COGNITIVE BIAS IN KNOWLEDGE ENGINEERING COURSE

Tatiana Gavrilova, Seppo Puuronen

Abstract: The paper presents experience in teaching of knowledge and ontological engineering. The teaching framework is targeted on the development of cognitive skills that will allow facilitating the process of knowledge elicitation, structuring and ontology development for scaffolding students' research. The structuring procedure is the kernel of ontological engineering. The 5-steps ontology designing process is described. Special stress is put on "beautification" principles of ontology creating. The academic curriculum includes interactive game-format training of lateral thinking, interpersonal cognitive intellect and visual mind mapping techniques.

Keywords: ontologies, knowledge engineering, analytical skills.

ACM Classification Keywords: I.2 Artificial intelligence

Introduction

Young researchers of computer science and information technologies use a lot of informal rules-of-thumb advice that may help but not a systematic guidelines. Major recommendations deal with library work, citation and other important but not essential components of research activity. Web resources now help to streamline the process of finding, selecting, and entering information from the Web, corporate databases, and reference materials into a paper. We are speaking about not syntax but semantic of study. Our course is aimed at information engineering – structuring and shaping the research framework. This issue has hardly been explored yet.

Students are engaged in various semantically-based activities. Indeed, any conceptual data modeling is a form of informal Semantic Modeling [26]. They do all the "bottleneck" activity including data and knowledge elicitation, structuring, formalizing. But do they do it professionally? They need knowledge engineers' analytical skills.

Knowledge Engineering traditionally emphasized and rapidly developed a range of techniques and tools including knowledge acquisition, conceptual structuring and representation models [1], [24]. But for practitioners it is still a rather new, eclectic domain that draws upon areas like cognitive science. Accordingly, knowledge engineering has been, and still is, in danger from fragmentation, incoherence and superficiality. Still few universities deliver courses in practical knowledge engineering.

This paper describes recent experience in teaching such course. The total number of students that were taught is more than 160 – in Finland, Russian and USA.

Teaching Framework

Knowledge Engineering course (KEC) is based on university courses in intelligent-systems development, cognitive sciences, user modeling, and human-computer interaction delivered by authors in 1988-2005. KEC proposes information structuring multi-disciplinary methodology, including the principles, practices, issues, methods, techniques involved with the knowledge elicitation, structuring and formalizing. Emphasis is put not on technologies and tools, but in training of analytical skills. KEC also includes Ontological Engineering that is further development of knowledge engineering towards ontology design and creating.

Students are introduced to major issues in the field and to the role of the knowledge analyst in strategic information system development. Attention is given both to developing inter-personal information communication skills and analytical cognitive creative abilities.

The class feature short lectures, discussions, tests, quizzes and exercises. Lectures are important but the emphasis is put on learning through discussions, simulation, special games, training and case studies. A good deal of the course focuses on auto-reflection and auto-formalizing of knowledge, training of analytical and communicative abilities, discovery, creativity, cognitive styles features, and gaining new insights.

KEC consists of 4 inter-connected modules:

- Getting Started in KE (12 hours),
- Practical KE in depth (12 hours),

- Ontological Engineering (12 hours),
- Business Processes Modelling (12 hours).

Different combination of sub-topics is possible. Fig.1 illustrates the structure.

