Teaching with Technology: Promoting Knowledge Work Practices in Technology School Education

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Abstract – **The paper considers challenges that face educational institutions to meet requirements of knowledge society. Based on brief introduction of trialogical learning approach, the educational practices to promote necessary competences are outlined. Against this background the effort done at Technology School "Electronic Systems" in changing pedagogical practices to promote collaborative knowledge creation in technology-rich environment is considered. The compulsory course re-designing from traditional face-to-face to project oriented applying modern online learning platform, cloud collaboration and social software is discussed. The results from pilots conducted in using collaboratively development of shared project are also highlighted.**

Keywords – **trialogical approach, project oriented online learning, cloud collaboration.**

I. INTRODUCTION

Knowledge has always been a factor of production, and a driver of economic and social development. The digitization 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. 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 [1].

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. Workers at all levels in the 21st century knowledge society will need to be lifelong learners, adapting continuously to changed opportunities, work practices, business models and forms of economic and social organisation [2]. Education is, therefore, a critical requirement in creating knowledge societies that can stimulate development, economic growth, and prosperity.

Thus, effective education in a knowledge society must also deal with sharing information, knowledge, and other resources. In this context, the link between ICT, education and development appears obvious.

A current challenge for education is to prepare learners for the emergent knowledge society through appropriate pedagogical practices that promote competencies for sharing, creating and working with knowledge and knowledge artifacts in an innovative way. Formal education is expected to develop methods that support students in acquiring versatile competencies for knowledge work.

The current approaches of working with knowledge in educational are still focused on individuals' skills and knowledge structures (knowledge acquisition) on the one hand, or on social and cultural interaction (participation) on the other hand. The problem is that they do not provide sufficient models for facilitating processes of knowledge creation with related technological, practical and organizational means.

The key features of 21st century pedagogy include [3]:

- Building technological, information and media fluencies;
- Developing thinking skills and making use of high order thinking skills;
- Making use of project based learning;
- Fostering problem solving as a teaching tool;
- Using assessment with timely, appropriate and detailed feedback and reflection;
- Encouraging collaboration using enabling and empowering technologies;
- Fostering contextual learning bridging the disciplines and curriculum areas.

To teach using 21st century pedagogy educators must be student centric. The curricula and assessments must be inclusive, interdisciplinary and contextual based on real world examples. Educators must develop, in students, key fluencies and make use of higher order thinking skills. They should make use of collaborative, project based learning, using enabling tools and technologies to facilitate this. Teachers must establish a safe environment for students to collaborate in but also to discuss, reflect and provide and receive feedback in.

Educational analysts and industry representatives report that students leave higher education with an underdeveloped ability to solve open-ended problems. Pedagogical methods are still largely based on well-defined problems with known solutions. Facing with real-world complexity and collaboratively solving complex problems are ways of bringing educational practices closer to the requirements of the surrounding society. This is a same challenge for secondary and higher education. Secondary schools should prepare students for the practices of higher education, including demands for more independent studying and managing complex, open-ended tasks, which are not well supported in the rather teacher-centered practices in secondary schools today.

To answer these challenges the KNORK (Promoting Knowledge Work Practices in Education) project [4] aims at developing pedagogical models and technology to support collaborative practices in technology-rich environment. The focus is on supporting secondary and tertiary level teachers to promote students' knowledge-related practices where digital

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competence is crucial. KNORK is an EU-funded integrated project with 9 partners from 4 countries. The partners represent the synergies between high education institutions and secondary schools in each country.

The paper discusses efforts done at the Technology School "Electronic Systems" associated with the Technical University of Sofia to include new technologies and creative pedagogies in the curriculum to address knowledge work practices and digital competence. Such key competencies are most effectively acquired through collaborative learning approaches around shared advancement of knowledge objects. A case study of restructuring Computer Aided Design (CAD) in Electronics course to promote knowledge work practices in cloud environment is considered. The result from pilots conducted with 11 grade students (17 years old) are also highlighted.

II. 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.

The development of schools through the introduction of information and communication technology (ICT) is a central focus of educational discussion. New strategies are needed because research results indicate that pedagogical change in schools through ICT has not actualized as expected. Teachers often reproduce practices focusing on content learning rather than use technologies to foster higher-order innovation skills.

There is an emergent trend to highlight knowledge creation practices as a basis for understanding modern knowledge work, but fewer pedagogical approaches for promoting related competencies. Often the focus is still on the individual acquisition of domain knowledge, although increasing amounts of study programs are based on modules including distance learning, group work or web-based discourse. Besides these monological (acquisition of knowledge by individuals) or dialogical (participation in social interaction) models, there is a need for practical examples of supporting "trialogical" learning (collaborative knowledge creation): processes where the aim is to develop new products and solutions as in real knowledge work [5].

