Trialogical Approach to Knowledge Practices in CAD Education

Stela Angelova Stefanova and Tania Krumova Vasileva

Abstract – **The paper considers the key features of 21st Century pedagogy, knowledge work competences and requirements that educational institutions have to meet. Reconstruction of curriculum, re-designing course and pedagogical practices applying a trialogical approach are also discussed. The results from pilot course in CAD Education of 11 grade classes in Technology School "Electronic Systems" associated with Technical University of Sofia are demonstrated.**

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

I. INTRODUCTION

Information and communication technology (ICT) is the enabler for both innovation and education – without which a knowledge society cannot be realized, supported or further developed. ICT is considered a critical tool in preparing and educating students with the required skills for the global workplace. The potential impact of ICT on learning is the vision that it enables learning 'anywhere, anytime, and anyhow'. With ICT, knowledge is not constrained by geographic proximity, and offers more possibilities for sharing, archiving, and retrieving knowledge [1].

In addition, the knowledge society and widespread use of ICT generates a need for new digital skills and competences for employment, education and training, self-development, and participation in society. ICT has potential to widen access to educational resources, improve the quality of learning, and improve management efficiencies of the education system [1].

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. Knowledge Work Competences

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].

Currently students leave both secondary and higher education with an underdeveloped ability to solve real-life problems. This creates challenge for the development of pedagogical practices in secondary education and universities to promote necessary competencies.

Knowledge work competences are understood as students' capability [3]:

- to act, study and work effectively both individually and together with others, to use the collective efforts in solving complex problems and in creating novel solutions and new knowledge
- to meet complex demands that make it possible to act in continuously changing situations during studies and after them
- to cope and act in an uncertain and unknown world and future, in continuously changing circumstances as well as deal with incomplete and imperfect outcomes.

B. Key features of 21st Century Pedagogy

The key features of 21st century pedagogy shown in Fig. 1 are [4]:

- building technological, information and media fluencies;
- developing thinking skills;
- making use of project based learning;
- using problem solving as a teaching tool;
- using 21st century assessment with timely, appropriate and detailed feedback and reflection;
- It is collaborative in nature and uses enabling and empowering technologies;
- It fosters Contextual learning bridging the disciplines and curriculum areas.

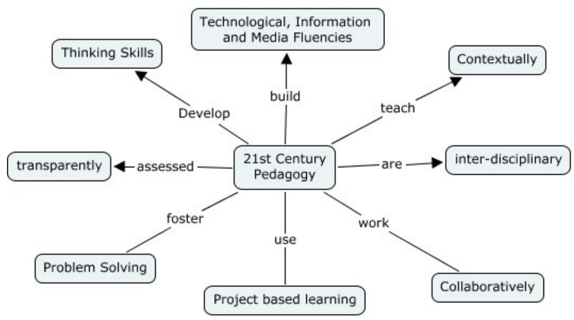

Fig. 1. Key Features of 21st century pedagogy

To teach using 21st century pedagogy (see Fig.2) [4], educators must be student centric. The curricula and assessments must inclusive, interdisciplinary and contextual; based on real world examples.

Students must be key participants in the assessment process, intimate in it from start to finish, from establishing purpose and criteria, to assessing and moderating. Educators must establish a safe environment for students to collaborate in but also to discuss, reflect and provide and receive feedback in.

S.Stefanova is with the Technology School of Electronic System, associated with Technical University of Sofia, Mladost 1, 1750 Sofia, Bulgaria, e-mail: sstefanova@elsys-bg.org

T. Vasileva is with the Department of Electronics and Electronics Technologies, Faculty of Electronic Engineering and Technologies, Technical University - Sofia, 8 Kliment Ohridski blvd., 1000 Sofia, Bulgaria, e-mail: tkv@tu-sofia.bg

They should make use of collaborative and project based learning, using enabling tools and technologies to facilitate this.

