Fact Based Modeling as Mandatory Subject in the First Year of a Knowledge Engineering Program

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Abstract. In this paper we discuss the introduction of a course on fact-based modeling in the first year of the bachelor program Knowledge Engineering at Maastricht University. We will discuss the course built-up and the course assessment.

1 Introduction

Since 1993 Maastricht University has a bachelor program on Knowledge Engineering. In the first year of this program students will be introduced to subjects like *computer science*, *discrete mathematics*, *knowledge representation and cognitive psychology*, *linear algebra*, *calculus*, *data structures and algorithms*, *logic*, *numerical mathematics* and *software engineering*. In the academic year 2016/2017 students have been introduced to the concepts of fact-based modeling in the newly designed course *ICT and Knowledge Management*.

2 Knowledge Management Approaches

Knowledge Management studies how organizations can manage, retain and exploit their knowledge resources. Having insight in its knowledge is important for an organization because the world changes rapidly and therefore organizations have to be able to respond to that change in an ever increasing pace. The amount of knowledge grows but this doesn't mean that this growing amount of knowledge is accessible at all times. Knowledge in many cases is bound to individual persons, making organizations more and more dependent on these individuals. For an ever growing number of organizations, the intellectual capital of an organization determines the value of that organization.

Knowledge is a fundamental prerequisite in the ability of a person to execute a task. This ability consists of explicit knowledge or information, implicit knowledge or experiences, skills and attitudes.

Knowledge can be analyzed from different perspectives, depending on which element in the definition the emphasis is placed. In knowledge management, basically three dominant approaches exist:

C. Debruyne et al. (Eds.): OTM 2017 Workshops, LNCS 10697, pp. 133–140, 2018.
https://doi.org/10.1007/978-3-319-73805-5_14

- The *ICT approach (or technocratic school* [1]*)*, with focus on making knowledge explicit and structuring the knowledge in such a way that the knowledge can be objectively shared.
- The *Economic school,* with focus to see knowledge as an asset [1].
- The *Behavioral school* [1], with focus on providing means to stimulate the pooling and exchange of knowledge.

Independently of the approach, *the aim of knowledge management is expliciting the relevant knowledge to the highest possible extent*. In the knowledge engineering course *ICT and Knowledge Management* we have focused on the first approach (the ICT approach) in which we also clearly make a link to other courses in the first year of the bachelor of Knowledge Engineering. Knowledge Management is an integral approach for the identification, the structuring, the sharing and evaluation of knowledge in the organization.

The educational goal of a course on ICT and Knowledge Management is to provide the knowledge engineering students the basic tools for capturing *fact types*, *integrity rules*, *concept definitions*, *derivation rules* and *business processes*.

3 The Modeling of Knowledge in the Course ICT and Knowledge Management

In this course the identification and structuring of knowledge is considered as a modeling process that will result in models that represent the structure of the knowledge. The knowledge model that has been used in this course consists of 4 dimensions: *Data*, *Semantics*, *Rules* and *Processes*.

Table 1. Content of sessions/tutorials

Session	Content
Session 1: Knowledge management 1	Introduction to 4 dimensions Knowledge Management: Importance of modeling
Session 2: Tutorial	Data, semantics and integrity rules 1
Session 3: Knowledge management 2	More Integrity rules
Session 4: Tutorial	Data, semantics and integrity rules 2
Session 5: Knowledge management 3	Derivation rules and DMN[a]
Session 6: Tutorial	Integrity rules and derivation rules
Session 7: Mid-term test	
Session 8: Tutorial	Integrity rules and DMN
Session 9: Knowledge management 4	BPMN[b]
Session 10: Tutorial	BPMN and Data
Session 11: Tutorial	BPMN and data and derivation rules
Session 12: Tutorial	Application to laws and regulations

[a]DMN stands for Decision Model and Notation. DMN is an OMG standard for modeling structured decisions in organizations an make them interchangeable [2].

[b]BPMN stands for Business Process Model and Notation. BPMN is an Omg standard that will facilitate the description and understanding of business processes within and between organizations [3].

