Promoting Knowledge Practices in Electronic Education

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Abstract – **The paper considers challenges that face educational institutions to meet requirements of knowledge society. Reconstruction of curriculum at the Electronics Department and re-designing courses and pedagogical practices to promote necessary competences is also discussed. The results from pilots courses conducted in ASIC Design and VLSI Design are also highlighted.**

Keywords – **knowledge society, collaborative learning, knowledge practices, knowledge work competences**

I. Introduction

The emergence of the knowledge society, building on the extensive influence of modern information and communication technologies (ICTs), create conditions for a fundamental reshaping of the global economy.

Knowledge has always been a factor of production, and a driver of economic and social development. The digitisation of information and widespread of the Internet facilitate a new intensity in the application of knowledge to economic activity, to the extent that it has become the predominant factor in the creation of economic growth.

In an increasingly global economy, effective creation, use and dissemination of knowledge is the key to success. Current technology now offers many more possibilities for sharing, archiving, retrieving, combining and generating new knowledge.

Knowledge society is identified as society based on the creation, dissemination and utilization of information and knowledge. It is characterised with four main pillars – Education, ICT, Science and Technology, and Innovation as shown in Figure 1. [1]

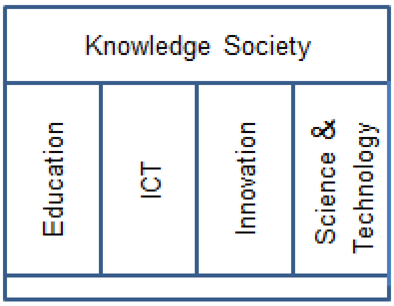

Fig. 1. Four main pillars of a knowledge society

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Education is of vital importance in the knowledge society, as a source of basic skills, as a foundation for development of new knowledge and innovation, and as an engine for socio-economic development. Education is, therefore, a critical requirement in creating knowledge societies that can stimulate development, economic growth, and prosperity.

Rapid changes and demands of the knowledge society, acceleration of technology and networking challenge educational institutions to reconsider and revise their curricula and pedagogical practices to ensure that students acquire necessary future competencies during upper secondary and university education.

The paper discusses efforts done in the Department of Electronics at the Technical University of Sofia to reconstruct curricula and pedagogical practices to promote necessary competences. A case study of applying trialogical approach to learning in bachelor and master degree courses is discussed. The results from pilots conducted in ASIC Design and VLSI Design courses are also highlighted.

II. Curriculum Development

Electronics curriculum at TU-Sofia was reconstructed and updated after a thorough examination [2], including:

- Research and analysis of labor market
- Interviews with employers
- Research and analysis of existing curricula
- Study of the curricula and syllabuses of world leading universities.

Representatives from business, industry, and labor were strong collaborators with educators in the effort to identify desired learner outcomes that represent what students should know as the result of their education. These business people have a first-hand understanding of the skills that students need and the specific concerns and work opportunities in the area.

Business partners share the requirements and standards their employees must reach to be successful. They provide information on current industry practices; give examples of classroom concepts applied in the workplace through industry standards, documents, and activities derived from real experiences at the worksite.

Restructured curriculum should improve theoretical knowledge (analytical approach to apply theoretical knowledge) and practical skills (experience in using software and CAD tools), improving practical work with the specifications and standards [3] .

The recommendations from business partners for the new upgraded curriculum include:

- to increase students' practical training – more exercises using modern equipment and methods.
- to enhance the using of English language – technical

English for presentations as well as ability to speak fluently including project defense in English
- more practically oriented projects
- more individual practical work with CAD systems
- end skills for debugging

Some university teachers expressed concern that the involvement of business and industry in the planning of the curriculum will lead to less academically oriented curriculum and will focus on skills and training useful for a specific job. They believe that business and industry should not dictate what university should be teaching to students especially in era of rapidly changing technology and market conditions, which require broader education in principles rather than in particular skills.