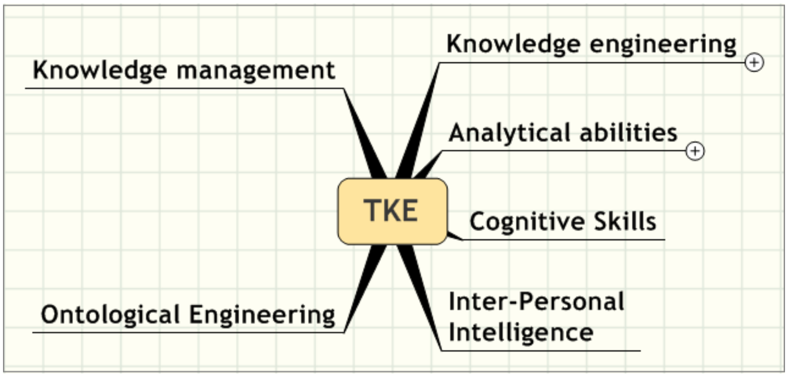

Fig.1. Outline of training on knowledge engineering

The main difference of KEC to existing curricula is cognitive (not technological) bias. Fig.2. shows the main issues covered by tests and practical exercises. Students of IT-departments often under-value the significance of psychological background of categorization, laddering and lateral thinking. But during learning process some of them feel "insight" and become very enthusiastic.

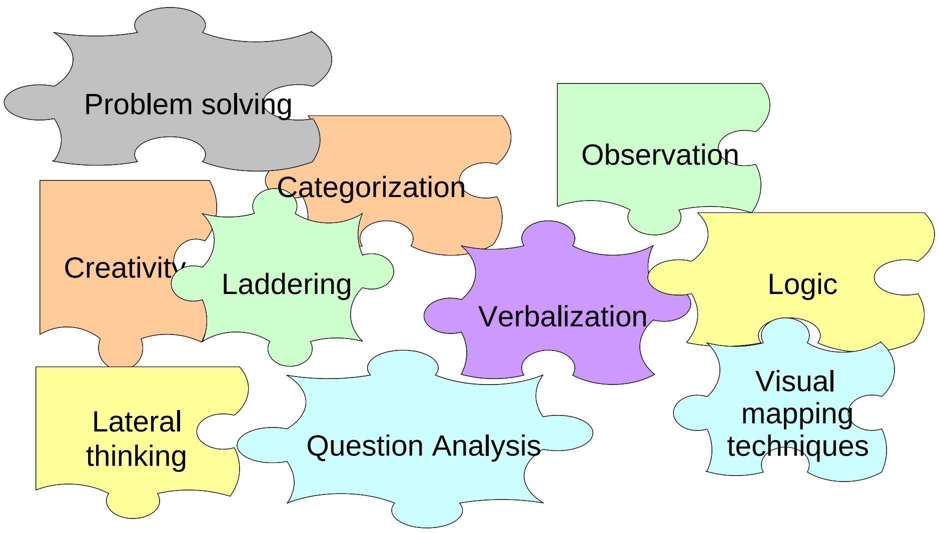

Fig.2. The main topics of practical exercises

The practical methods of knowledge elicitation gain the main interest during teaching as they really work. The training is organized that students study main techniques in pairs "expert – knowledge analysts" with a shift of roles when needed. Some psychological assessment techniques help students to realize their strong and week points in inter-personal communication and intelligence.

But only knowledge structuring exercises show the importance of obtained analytical skills for the students. Even simple tests from their own research domains are rather difficult at the first classes.

The study is aimed on semantics not syntax of knowledge engineering. We suppose that systems and languages may be self-studied while general scope and knowledge-stressed approach should be trained thoroughly. Students often under-estimate the role of cognitive styles, verbal skills and logics in information processing. It is supposed to be common sense while it needs to be taught.