Educators must develop, in students, key fluencies and make use of higher order thinking skills.

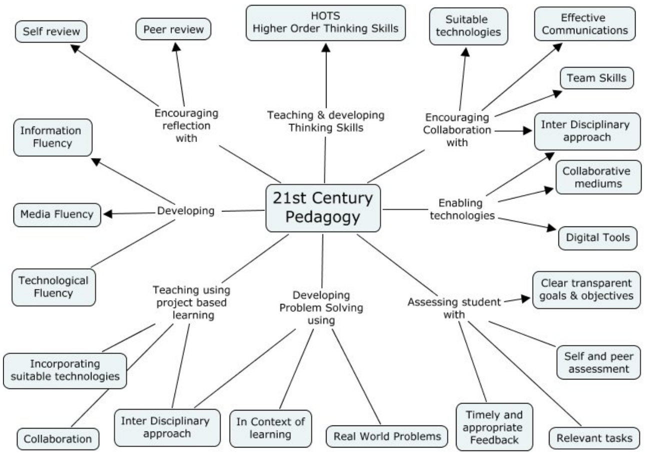

Fig. 2. 21st century pedagogy

To answer these challenges the KNORK (Promoting Knowledge Work Practices in Education) project [5] aims at developing pedagogical models and technology to support collaborative practices in technology-rich environment. KNORK is a 3 year, 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 in the Technology School “Electronic Systems” associated with the Technical University of Sofia to reconstruct a course and pedagogical practices applying a trialogical approach in Computer Aided Design (CAD) in Electronics education. The results from pilot course in CAD in Electronics education in 11 grade classes are highlighted.

II. Pedagogical Design and Course Plan

A. 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. The *trialogical* approach is intended to elicit innovative practices of working with knowledge within educational community [6].

A specialized course in the field of Computer Aided Circuit Design, gives the students opportunity to obtain:

- 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 and how they are resolved, or why these problems cannot be resolved.

Six design principles were developed to explicate learning practices which promote innovation skills and digital competence. 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.

The course plan for education CAD in Electronics, re-designed to implement the trialogical design principles, is given in Table 1.

TABLE 1. IMPLEMENTATION OF TRIALOGICAL DESIGN PRINCIPLES

Design principle (DP)	***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.

B. Course Plan

Pedagogical context: The questions we need to answer are why the course needs development, what skills and knowledge students should have beforehand, which are the links with the curriculum and other courses, etc. **Previous achievements:** The course is taught during the second term of the fourth year and students are expected to use the knowledge, they have obtained previously

Prerequisites: Electrical engineering, Electronics, Digital and Analog circuit design, Information technologies

Objectives: The course is designed to give the student an understanding of different design steps and tools required to carry out computer aided electronic circuit design.

Knowledge and understanding

- Explain and understand digital circuits design principles
- Explain and understand analog circuits based on transistors, operational amplifiers and passive analog components
- Apply the theoretical knowledge to a real project

Skills and ability: After finishing the course students should have abilities to:

- Use modern professional tools for circuit design and simulation,
- Work efficiently as a group,
- Manage their work in terms of tasks and time distribution for achieving deadlines;
- Present and report their work considering the problems they face.
- Hold and evaluate, discuss and justify the proposed solutions.
- Make peer reviews and comment results

ICT tool(s): The ICT tools used in the course are SPICE, Orcad and other CAD tools for circuit design and Google Tools: Doc, Application, Drive, Sites for collaborative activities – collaborative editing of the project reports, reviewing, commenting and sharing project artifacts.

Preparations before the course: Find potential projects. Prepare the platform (Google Apps): create folders for the groups, the workspaces, upload learning material, and create project development agenda.

Description / ”manuscript” of the pedagogical design

The students have weekly assignments, developed collaboratively with shared report in the field of Analog and Digital circuits design and simulation. The homework activities are presented, discussed and analyzed in class.