Developed integrated curriculum keeps the focus on educational objectives taking into account all suggestions, academic and industry standards. It supplies opportunities for students to work on tasks and assignments that have a career focus and to obtain valuable experience.

III. New Pedagogical Design

Present-day students will be employed in positions representing modern knowledge work. These involve abilities of group work, collaborative learning, networking, working in multidisciplinary and multicultural teams, complex problems, and dealing with uncertainty and confusion.

Changing of curricula and the content of specific subject area are not enough to meet requirement of knowledge society. The question is how university students should be taught to guarantee learning of knowledge work competences.

The features of learning activities promoting learning of knowledge work competences include [4]:
- facing open-ended problems,
- utilization of community's collective efforts and resources,
- rich use of modern technologies,
- encounters with real-world complexity,
- utilizing multiple knowledge sources,
- various types of authentic tasks

This requires new pedagogical practices to be developed to promote necessary competences. Trialogical approach to learning is one possible solution to these challenges.

B. Trialogical approach

Thrialogical approach builds on the assumption that learning is not just individual knowledge acquisition (monological) or social interaction (dialogical), but activity is organized around transforming, or creating shared knowledge objects (see Figure 2) [5].

While the *acquisition* and *participation* approaches provide valuable resources, respectively, for understanding individual and social aspects of learning, these metaphors do not appear to provide tools for understanding deliberate processes of advancing and creating knowledge typical of knowledge-intensive work in the present age. The *trialogical* approach is intended to elicit innovative practices of working with knowledge within educational and professional communities.

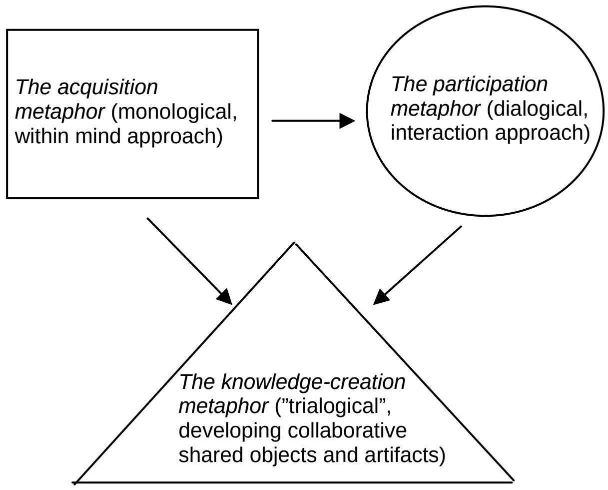

Fig. 2. Three metaphors of learning

Design principles for the trialogical pedagogy include:
- DP1. Organizing activities around shared "objects" (plans, reports, models)
- DP2. Supporting integration of personal and collective work
- DP3.Emphasizing development and creativity through knowledge transformations and reflection
- DP4. Fostering long-term processes of knowledge advancement
- DP5. Promoting cross-fertilization of knowledge practices and artifacts across communities
- DP6. Providing flexible tools for developing artifacts and practices

The problem is how to re-design our courses to better promote students' knowledge work competencies and how to implement the trialogical design principles in own teaching.

C. New pedagogical solution – project based course

Before restructuring the pedagogical practices used in our teaching, we have carefully reviewed our courses, their positive outcomes and drawbacks. Currently, to the students in the laboratory are given many unrelated tasks they perform in groups of 3-4 people. Each student should individually prepare a separate report on the outcome of the practical work. Teacher guides individual student when needed.

This way of conducting training allows some students just to attend in classes without being actively involved in the tasks during the semester. Teachers cannot assess the progress of students as they evaluate the final product of their work. Since the multiple tasks are the same for all students most of them just copy the reports from their colleagues without understanding. Because assessment is based on individual final product, the teacher has thoroughly to conduct face-to-face examination of each student in order to evaluate him correctly.

We decided to reconstruct the whole course to give students opportunity to work collaboratively in group with clear role of each participant in common work. In course redesign we have used examples and experiences from previous courses based on trialogical approach on learning, which are summarized in Table 1 [6].

