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Towards Web-Based Education of Demography

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Abstract. This paper describes steps taken towards introducing Web-based educational technology in teaching demography at the university level. Traditionally, demography is taught by giving lectures to the students, who are then expected to study from textbooks and exercise in demographic calculus. Some students find this way of learning monotonous and exhausting, hence their motivation gradually drops. Modern learning technology can help prevent such a situation, at least to an extent. Of course, using any technology to support teaching and learning requires representing essential parts of the domain knowledge with that technology first. The paper presents initial results in building such a knowledge infrastructure for Web-based education (WBE) in the domain of demography.

Key words: Web-based education, reusable learning objects and standards, teaching and learning technologies for WBE, demography.

Introduction

The importance of demographic studies increases progressively in the last 50 years, and so does the interest in integrating quantitative and theoretic knowledge of human population (Clarke, 1973; Pressat, 1972; Hinde, 1998). Currently, demography as a scientific discipline is taught mostly at universities, since it requires a certain level of maturity and prerequisite knowledge higher than that at high-school level. On the other hand, learning demography requires mastering of a number of abstract concepts and specific skills are required in order to progress in learning effectively. Unfortunately, traditional textbook-and-exercise way of learning such a discipline is not always effective.

This results in the need to introduce other approaches in teaching and learning in this domain. WBE has proven to be effective as a teaching and learning approach in a number of other disciplines, and it can especially increase the students' motivation when learning abstract concepts. From the teachers' perspective, it requires keeping up with the progress of technology in their own studies, and supports avoiding staleness in their knowledge and pedagogical skills. From the learners' perspective, it supports pro-active studying and systematic adoption of the domain knowledge.

We have taken several steps in order to gradually introduce WBE in teaching and learning demography at our university. First, a team of software professionals has built a Web classroom – a network-based technological support for learners that will help them utilize current Web technologies to grasp domain concepts more easily. Initial practical experience with the Web classroom in learning topics from other domains is extremely encouraging (Šimić and Devedžić, 2003). Second, we want to introduce the technology of Web-based *intelligent tutoring systems* (ITS) (Brusilovsky, 1999) in the Web classroom, so that adaptive and personalized learning will be supported. Finally, we are in the process of building Web-based knowledge infrastructure to enable easy creation of teaching material, intelligent support for learning, and reuse of learning resources.

Web Classroom

Our Web classroom is a client–server learning environment designed as in Fig. 1. Students and teachers work in a real or in a virtual classroom; in both cases, students learn individually and Web technology connects the server and the client sides. The Web classroom differs from more conventional computer-based learning in several aspects. First, it is an intelligent learning environment (an ITS), with built-in pedagogical module that guides the learning process. It also maintains a student model for each student registered with the system at any time. The student model stores all the necessary parameters about the specific student, such as his/her learning goals, learning history, learning style and other preferences, current level of topic/course mastery, and the like. Moreover, Web classroom's adaptivity and personalization in learning-material presentation ensures for adaptive, learner-centered individualization of the learning process. Finally, note that it is not necessary for the students and the teacher to sit at their computers at the same time – the built-in tutor (pedagogical module) takes over the role of the teacher in most sessions.

There are two major actors in this environment: the student on the client side, and the teacher on the server side. There are four modes of a student's interaction with the

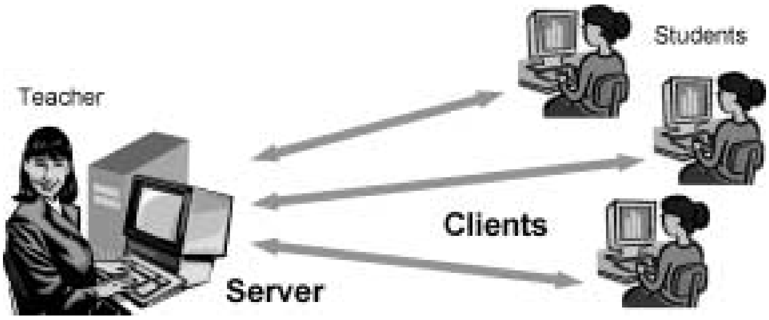


Fig. 1. A Web classroom.

