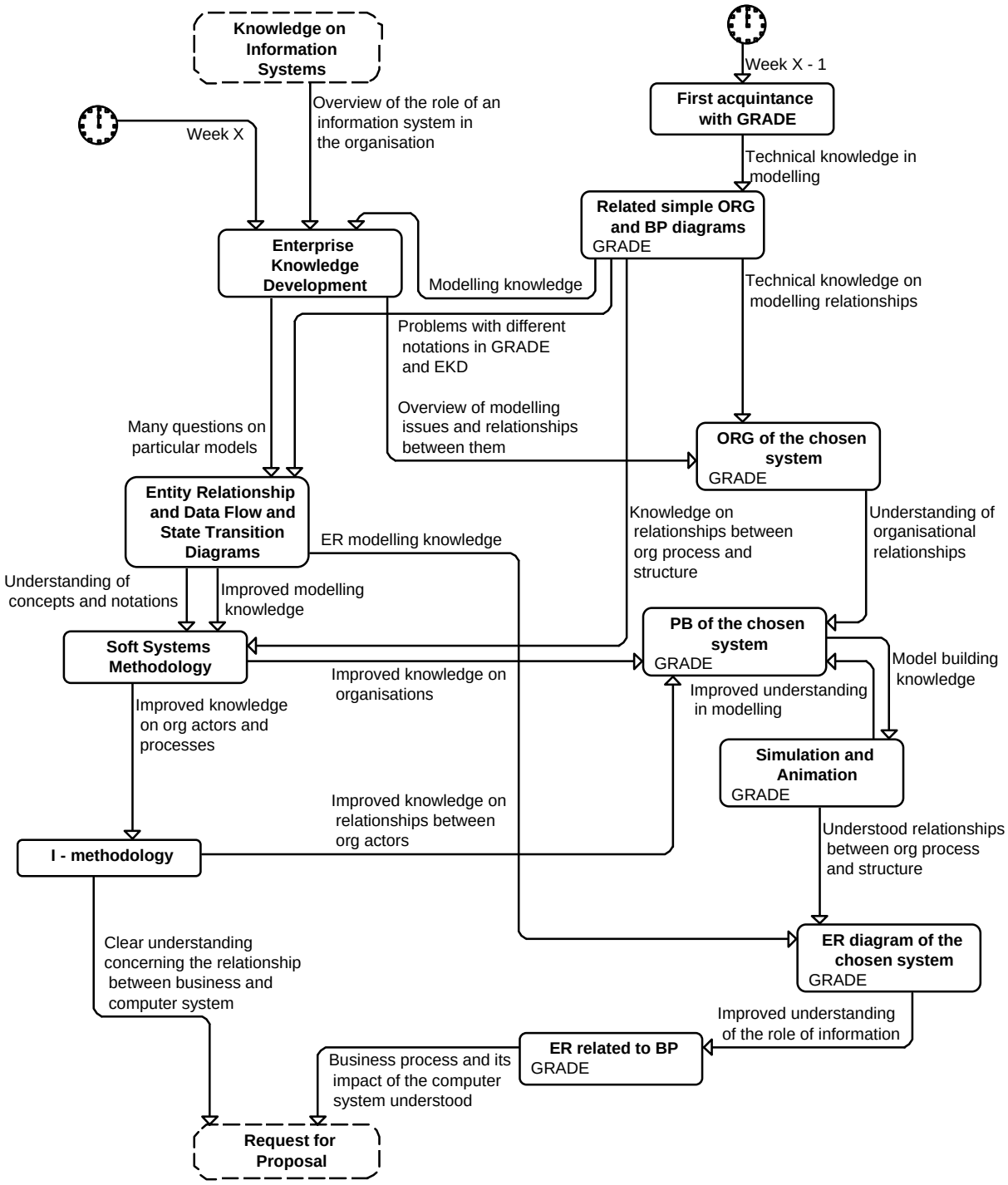

Figure 4. Part of knowledge flow between components of Business Modelling module delivered to Port Management students (ORG - diagram of organisational structure, BP - Business Process Diagram, ER - Entity-Relationship Diagram)

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