Instead of giving students many separate or loosely connected tasks we provide them with a large task (a three month long project), continuous working process, shared research plan and final presentation in groups. All group activities are organized around shared objects – collaboratively development of common project, and preparation of shared report.

Project development in such practice permits for self-selected time and place allocation of the participants and teachers. Guidance is provided through systematic instructions and group work rules. Assessment includes process and product assessments, group's self-assessment, and contribution evaluation of each participant to the collaborative project development.

TABLE 1. COMPARISON OF PEDAGOGICAL PRACTICES

Previous practices	New "trialogical" practices
Acquiring concepts and theories	Examining applied problems and solutions
Individual tasks and products	Solutions and products in groups; responsibility roles;
Separate or tightly connected tasks	Continuous working process with interconnected tasks
Sharing only the final product	Iterative product development; sharing drafts
Technology used for commenting. email in use	Technology used also for co-authoring; also some social software applications in use
Teacher's guidance for individual students when needed	Teachers' tailored guidance for groups
Teacher's approval or grading based on the final product; self-assessment at the end	Process and group product evaluation; peer evaluation self-assessment of group work

This approach permits for educational methods of direct student-educator contact that are not face-to-face, but are mediated through new communications technologies. Online communication allows students and academics to remain separated by space and time, but to sustain an ongoing dialogue.

IV. ONLINE LEARNING PLATFORM

C. Collaborative workspace for project work

The environment consists of public cloud based services, combined in a way that supports collaborative electronic design projects development (see Figure 3). The VLSI design courses are project oriented. Working in teams of 2-3 persons, the students are required to design a digital integrated circuit.

The design workflow is based on modelling, verification and synthesis. The language of choice is VHDL. An effort is made to follow the test driven development process - first create a test-bench then the model that makes all the tests pass. Students are aware that the comprehensive test coverage will be one of the primary project evaluation and scoring criteria. All tests-benches should be self-checking - i.e. no "manual evaluation" of the simulation results should be required to determine the correctness of the model.

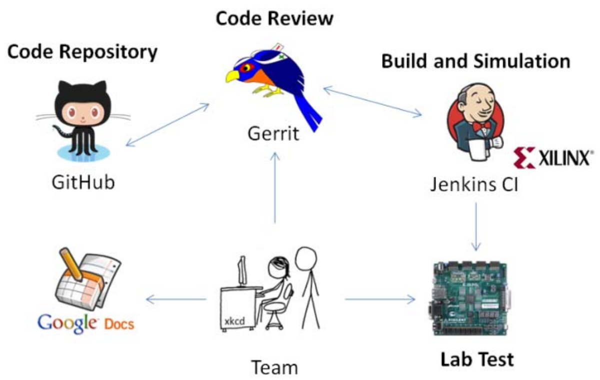

Fig. 3. Collaborative workspace structure

The main design artefacts (VHDL models and test-benches) are text files; therefore we are able to borrow many tools and workflows from the software development community. Projects are hosted on GitHub [7] – one repository per project.

Team members have a collaborator rights for the respective repositories, but they were asked not to commit directly. Each change had to be peer reviewed before it can be committed to the project repository. For the first pilots, the code review was done on a private Gerrit [8] installation. In the future we intend to explore GerritHub [9] which is well integrated with GitHub.

When a team member submits a change for code review, the project is automatically built and the tests are executed. The build infrastructure consists of Jenkins [10] continuous integration server and Xilinx FPGA design tools [11]. Each project has a Jenkins build job which executes the Xilinx tools via shell scripts. The outcome of the build job is reported back to Gerrit as +1 (pass) or -1 (fail) vote, but they are not enough to approve or reject a change.

Another team member shall perform a code review and either approve the change (+2 vote) or return it to the submitter for rework. Gerrit allows the reviewer to attach comments to a source code file or a particular line inside the file (Figure 4).