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. 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. In order to achieve this aim, it is essential to increase cross-fertilization between schools, higher education institutions and professional organizations. Students on all levels need to apply their expertise in interdisciplinary, goal-oriented projects that go beyond separate, single study units.

III. New Pedagogical Solution – Collaborative Project Based Course in the Secondary School

Our primary goal was to investigate and develop pedagogical practices that support students' knowledge work competences using trialogical design principles.

The problem was how to re-design our courses to better promote students' knowledge work competencies and how to implement the trialogical design principles in own teaching, using modern computer and communication technologies. The CAD in Electronics course in the Technology School "Electronic Systems" was re-designed to be project oriented.

The goal of course restructuring was:

- To increase the commitment and motivation of students, engaging them through 21st Century Learning.
- To meet the requirements of business for better practical training, team work on common task, shared responsibility for the quality of the overall product, distribution of tasks in line with the specified deadline.

In order to achieve these objectives new educational approaches are introduced, which use cloud computing technologies, up-to-date communication tools for student-teacher connection, continuous monitoring and assistance of students' activities. The compulsory course plan for education in "CAD in Electronics" was re-designed to implement the trialogical design principles, as shown in Table 1.

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. 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.

Working in teams of 2 persons, the students are required to design and simulate digital and analog circuits. During the long term projects teams have to gather information, discuss the given problem in collaborative environment, analyze and simulate the digital or analog circuit using dedicated CAD software – Cadence Orcad Capture and Pspice. 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.

IV. Collaborative Workspace for Project Work

For the collaborative project development the environment consists of public cloud based services, combined in a way that supports collaborative electronic design projects

development (see Fig. 1). Tools for collaborative development of a common shared object in the cloud are used, which makes the participation of each member independently of the others in any place and at any time – Google Drive, Google Docs, Google Sheets.

Google calendar aims to set deadlines and to monitor progress – assignments, intermediate stages reporting, deadline for submission of project.

Table I. IMPLEMENTATION OF TRIALOGICAL DESIGN PRINCIPLES IN "CAD IN ELECTRONICS" COURSE

Design principle	Implementation in own teaching
DP1: **Organizing activities around shared objects**	Collaboratively development of common project, and preparation of shared report Teams formation (team members will choose the partners they want to work with). Task distribution between the members of a team Teaching activities: regular meetings for discussion project tasks and preliminary review of the used tools and the progress of the project development
DP2: Supporting integration of personal and collective agency and work	Coordinating participants – team members to choose an appropriate project they want to develop (offering lists of possible projects themes). Motivating students to distribute tasks between team members having respect to project deadline. Collective responsibility – all members in a group should contribute to the group solution. Each member of the group takes the responsibility for his/her project task. They should decide on their own how each one does this. There is freedom to choose on which parts of the solution each member will contribute.
DP3: Emphasizing development and creativity through knowledge transformations and reflection	Discussion and analysis of problems the teams faced during their collective work on the common project. Support versatile use of various kinds of knowledge: theoretical or literary sources; practical examples and cases. Students comment on each other's / other groups work throughout the course Practice already gained knowledge and skills in using dedicated CAD software to solve the tasks of the project. If students need help they can always send messages to the teachers and get the supervision needed. Reflection: Students are expected to reflect on their individual report regarding their collaboration in the group
DP4: Fostering long-term processes of knowledge advancement	Prolonged working process with iterative circuits simulations – performing number of analysis of the designed circuit to refine the circuit parameters and characteristics. Planning and writing reports, sharing the drafts, asking the teacher and other students for feedback, improving the project and project documentation, submitting respective report and presenting the obtained design and simulation results. Using forums, blogs and social media for discussing problems and talk about their points of view and opinions.
DP5: Promoting cross-fertilization of knowledge practices and artifacts across communities	Students collaborate with specialists from the CAD industry. Students are provided with professional project work models, working templates, and good examples. Industry professionals, teachers and students discuss and analyze collaborative experience. Students use modern professional tools to plan, organize, and execute the project tasks and to write project documentation.
DP6: Providing flexible tools for developing artifacts and practices	Skype for face to face and virtual meetings. Google Apps for easy sharing materials or/and comment. Google Docs for collaborative editing and commenting. Google Drive for file sharing. Google+ for discussions. As alternative a CMS based site might be a suitable solution. Project management –Google Apps The Google Calendar is very useful for project scheduling – related events by sending RSVP invitations (request for a response from the invited person or people)

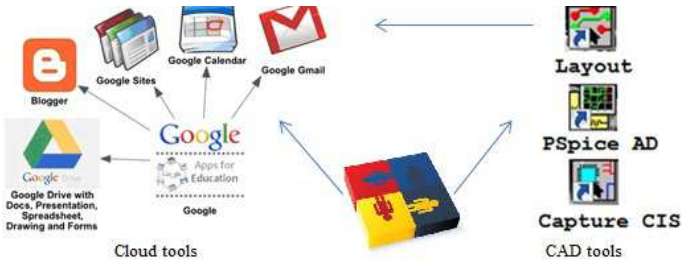

Fig. 1. Collaborative workspace structure used in CAD course

Most of developments take 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 (see Fig. 1): Groups, Gmail, Docs, Talk, Calendar, Drive and Google+. Students were encouraged to submit their questions as emails instead of chat messages.