The two month long projects have to be developed from groups of students. Group members have to gather information, discuss the given problem in collaborative environment, analyze and simulate the digital or analog circuit using dedicated CAD software.

The students have to document their collaborative work at every step of the development process. In the end of the two month long term project students have to present their final design solution.

The assessment is based on the written project report and the discussion with the project team. The evaluation criteria are: fulfillment of design goal according given technical specifications, quality of the design solution, meeting the deadlines for submission of intermediate and final reports, quality of the written reports.

Experiences, development ideas and alternative solutions: We manage to transform course from classical face to face teaching to using project based approach in order to motivate student and increase students motivation, their knowledge work competences and digital skills.

III. COLLABORATIVE LEARNING PLATFORM

A. Collaborative workspace for project work

The CAD in Electronics course in the Technology School “Electronic Systems” is re-designed to be project oriented. 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 [7].

The students have to document their work at every step of the development process and to upload in Google Drive project space. In the end of the two month long term project students are required to present their solution of the given project.

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 Figure 3): Groups, Gmail, Docs, Talk, Calendar, Drive and Google+.

Students were encouraged to submit their questions as emails instead of chat messages.

Fig. 3. Collaborative workspace structure

Instead of 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 Figures 4, 5).

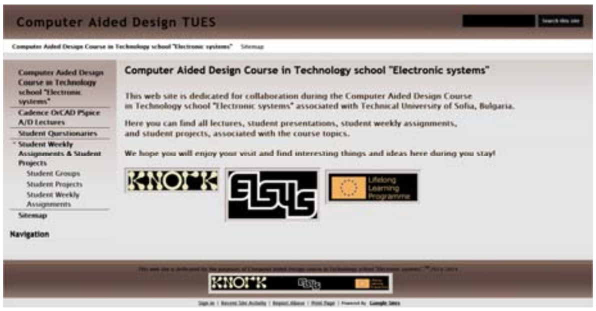

Fig. 4. Home page of Google site of CAD course

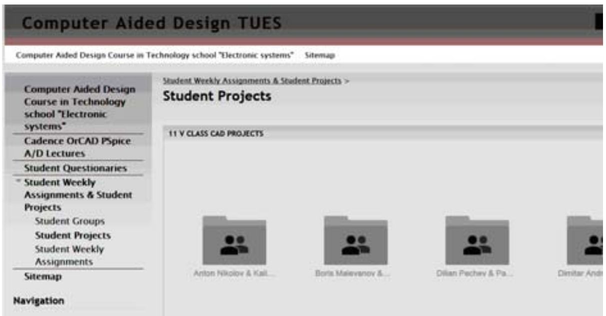

Fig. 5. Students projects in CAD course

IV. Pilots Activities

The pilots were conducted with two classes of 52 students – 11 grade classes (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.

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 Figure 6 together with their answers to the statements before the course.

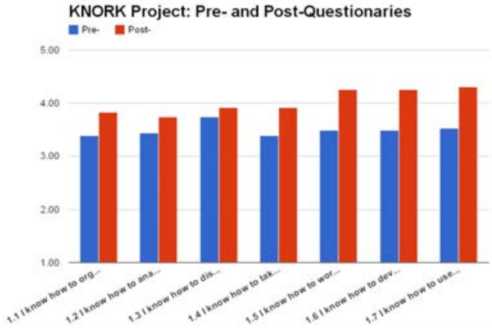

Fig. 6. Average of the students’ answers

V. Conclusion

The paper discusses a course redesign to promote new pedagogical practices, which were successfully used for improving obligatory course CAD in Electronics in secondary education. These practices include longitudinal work supporting in-depth focusing and students’ collaboration for a shared outcome.

Pilots’ results are also highlighted. Students learned knowledge work practices (e.g., information processing, analysis and presentation, sharing, versioning, as well as commenting, longitudinal work, using digital tools and group work). 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.

Acknowledgement

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