In parallel with the code development, the teams are required to create and maintain a Google Docs document which is one of the major deliverables. Initially the document contains the technical specifications of the design. Later on, the students have to add description of the implemented algorithms and architectures, argumentation of the tradeoffs made and the results from the simulation, synthesis and physical design.

Most of development takes place outside the regular classes. For their intra-team communication, the students are free to choose whatever tools they prefer (chat, conferencing, email).

For student - teacher communications we decide to use the Google tools: Gmail, Docs, Talk, Calendar, Drive and Google+. Students were encouraged to submit their questions as emails instead of chat messages.

The teams can test their projects in the laboratory during the scheduled classes.

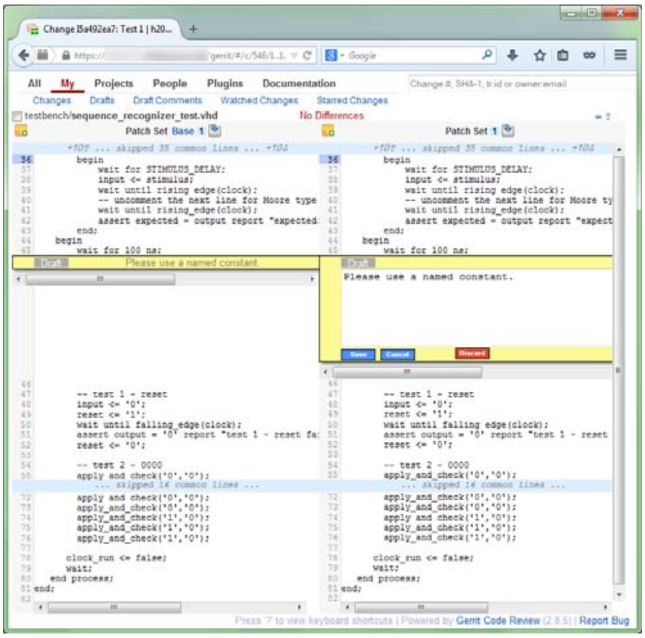

Fig. 4. Code review with Gerrit

V. PILOTS ACTIVITIES

The pilots were conducted with two classes – fourth year bachelor (10 weeks) and first year master students (15 weeks). In addition to the project work, students were required to submit five individual homework assignments. Each team had to choose a project subject from a list provided by the teacher. Two project milestones were set – intermediate report and final report.

All participants had to register individual Google and GitHub accounts. The teacher was responsible for creating a Google Docs document for each project report and sharing it with the team.

Students were encouraged to ask for help or advice, via email, at any time and not to wait for the scheduled classes. Usually they were getting a response during the same day. Announcements were made on a Google+ hangout and via email. Each class had a Google calendar with all relevant milestones and class schedules.

At the end of the semester, the projects were presented by the teams. The scores were based on the project outcome, the individual homeworks and the activity of the student during the semester (email, participation in discussions, git commits).

VI. CONCLUSION

Introducing new technologies and paradigms in established engineering courses is always challenging. In addition to the core subject matter, students had to learn new tools and development workflows. In a whole, it has been a rewarding experience for both students and teachers. Bellows is a summary of the positive and negative outcomes of the pilot courses:

- The students appreciated the visibility of their contributions to the project – git commit history and Google doc revision history.
- Playing (and learning) with new technologies is fun. Although the students had no previous experience with version control and code review tools, they were not intimidated. Most of them enjoyed playing with the new toys and learning "cool" new skills.
- The immediacy of the help provided via email, compared to the scheduled face to face meeting, was cited as a major plus in the post-course surveys. Students were doing most of the thinking and development during the weekends and evenings. Being able to receive a timely advice on their design problems was highly regarded.
- The introduction of relatively complex, "real world" design workflows and tools highlighted even more the difference between the motivated teams and the students that just wanted to "get over it". This observation was confirmed by the scores distribution – most were clustered in the top and bottom of the scale with very few in between.

ACKNOWLEDGEMENT

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