In the course *ICT and Knowledge Management* a variety of educational formats is used. It is a combination of lectures in which the theory is presented and illustrated by exercises and cases, and tutorials in which students are expected to have prepared exercises and small case studies. During the tutorial sessions, feedback on the exercises and case studies is provided. During the tutorial hands-on explanations with respect to the case studies is provided. In the *lectures* and *problem based tutorials* the focus is on the given dimensions one by one first and gradually those perspectives will be integrated in application exercises and cases. In Table 1 an outline of the content for the lectures/sessions is given [4].

4 The Content of the Lectures and Tutorial Sessions

4.1 Session 1 (Lecture): Introduction to 4 Dimensions Knowledge Management: Importance of Modeling

In the course we demonstrated that a knowledge specification consists of 4 dimensions, namely: *data*, *semantics*, *processes* and *rules*, that form an integrated whole. The integration of these dimensions within the context of Knowledge Management can be depicted clearly by means of the *knowledge triangle* (see Fig. 1).

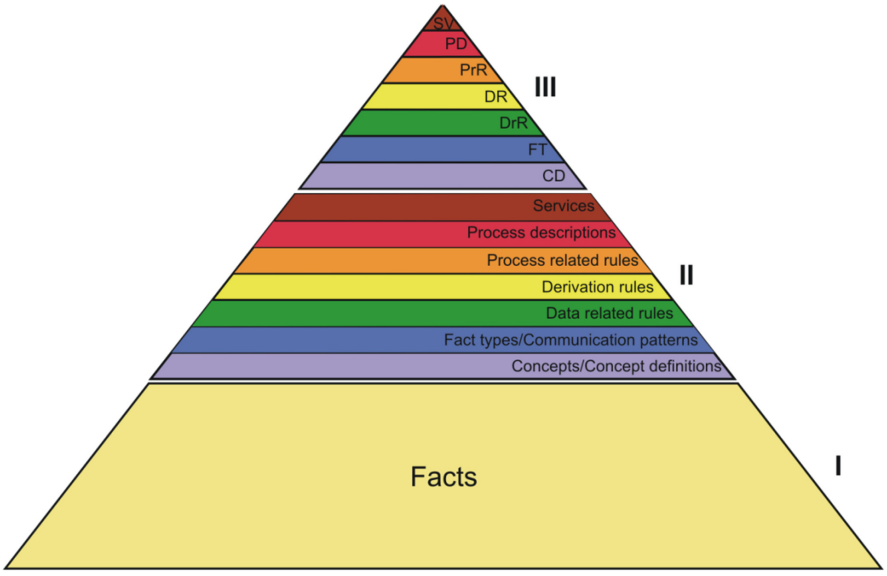


Fig. 1. CogNIAM's knowledge triangle (Note that the names of the 'layers' in level 3 of the knowledge triangle are abbreviated. Their full description can be found on the corresponding color 'slice' of level 2)

During the first session we have focused on the data dimensions by introducing a framework and protocol for developing these model dimensions. The lecture ended with a perspective on the integration: how are the 4 dimensions related to each other, and provide some insight on the dependencies between them.

The following steps of the CogNIAM modelling protocol were introduced and explained during the first lecture:

Step 1: Verbalise
Step 2: Denote variable and constant parts
Step 3: Qualification of variables
Step 4: Identification of concepts
Step 5: Generalization towards fact type forms and fact types
Step 6: Adding Uniqueness rules

4.2 Session 2 (Tutorial): Data, Semantics and Data Related Rules 1

In this session the students were expected to have prepared a number of (modeling) exercises and they were asked to hand-in the workouts of these tasks at the beginning of the tutorial. The students were asked to derive level I and the first three layers of level II of the knowledge triangle by applying the CogNIAM modelling protocol on some 'scaled-down' real-life (business) examples. In terms of integrity rules only *uniqueness* rules needed to be derived.