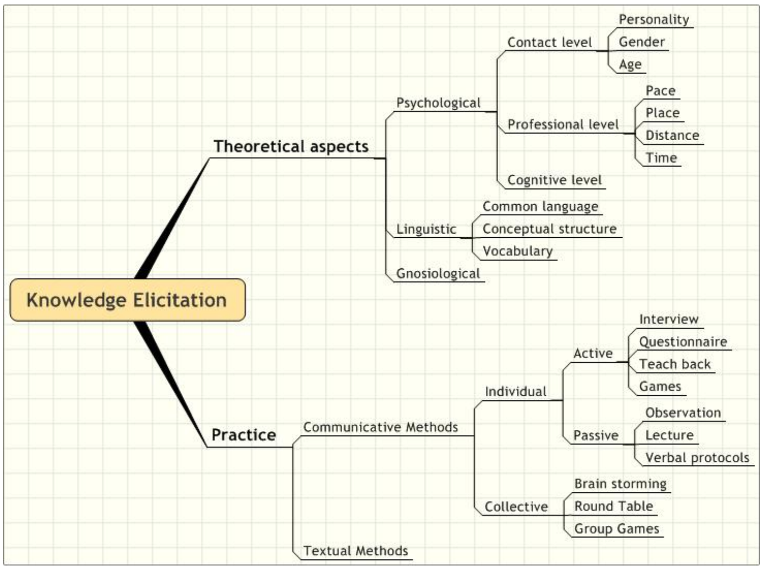

Fig.3. Theory and practice of knowledge elicitation

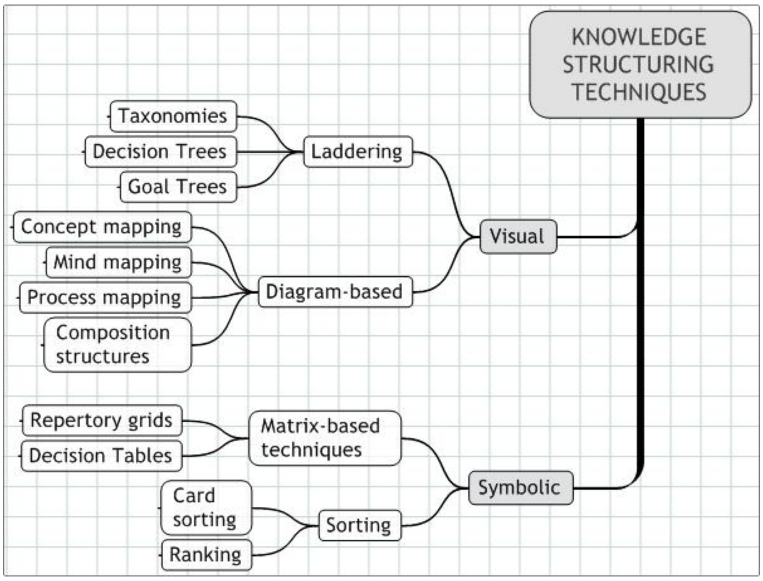

Fig.4. Knowledge structuring techniques

Stress on Ontological Engineering

Ontologies are fashionable now. But our experience in training show that nobody can deal with ontologies without knowledge engineering practice. How to teach ontology design? The theory differs from practical needs…

There are numerous well-known definitions of this milestone term (Gruber, 1993; Guarino and Giaretta, 1998; Jasper and Uschold, 1999; Mizogushi and Bourdeau, 2000; Neches, 1991) but they may be generalized as “Ontology is a hierarchically structured set of terms for describing an arbitrary domain” [9]. In other words “ontologies are nothing but making knowledge explicit” [12].

Since 2000 a major interest of researchers focuses on building customized tools that aid in the process of knowledge capture and structuring. This new generation of tools – such as Protégé, OntoEdit, and OilEd - is concerned with visual knowledge mapping that facilitates knowledge sharing and reuse [18], [19], [22]. The problem of iconic representation has been partially solved by developing knowledge repositories and ontology servers where reusable static domain knowledge is stored. Ontolingua, and Ontobroker are examples of such projects [20], [21].

Ontology creating also faces the knowledge acquisition bottleneck problem. The ontology developer encounters the additional problem of not having any sufficiently tested and generalized methodologies, which would recommend what activities to perform and at what stage of the ontology development process. The lack of structured guidelines and methods hinders the development of shared and consensual ontologies within and between the specialists. Moreover, it makes the extension of a given ontology by others, its reuse in other ontologies, and final applications difficult [11].