Web classroom: "Authentication" (logging in for a new session), "Learning" (selecting one of the material to learn from and reading the corresponding illustrated lessons; some of the lesson pages are filled with text and graphics, and some of them also have supporting audio and video clips), "Assessment" (answering questions the system asks after the learning of a lesson is completed), and "Validation" (the mode in which the system checks and updates the student model by estimating the student's knowledge about different topics from the material he/she was supposed to learn).

The teacher is on the server side. His/her tasks include authentication, starting the server, monitoring the students' sessions, editing the domain knowledge (learning material) and stopping the server. Of course, these tasks are rather diverse (system administration, authoring, teaching, and assessment), hence in practice they are done by several specialists. Some of the tasks are very different from those on the student side – for example, editing the domain knowledge, which is allowed only to the teacher. In this mode, the teacher adds, edits or deletes the learning and assessment material. A specific server-side module, also accessible only by the teacher, is used for monitoring the students' sessions.

The server exhibits enough intelligence to arrange for *personalization* of the learning tasks it supports. In fact, from the learner's perspective the server appears to act as an intelligent tutor with both *domain* and *pedagogical* knowledge to conduct a learning session. It uses a *presentation planner* to select, prepare, and adapt the domain material to show to the student. It also gradually builds the *student model* during the session, in order to keep track of the student's actions and learning progress, detect and correct his/her errors and misconceptions, and possibly redirect the session accordingly.

Web-Based ITS

Research and development in the area of Web-based ITS have a long tradition. First-wave Web-based ITS like ELM-ART (Brusilovsky *et al.*, 1996) and PAT Online (Ritter, 1997), to name but a few, were followed by a number of other learning environments that used Web technology as means of delivering instruction. More recent Web-based ITS address other important issues, such as integration with standalone, external, domain-service Web systems (Melis *et al.*, 2001), using standards and practices from international standardization bodies in designing Web-based learning environments (Retalis and Avgeriou, 2002), and architectural design of systems for Web-based teaching and learning (Alpert *et al.*, 1999; Devedžić and Harrer, 2002; Mitrović and Hausler, 2000). Rebai and de la Passardiere try to capture educational metadata for Web-based learning environments (Rebai and de la Passardiere, 2002).

An important line of research and study in Web-based ITS is that of pedagogical agents, autonomous software entities that support human learning by interacting with students/learners and authors/teachers and by collaborating with other similar agents, in the context of interactive learning environments (Johnson *et al.*, 2000). Pedagogical agents help very much in locating, browsing, selecting, arranging, integrating, and otherwise using educational material on the Web.

Ontological Support for WBE of Demography

In order to enable authoring of learning material to support intelligent teaching and learning of demography in the Web classroom through a Web-based ITS, it is necessary to provide a substrate of essential domain knowledge for the ITS to be based on. Likewise, it is also important to develop such educational content on the server in accordance with important pedagogical issues such as instructional design and human learning theories, to ensure educational justification of learning, assessment, and possible collaboration among the students. Moreover, the core of both the domain (demographic) and instructional (pedagogical) knowledge should be made available in machine-understandable and machine-processable form for different courseware in the Web classroom to reuse them.

Ontological Infrastructure

The way to provide all that is to develop a number of shareable and reusable *ontologies*, as machine representation of the core-knowledge infrastructure around which knowledge bases of a demographic Web-based ITS can be built. Each such an ontology should provide a set of knowledge terms, including the vocabulary, the semantic interconnections, and some simple rules of inference and logic for some particular topic or service (Hendler, 2001). Once a number domain and instructional ontologies are developed, the author of learning material can rely on them in developing, representing and structuring the body of knowledge in the courseware he/she creates. With an appropriate authoring tool, the learning material gets automatically annotated with pointers to a number of shareable domain (as well as instructional) ontologies.

There are many concepts in demography that are used in other disciplines as well (e.g., population growth and migrations are important in political sciences as well). Hence different domains can share some ontologies or parts of them, and sometimes complex ontologies can be composed of several simpler ontologies. In other words, ontologies can be stored on different servers on the Web, can point to each other, and can be reused by educational applications and different courseware, Fig. 2.