In addition to long term project development the students have to prepare several weekly assignments, in the field of Analog and Digital circuits design and simulation. These

homework activities are presented, discussed and analyzed in the class and uploaded in Google Drive and Google Site of the CAD Course (See Figs 2 and 3).

V. Pilots Activities

To experiment trialogical approach we have conducted pilot courses using collaboratively development of shared project with two classes of 52 students – 11 grade classes (17 year's old students) within 15 weeks. Each team had to choose a project subject from a list provided by the teacher. In addition to the project work, students were required to submit several homework assignments. All participants had to register individual Google accounts. The teacher was responsible for creating a Google Docs document for each project report and sharing it with the team.

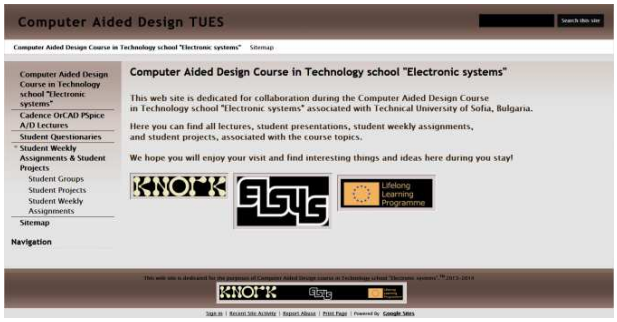

Fig. 2 Home Page of Google Site of CAD Course

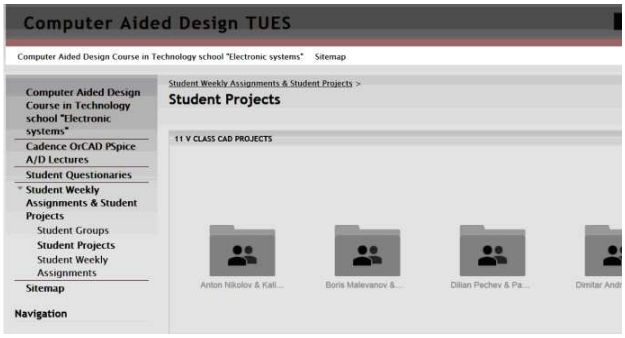

Fig. 3 Students Projects in CAD Course

In the beginning of the course a pre-survey was done. A questionnaire was sent to the students in order to find out more about their background and study skills. After the course the students were asked several questions to evaluate students' self-reflections concerning knowledge work practices related to their experiences in the implemented CAD course and to observe their progress. The 35 students' answers to the seven statements after the course are reported in Fig. 4 together with their answers to the statements before the course.

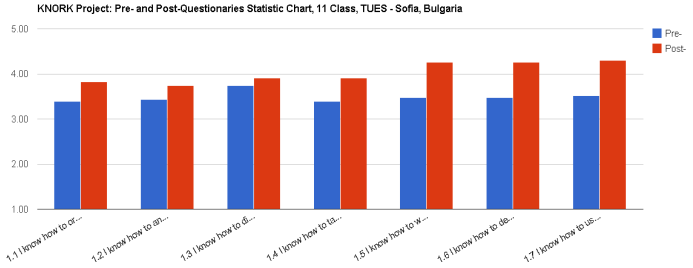

Fig. 4. Average of the students' answers

VI. Conclusion

The paper discusses a course redesign to promote new pedagogical practices, which were successfully used for introducing knowledge work in compulsory course "CAD in Electronics" at secondary education. These practices include longitudinal work supporting in-depth focusing and students' collaboration for a shared outcome. Students learned knowledge work practices (e.g., information processing, analysis and presentation, sharing, versioning, as well as commenting, using cloud digital tools and group work).

Introducing new technologies and paradigms in established courses is always challenging. In addition to the core subject matter, students had to learn new tools. Besides their knowledge on the subject they acquire skills to work in a team and to use advanced tools for collaboration and communication in the network. The restructured course gives the students opportunity to obtain better:

- Practical knowledge in electronic circuits design;
- Ability to use up-to-date professional tools for circuit design;
- Skills in teamwork;
- Knowledge how to manage their work in terms of tasks and time distribution for fulfilling deadlines;
- Ability to present and report their work, considering the problems they face, how they are resolved, or why these problems cannot be resolved.

In a whole it has been rewarding experience for both students and teachers. Greater interest and involvement of the majority of students were observed. Playing (and learning) with new technologies is a fun. The transformed CAD course has room for improvement. We need to find ways to promote even further the collaboration between the students and monitor their group process and individual progress.

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