Until now, only few effective domain-independent methodological approaches have been reported for building ontologies [4]; [25], [16]. What they have in common is that they start from the identification of the purpose of the ontology and the needs for the domain knowledge acquisition. However, having acquired a significant amount of knowledge, major researchers propose a formal language expressing the idea as a set of intermediate representations and then generating the ontology using translators. These representations bridge the gap between how people see a domain and the languages in which ontologies are formalized. The conceptual models are implicit in the implementation codes. A re-engineering process is usually required to make the conceptual models explicit. Ontological commitments and design criteria are implicit in the ontology code.

Figure 3 presents our vision of the mainstream state-of-the-art categorization in ontological engineering [12], [13], [28] and may help students and analyst to figure out what type of ontology he/she really needs. We use Mindmanager™ and Cmap™ as they proved to be rather powerful visual tools.

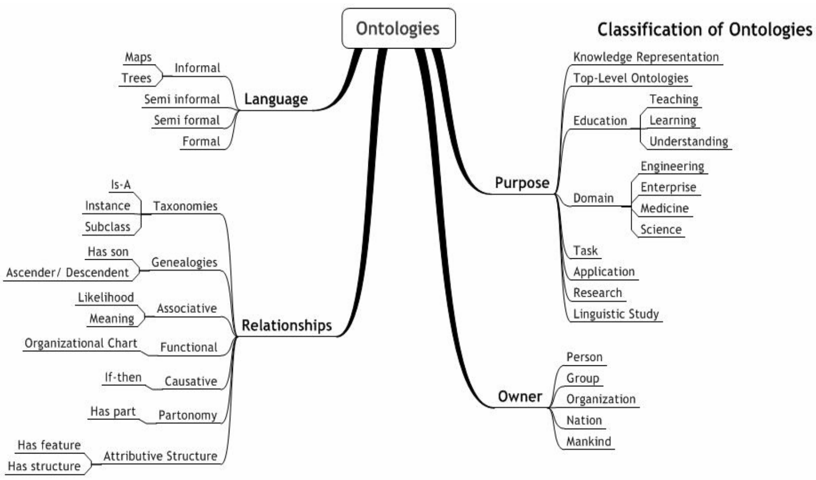

Fig.5. Ontology mind map

We try to simplify a bunch of different approaches, terms and notations for practical use (Fig. 5) and even dare to propose a 5-step recipe which help practical ontology design.

Exercises during training help us to evaluate and update it unless it starts to work.

Ontology Design Recipe

The existing methodologies describing ontology life cycle [28], [16], [9] deal with general phases and sometimes don't discover the design process in details. Five simple practical steps were proposed.

Step 1. Glossary development: The first step should be devoted to gathering all the information relevant to the described domain. The main goal of this step is selecting and verbalizing all the essential objects and concepts in the domain.

Step 2. Laddering: Having all the essential objects and concepts of the domain in hand, the next step is to define the main levels of abstraction. It is also important to elucidate the type of ontology according to Figure 1 classification, such as taxonomy, partonomy, and genealogy. This is being done at this step since it affects the next stages of the design. Consequently, the high level hierarchies among the concepts should be revealed and the hierarchy should be represented visually on the defined levels.

Step3. Disintegration: The main goal of this step is breaking high level concepts, built in the previous step, into a set of detailed ones where it is needed. This could be done via a top-down strategy trying to break the high level concept from the root of previously built hierarchy.

Step4. Categorization: At this stage, detailed concepts are revealed in a structured hierarchy and the main goal at this stage is generalization via bottom-up structuring strategy. This could be done by associating similar concepts to create meta-concepts from leaves of the aforementioned hierarchy.

Step 5. Refinement: The final step is devoted to updating the visual structure by excluding the excessiveness, synonymy, and contradictions. As mentioned before, the main goal of the final step is try to create a beautiful ontology. We believe what makes ontology beautiful is harmony.