Interoperability and knowledge sharing between different educational applications can be achieved by using appropriate *languages* for representing ontologies and edu-

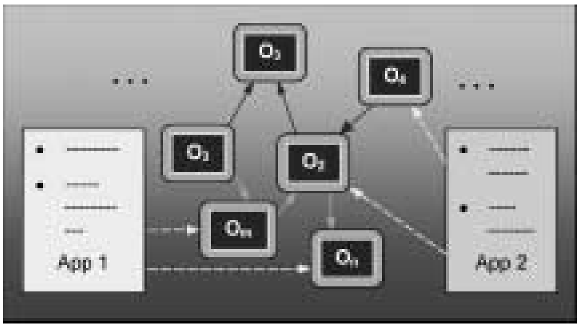


Fig. 2. Different Web-based ITS can share ontologies (O_i – ontologies).

cational content and services. Current trends in *Web technology* suggest that appropriate representation languages include *XML*, *XML Schema*, *RDF*, and *RDF Schema* languages, all developed under the auspices of WWW Consortium (`http://www.w3.org/XML`; `http://www.w3.org/RDF`). For developing domain ontologies, higher-level languages and graphical tools built on top of those four are a good choice.

Demographic Ontologies

For a demographic Web-based ITS, two kinds of ontologies are needed – demographic (domain) and pedagogical. We have developed some pedagogical ontologies according to the GET-BITS framework for building ITS (Devedžić *et al.*, 2000). They are applicable in different Web-based ITS, and are beyond the scope of this paper. As for domain ontologies, we have started designing and developing them relying on domain knowledge represented in well-known textbooks such as (Clarke, 1973; Pressat, 1972) and (Hinde, 1998).

Fig. 3 represents a part of the knowledge structure pertaining to some well known concepts in demography, according to (Clarke, 1973). We used it as the starting point for developing a set of demographic ontologies. Without going into more detailed explanations, it suffices to say that *population composition* denotes population structure based on the value or modality of a certain criterion. While the notion of the concepts from Fig. 3 is intuitively clear, it should be noted that other authors may have a different categorization.

Starting from these concepts and a number of other demographic concepts, their relationships and attributes, as well as from formulae needed to calculate various quantitative demographic indicators, we have designed and developed a set of demographic ontologies. We used the Protégé-2000 ontology development environment (`http://protege.stanford.edu/`). The following section presents details.

Design and Implementation

Fig. 4 a screenshot from *Population composition* ontology, one of the demographic ontologies that we developed using the knowledge structure from Fig. 3. In order to make

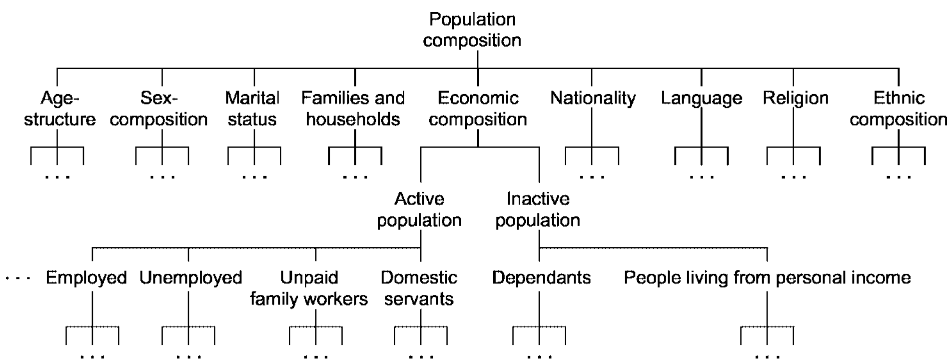


Fig. 3. Important concepts in demography.