4.3 Session 3 (Lecture): More Data-Related Rules

One of the important elements of the data dimension are the data-related integrity rules that ensure that the data specified are useful and correct. In this session, we have discussed and applied the protocol for deriving additional data-related rules. The semantic dimension of the knowledge model specifies the meaning of concepts, how concept definitions can be formed, and we have introduced a maturity model for determining the quality of such a concept definition structure. In this lecture we have extended the CogNIAM protocol with further modeling steps 7 and 8:

Step 7: Add other integrity rules:
- Set comparison rules: subset, equality, exclusion
- Mandatory (non-empty) rule
- Value rule
- Occurrence frequency rule
- Non-overlap rule
- Value comparison rule
- General rule

Step 8: Define concepts

4.4 Session 4 (Tutorial): More Integrity Rules

In this session the students were asked to have prepared an additional number of tasks. These tasks were worked on during the tutorial, by asking students to come forward and present their solutions. That served as a starting point for the instructional process in which in a tutorial class-room setting (maximally 15 students) the educational process will lead to an agreed solution.

4.5 Session 5 (Lecture): Derivation Rules and DMN

The third dimension of the complete knowledge model is the rules dimension, in particular the *derivation rules*. *Derivation rules* define the way how new facts are determined from existing facts. One of the major types of derivation rules that is of importance for an organization's agility are the decision rules. In this lecture we have focused on *DMN* (*decision modeling notation*) the standard for modeling decision rules. The session ended with a perspective on the integration: how are the 4 dimensions related to each other, and the dependencies between them. Furthermore, we have introduced step 9 of the CogNIAM modeling protocol: Derive derivation rules.

4.6 Session 6 (Tutorial): Integrity Rules and Derivation Rules

In this session the students were once again asked to have prepared a number of tasks. These tasks were worked on during the tutorial, by asking students to come forward and present their solutions. This once again served as a starting point for the instructional process in which in a tutorial class-room setting (maximally 15 students) the process will lead to an agreed solution. In this session the types of cases were of an integrated nature in which all steps of the modeling protocol needed to be applied on these integrated knowledge domain exercises and case studies.

4.7 Session 7: Mid-Term Test

This was a 2 h open book test on the subjects from sessions 1, 2, 3, 4, 5 and 6 and accounts for 40% in the final grading of the course.

4.8 Session 8 (Tutorial): Integrity Rules and DMN

In this session the students were once again asked to have prepared a number of tasks. These tasks were once again used in the tutorial, by asking students to come forward and present their solutions. This as a starting point for the instructional process. In this session the types of cases were of an integrated nature in which all steps of the modeling protocol needed to be applied. During the teaching of the course it turned out that the initial exercises for session 4 and 6 were of such a level, that it was decided to use the respective sessions as guiding sessions in which (significant) parts of the work-outs were presented and internalized, and hence the final complete work-out was postponed till the following tutorial session.

4.9 Session 9 (Lecture): BPMN

This lecture was focused on the fourth dimension of the knowledge management framework: (business) processes. Until this session the CogNIAM modeling protocol had been applied to model the *data*, *semantics* and *integrity rules* of a subject domain. It was also shown that in certain application domains derived fact types play an important role and hence, we have introduced the DMN standard that allowed us to easily model relatively complex derivation rules. The focus of this lecture was on the

business process dimension and the accompanying process description and process related rules in level II of the *knowledge triangle*. We have introduced the business process modeling constructs and notation as laid down in the BPMN standard. A business process defines the order in which activities are performed, by whom they are performed, which decisions are made and what events influence this order. In CogNIAM, the prescriptions of the activities and decisions are expressed using exchange rules and derivation rules. In this session we have introduced a best practice, covering a subset of the BPMN symbols and introducing a structured way of working for modeling business processes with BPMN.

4.10 Session 10 (Tutorial): BPMN and Data

In this tutorial the integrated CogNIAM protocol for process and data modelling has been applied (steps 1 through 9 in Sect. 4 and the BPMN protocol). The modeling results will consist of a CogNIAM data model and the accompanying (excerpts of) a BPMN model. In this session the students were expected to have prepared a number of integrated tasks and they have finalized s set of tasks that were introduced in the tutorial of session 8 and were only partly discussed in session 8.