Using these tips the students develop several huge practical ontologies to conduct systemically more structured research. This approach is based on developing of a set of ontologies:

- Problem-ontology definition (ontology N1 describing main concepts)
- Ontology of reviewed approaches (ontology N2 describing the history of the problem)
- Experiment framework design (ontology N3 presenting experimental conception)
- Data structure ontology (ontology N4 presenting input and output data)t
- Mathematical modelling and main results ontology design (ontology N5 describing results)

Not all five ontologies are obligatory, but even an attempt to create them is a first step to perform systemic scientific study.

Conclusion

Students and teachers both are knowledge workers. So students enter “the world of ontologies” with interest and begin to use it in their practical research work.

Our experience in training of knowledge analysts and teaching this course in the period of 1999-2006 confirm the unique role of knowledge structuring for developing ontologies quickly, efficiently and effectively. We follow David Jonassen’s idea of “using concept maps as a mind tool” [14]. The use of visual paradigm enables students to process and understand greater volume of information.

The course is double-ontological as the development of educational knowledge structures in the form of ontologies provides training and learning support. Teaching ontologies scaffold and improve students’ understanding of the courseware and later help to realize substantive and syntactic company knowledge. As such, they can play a part in the overall pattern of learning, facilitating for example analysis, comparison, generalization and transferability of understanding to analogous problems.

Ontological framework scaffolds the student’s research activity. But ontological engineering is rather easy for «old» sciences with good structure. Researchers in new, multi-disciplinary and ill-structured disciplines as HCI, cognitive sconces, management, etc. will face a bunch of difficulties in design and development phases. Ontologies also are rather subjective.

Our paper presents one of the first attempts to show the visionary role of knowledge engineering in helping student research. Ontologies are good for better self-understanding of research and then for knowledge sharing.

We also have experienced to teach the modification of this course to the practitioners. It was in-service training of analysts for IT-departments of some companies. The training was a success, as knowledge engineering is a unique set of methods that help everywhere. It is a real ‘silver bullet’.

Acknowledgements

This work is partly supported by the grant of Russian Foundation for Basic Research No.07-01-00053 and grant of Academy of Finland.

Bibliography

1. Adeli, H. (1994) Knowledge Engineering. McGraw-Hill, New-York
2. Boose, J.H. (1990) Knowledge Acquisition Tools, Methods and Mediating Representations. In Knowledge Acquisition for Knowledge-Based Systems (Motoda, H. et al., Eds), IOS Press, Ohinsha Ltd., Tokyo, pp.123-168.
3. Eisenstadt, M., Domingue, J., Rajan, T. & Motta, E. (1990) Visual Knowledge Engineering. In IEEE Transactions on Software Engineering, Vol.16, No.10, pp.1164-1177.
4. Fensel, D. (2001) Ontologies: A Silver Bullet foe Knowledge Management and Electronic Commerce. Springer.