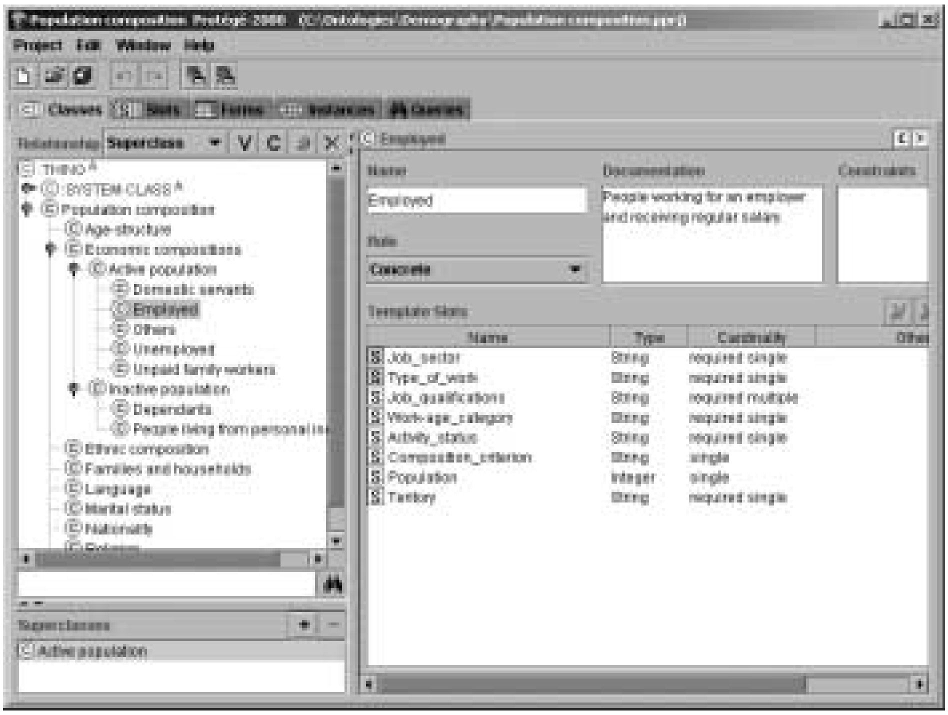
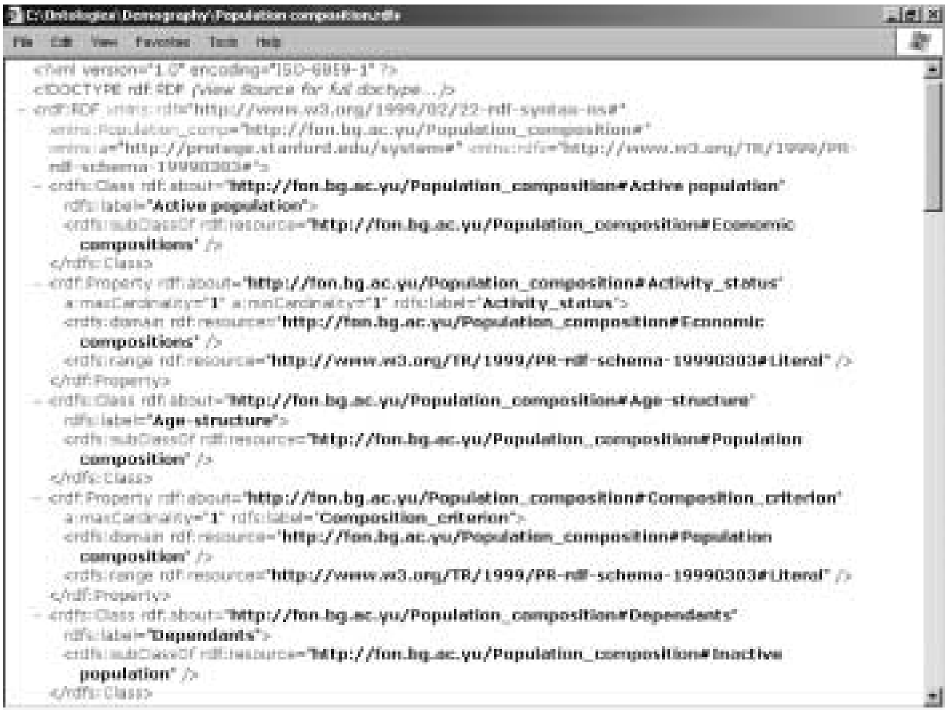


Fig. 4. Creating *Population composition* ontology in Protégé-2000.

our ontologies shareable and reusable, we converted them into RDF Schemata. Fig. 5 shows an example.