4.11 Sessions 11 and 12: Application to Laws and Regulations

In this final tutorial the knowledge triangle was applied (steps 1 through 9 in Sect. 4 and the BPMN protocol) in the context of regulations. As an example the regulation 261.2004 of the European commission on compensation and assistance to passengers in the event of denied boarding, flight cancellations or long delays of flights has been used to apply the modeling protocol on all 4 dimensions: *Data*, *Semantics*, *Rules* and *Processes*.

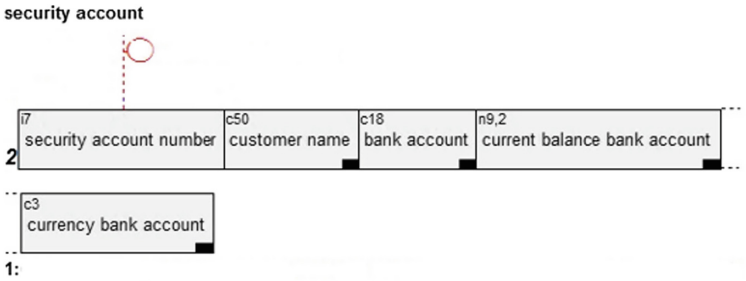
5 Assessment and Attendance for the Course ICT and Knowledge Management

In order to pass this block the following requirements should have been met: fulfilling presence requirement, a grade for the final exam on ICT and Knowledge Management in the exam period that is at least a 5.0 and sufficient participation in the 7 tutorials of the course.

The final grade for the block is composed as follows: Mid-term test in week 3 (relative weight 40%), participation in the tutorials (relative weight 20%) and the result of the final exam (relative weight 40%).

5.1 Example of Assessment

In this section an example is given of an exam question in which students have to assess a description of a use case and evaluate which fact type and integrity rule is applicable.



Question 1.1
An integrity constraint applies to the security type as shown in the fact type diagram 'security' (marked with a '1.'). Which integrity rules applies? Choose the symbol associated with this rule from the options below.

a) ⓘ b) ⓗ c) ⓒ
d) ⓤ e) ⓧ f) no integrity rule applies

In the mid-term exam the focus was on the *data*, *semantics* and *integrity rules*. In the final exam this was extended with the *derivation rules* and *processes*.

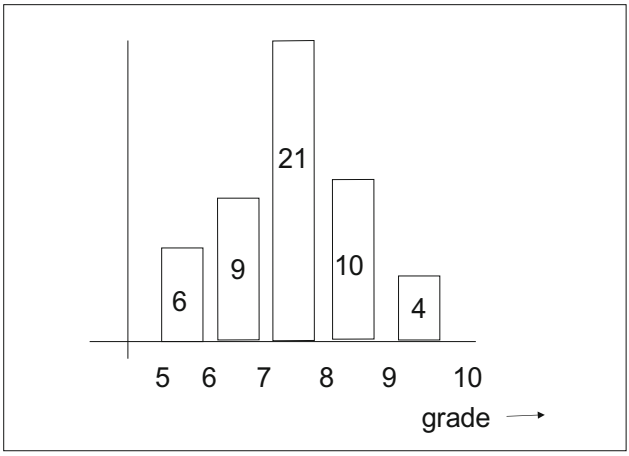


Fig. 2. Frequency distribution grades final exam

5.2 Grade Distribution for Final Exam

In Fig. 2 we have shown the frequency distribution of the grades for the final exam. A perfect normal distribution with a mean of around 7.5.

6 Conclusion

The course on ICT and knowledge management for this year's cohort 1st year students for the bachelor in Knowledge Engineering has been totally redesigned in order to cover all relevant aspects of data, semantics, rules and processes. A few lessons that we have learned from the course evaluations is that the mid-term and final test should be more in line with the type of exercises and case study that is used during instruction. This year we had for most subjects, questions in a multiple-choice format. These questions were created in a way that it took students a long time to read each of the 8 answering options and compare the options as a kind of 'find-the-difference' exercise. Furthermore, the educational material will be changed in order to make it more challenging for this type of student, by creating smaller exercises in terms of volume but at the same time make them more interesting by adding additional complexity in the use cases and henceforth looking for more challenging domains in which Knowledge Management can be applied.

References

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