5. Gavrilova, T., Voinov, A. (1998) Work in Progress: Visual Specification of Knowledge Bases // Lecture Notes in Artificial Intelligence 1416 "Tasks and Methods in Applied Artificial Intelligence", A.P.del Pobil, J.Mira, M.Ali (Eds), Springer, pp. 717-726.
6. Gavrilova, T.A., Voinov, A., Vasilyeva E. (1999) Visual Knowledge Engineering as a Cognitive Tool / Proc. of Int. Conf. on Artificial and Natural Networks IWANN'99, Spain, Benicassim. - pp.123-128.
7. Gavrilova, T. (2003) Teaching via Using Ontological Engineering // Proceedings of XI Int. Conf. "Powerful ICT for Teaching and Learning" PEG-2003, St.Petersburg, p. 23-26.
8. Gavrilova, T., Kurochkin M., Veremiev V. (2004) Teaching Strategies and Ontologies for E-learning // Int. Journal "Information Theories and Applications", vol.11, N1, pp.35-42.
9. Gómez-Pérez, A., Fernández-López, M., Corcho, O. (2004) Ontological Engineering with examples from the areas of Knowledge Management, e-Commerce and the Semantic Web, Springer.
10. Gruber, T. (1993) A translation approach to portable ontology specifications. Knowledge Acquisition , Vol. 5, pp. 199-220.
11. Guarino, N. & Giaretta, P. (1998) Ontologies and Knowledge Bases: Towards a Terminological Clarification. In Towards Very Large Knowledge Bases: Knowledge Building & Knowledge Sharing, IOS Press, pp.25- 32.
12. Guarino, N., Welty, C. (2000) A Formal Ontology of Properties. In R. Dieng and O. Corby (eds.), Knowledge Engineering and Knowledge Management: Methods, Models and Tools. 12th International Conference, EKAW2000. Springer Verlag, pp. 97-112.
13. Jasper, R. and Uschold, M (1999). A Framework for Understanding and Classifying Ontology Applications. In 12th Workshop on Knowledge Acquisition Modeling and Management KAW'99.
14. Jonassen, D.H. (1998) Designing constructivist learning environments. In Instructional design models and strategies (Reigeluth, C.M. (Ed), 2nd ed., Lawrence Eribaum, Mahwah, NJ.
15. Miller, G. (1956) The Magical Number Seven, Plus or Minus Two: Some Limits on Our Capacity for Proccessing Information. The Psychological Review, vol. 63, pp. 81-97.
16. Mizogushi, R. and Bourdeau J. (2000), Using Ontological Engineering to Overcome Common AI-ED Problems. International Journal of Artificial Intelligence in Education, v. 11, pp.1-12.
17. Neches, et al , (1991) Enabling Technology for Knowledge Sharing. AI Magazin, Winter, pp.36- 56.
18. OilEd, Bechhofer, S. and Ng G. Accessed from http://oiled.man.ac.uk/ at December 7, 2004.
19. OntoEdit, AIFB, University Karlsruhe Accessed from http://www.ontoknowledge.org/tools/ at December 07, 2004
20. OntoBroker, Accessed from http://ontobroker.aifb.uni-karlsruhe.de/ at December 7, 2004.
21. Ontolingua, Stanford University. Accessed from http:// www.ksl.stanford.edu/ software/ontolingua/ at December 7, 2004.
22. Protégé, Stanford Medical Informatics. Accessed from http://protege.stanford.edu/ at December 07, 2004.
23. Sowa, J. F. (1984) Conceptual Structures: Information Processing in Mind and Machine. Addison-Wesley, Reading, Massachusetts.
24. Scott, A., Clayton, J.E. & Gibson E.L. (1994) A Practical Guide to Knowledge Acquisition, Addison-Wesley.
25. Swartout, B., Patil, R., Knight, K. & Russ, T. (1997) Toward Distributed Use of Large-Scale Ontologies. In Ontological Engineering, AAAI- 97 Spring Symposium Series, pp.138- 148.
26. The CIO's Guide to Semantics, © 2004 Semantic Arts, Inc. www.semantic-conference.com
27. Tu, S., Eriksson, H., Gennari, J., Shahar, Y. & Musen M. (1995) Ontology-Based Configuration of Problem-Solving Methods and Generation of Knowledge-Acquisition Tools. In "Artificial Intelligence in Medicine", N7, pp.257-289.
28. Uschold, M., Gruninger M (1996). "Ontologies: Principles Methods and Applications", Knowledge Engineering Review,vol1, N1.
29. Wielinga, B., Schreiber, G. & Breuker J. (1992) A Modelling Approach to Knowledge Engineering. In Knowledge Acquisition, 4 (1), Special Issue, pp.23-39.
30. Werthheimer, M. (1959) Productive Thinking, HarperCollins.

Authors' Information

Tatiana Gavrilova – Professor Saint-Petersburg State Polytechnic University, Politechnicheskaya 29, 195251, St. Petersburg, Russia, gavr_csa@rambler.ru

Seppo Puuronen – Professor of University of Jyväskylä, P.O. Box 35, FIN-40014, Jyväskylänyliopisto, Finland, sepi@cs.jyu.fi