We have also developed ontologies related to *population growth*. Population growth depends on two components, *natural increase* (expressed in terms of *fertility* and *mortality*) and *net migrations* (i.e., *immigration* and *emigration*). A quantitative indicator showing the rate of population change is the *population increase rate*. Simple formulae are used to compute population increase rate and other quantitative indicators to initialize instances of the corresponding ontologies.

We are perfectly aware of the fact that our ontologies are not completed yet, neither individually, nor as an interrelated set of ontologies. It is now left to their users and domain experts to notify us of the usability and deficiencies of the ontologies we developed, and it is our responsibility to refine them in the future. As for the users, our intended users at the moment are Web courseware authors for our Web classroom. Indirectly, the students who are supposed to learn from the material the authors develop are also the users and potential critics of design of our ontologies. Once the design is refined to a satisfactory extent, we also hope for feedback from other institutions whose Web applications need demographic knowledge sharing and reuse, such as bureaus of statistics, electoral bodies, and other government organizations.



```
<?xml version="1.0" encoding="ISO-8859-1" ?>
<!DOCTYPE rdf:RDF (View Source for full doctype...)>
- <rdf:RDF xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
   xmlns:Population_comp="http://fon.bg.ac.yu/Population_composition#"
   xmlns:a="http://protege.stanford.edu/system#" xmlns:rdfs="http://www.w3.org/TR/1999/PR-
   rdf-schema-19990303#">
 - <rdfs:Class rdf:about="http://fon.bg.ac.yu/Population_composition#Active population"
     rdfs:label="Active population">
     <rdfs:subClassOf rdf:resource="http://fon.bg.ac.yu/Population_composition#Economic
       compositions" />
   </rdfs:Class>
 - <rdf:Property rdf:about="http://fon.bg.ac.yu/Population_composition#Activity_status"
     a:maxCardinality="1" a:minCardinality="1" rdfs:label="Activity_status">
     <rdfs:domain rdf:resource="http://fon.bg.ac.yu/Population_composition#Economic
       compositions" />
     <rdfs:range rdf:resource="http://www.w3.org/TR/1999/PR-rdf-schema-19990303#Literal" />
   </rdf:Property>
 - <rdfs:Class rdf:about="http://fon.bg.ac.yu/Population_composition#Age-structure"
     rdfs:label="Age-structure">
     <rdfs:subClassOf rdf:resource="http://fon.bg.ac.yu/Population_composition#Population
       composition" />
   </rdfs:Class>
 - <rdf:Property rdf:about="http://fon.bg.ac.yu/Population_composition#Composition_criterion"
     a:maxCardinality="1" rdfs:label="Composition_criterion">
     <rdfs:domain rdf:resource="http://fon.bg.ac.yu/Population_composition#Population
       composition" />
     <rdfs:range rdf:resource="http://www.w3.org/TR/1999/PR-rdf-schema-19990303#Literal" />
   </rdf:Property>
 - <rdfs:Class rdf:about="http://fon.bg.ac.yu/Population_composition#Dependants"
     rdfs:label="Dependants">
     <rdfs:subClassOf rdf:resource="http://fon.bg.ac.yu/Population_composition#Inactive
       population" />
   </rdfs:Class>
```

Fig. 5. The RDF Schema representation of the *Population composition* ontology.

Our demographic ontologies are parts of ongoing implementation of online teaching and learning material to be used in our Web classroom. Technical implementation details are presented in extenso in (Šimić and Devedžić, 2003).

Related Work

The research in ontologies in general is already maturing, and so is the research in Web-based education. However, in the demographic research and education community the work on ontologies is only at its beginning. A notable exception is a research project in the Netherlands, aimed at finding a theoretically and methodologically correct definition and measurement for the population at risk and the birth rate in the demography of firms (Brons, 2001). It uses ontological analysis and symbolic logic as the main research tools to clarify these concepts.

Other relevant research includes certain categorizations and hierarchies of demographic concepts, important for building ontologies. Although there is no official standardized terminology and taxonomy of demographic concepts, such publicly available thesauri and hierarchies represent important starting points to both ontological research and standardization in this knowledge area. Examples include the thesaurus published by the French Committee for International Cooperation in National Research in Demography (CICRED, 2003) and the one published by The British Academy (British Academy, 2003). Interestingly, some of such online thesauri are published by multidisciplinary institutions and organizations, not only by demographers. For example, the National Institute on Alcohol Abuse and Alcoholism in USA has published an AOD Thesaurus: annotated hierarchy of concepts from demography and epidemiology (National Institute on Alcohol Abuse and Alcoholism, 2003). Other ontologically founded taxonomies and hierarchies of demographic concepts can be found in general-purpose knowledge servers, such as CYC (CYC Corporation, 2003).

Conclusions

Since the GET-BITS view of both pedagogical and domain ontologies is that they should evolve, we started with a small set of ontologies that represent widely known demographic concepts. Although they are not highly elaborated yet, they still provide at least a limited initial semantic interoperability across pedagogical agents, courseware, tools, and educational servers. If over time these ontologies prove to be really useful for developing demographic Web-based ITS, it makes sense to believe that they will get upgraded and extended over time. If, on the other hand, they fade away, it is highly likely that some other, competing ontologies in the domain of demography, possibly published elsewhere on the Web, will gain more attention and will become more widely used for developing courseware for our Web classroom.

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Žiniatinkliu grindžiamas demografijos mokymo būdas

Mirjana DEVEDŽIĆ, Vladan DEVEDŽIĆ

Šiame straipsnyje aptariamas žiniatinkliu pagrįstų švietimo technologijų taikymas universitetinio lygio demografijos dalyko mokyme. Paprastai studentai mokomi demografijos jiems skaitant paskaitas bei reikalaujant, kad studentai mokytųsi iš vadovėlių bei atliktų demografinių skaičiavimų pratimus. Kai kurie studentai tokį mokymosi būdą laiko monotonišku bei sekinančiu, dėl to palaipsniui ima blėsti jų motyvacija mokytis. Modernios mokymo technologijos gali užkirsti kelią tokiai situacijai rastis, ar bent jau mažinti jos mastus. Žinoma, norint bet kokią technologiją naudoti mokymo ar mokymosi tikslais, pirmiausia reikia susipažinti su pagrindinėmis žiniomis apie ją. Šiame straipsnyje kaip tik ir kalbama apie pirmuosius pasiekimus kuriant tokią žiniatinkliu grindžiamo švietimo (WBE – Web Based Environment) infrastruktūrą demografijos srityje.

Tam, kad palaipsniui supažindintume su šio būdo teikiamomis galimybėmis mokant ir mokantis demografijos universitete, mes numatėme keletą priemonių. Pirmiausia, profesionalių kompiuterininkų komanda įrengė žiniatinklio klasę, kurioje besimokantieji galėtų pasinaudoti esamomis žiniatinklio technologijomis tam, kad kuo lengviau įsisavintų mokomąją medžiagą. Pirmieji žiniatinklio klasėje vykę praktiniai užsiėmimai, susiję su kitų mokomųjų dalykų temomis, teikė daug vilčių. Antra, tam, kad paskatintume šitaip pertvarkytą bei pritaikytą asmeniniams poreikiams mokymąsi, šioje klasėje įdiegėme žiniatinklio technologijomis pagrįstas intelektualaus mokymo sistemas. Galiausiai, tam, kad palengvintume mokomosios medžiagos pateikimą, suteiktume intelektinę paramą mokymuisi bei galėtume pakartotinai naudoti mokymo išteklius, ėmėme kurti žiniatinkliu pagrįstą infrastruktūrą. Ši infrastruktūra remiasi daugeliu ontologijų, kurių kiekviena pateikia tam tikras žinių išraiškas, tokias kaip žodynas, semantiniai ryšiai bei elementarios išvadų darymo ar loginio mąstymo svarstant konkrečią temą taisyklės.