Project-Based Learning Modelled with a Generalized Net

Daniela Orozova[1] and Maciej Krawczak[2]

[1] Faculty of Computer Science and Engineering
Burgas Free University
62 San Stefano Str., Burgas 8001, Bulgaria
e-mail: `orozova@bfu.bg`

[2] Systems Research Institute, Polish Academy of Sciences
Warsaw School of Information Technology, Warsaw, Poland
e-mail: `krawczak@ibspan.waw.pl`

Abstract: The paper discusses the opportunities that project-based learning provides in addition to traditional pedagogical approaches. A generalized net model is constructed of the process of learning based on developing a project. The model serves for conducting a research and analysis of the opportunities for students' work on projects, adapted for their levels of knowledge and skills, resulting in the development of integrated knowledge, acquired in the course of different learning disciplines.
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1   Project-based learning

Project-based learning provides vast opportunities for enriching the traditional pedagogical approaches to knowledge acquisition. In this article, we discuss the opportunities for working on projects, adapted to the students' levels of knowledge and skills, which result in combining pieces of knowledge that could be acquired in the course of different learning disciplines. The aim is to make the step ahead to bridging the thematic learning content with reality in the frames of the training of bachelor students in computer science, which will lead on its own to producing more experienced human resources for the

software development market. Assignment and development of projects in the courses of education can follow the modern technologies and the dynamics of their evolution. This goal requires careful selection of topics and contents of course projects, as well as their development when studying new disciplines. Qualitative implementation of a given project demands its being carefully prepared and structured in advance.

Essentially, project-based learning is a pedagogical model of interdisciplinary activities, oriented towards a real-life, existing problem area. It is a challenge for students to construct, acquire and further solidify their knowledge of upper level [3]. The main skills students develop are: identification of the stages of project development, activities planning, keeping up with scheduled deadlines, collaboration with other team members, self-assessment, participation in project discussions by developing and defending with arguments their own ideas and skills.

2 Process of Managing the Project-based Learning Tasks

Successful management depends on the leader of the discipline [4]: he/she disseminated the tasks for execution, create the work plan, controls the execution of the subtasks and oversees the whole process. For this aim, regular meetings can be scheduled for tracking the current results and discussing the activities, or the team can work within an appropriate interactive environment like Moodle, Acolad or a platform based on the wiki technology.

2.1. Main activities for defining projects

The preparation and planning of projects is related to defining the stages of execution, subtasks, deadlines, information resources, etc. These activities may be formalized as follows:

- Specification of the task of the particular project. Defining the goals and tasks, as well as the stages of the project's development.

- Defining the subtasks. It is necessary to determine all tasks (main tasks and subtasks), the timeframe for each task, and the person responsible for its execution.

- Defining and distribution of the resources, needed for the project implementation. Here, 'resources' mean all human, software, hardware resources, as well as the factor of time.

- Management of the tasks execution. The performance of the already defined tasks have to be controlled, i.e. to trace the project development, and to report of the completed subtasks, and present the tasks that are in process

of development, and the forthcoming ones.

   - Collection of various data for statistical purposes and for measuring the project development. The statistical data collected needed to serve as basis for measurement of other variables, determining the project itself – quality, complexity, size, etc.

   - Description of the possible risks in front of the project. The project manager describes any possible risk facing the project, develops plan for avoiding the risk and its management if necessary.

   - Generation of various reports for the project execution.

2.2. Planning the teams (work groups)

The main activities, related to planning the groups of students who will work on the projects, are:

   - Defining the number of team members per project. This number depends on the size of the project and the eventual tasks for execution.

   - Defining the structure of the team. It may be defined according to the members' interests, or to their capabilities, or some other criterion.

   - Determining the team manager, who can be either appointed by the teacher, or selected by the project team members.

2.3. Presenting the students with the task

When defining the project, the following items have to be consequently presented to the students:

   - preliminary information;

   - project task, presented in an interesting and motivating way;

   - stepwise description of the process of task implementation;

   - set of recommended information sources;

   - instructions for the organization and preservation of the information generated;

   - tools and criteria for evaluation of the task execution.

2.4. Activities of the students, implementing the projects

While implementing a project, the students have to: interpret the assigned question or task (for instance, to generalize or specify it); collect and analyse data from various sources; to share, generate and discuss different ideas; make argumentative proposals, hypotheses and forecasts; create artifacts (reports, databases, multimedia, models, prototypes); reach proofs, generalizations and conclusions; report and present in front of audience their ideas and discoveries; raise new questions and problems for discussion [6].

2.5. Planning the tools for evaluation and assessment

Planning the tools for evaluation and assessment of the results from the

project implementation includes:

- Defining the essence of what exactly will be evaluated: achievement of the goals being set, meeting the deadlines, assuring the quality of the developed product, and other indicators;

- Defining the tools for performing the evaluation (monitoring, completing check-lists), final check and assessment of the ready products, the teamwork and the individual members' performance, and project defense;

- Correct source citation (literature, internet addresses, help manuals for developers and users, etc.), used by the students in backing up the proposed solutions;

- Public presentation as a natural finish of the developed project, which needs to be stimulated and supported for publication and presentation in front of various student forums.

If the teacher users a data warehouse, collecting information about past projects, then after completing the work on the currently assigned projects, the data warehouse has to be updated. The advantage of supporting a data warehouse of past projects is that the evaluator can compare the projects and detect eventual plagiarized project developments. Moreover, the accumulated information can be used as a basis for collecting statistic data for the skills of the individual students and those of the educated group as a whole [5]. It is possible to evaluate the degree of development and errors the students make, in order to emphasize on them in consequent lecture classes.

3   Modelling the Process of Project-based Learning

In the GN [1,2] (see Fig. 1), the tasks (project-based) are represented by α-tokens, the theachers are interpreted by β-tokens, the students (the training objects) by γ-tokens, the evaluation criteria are interpreted by δ-tokens, respectively.
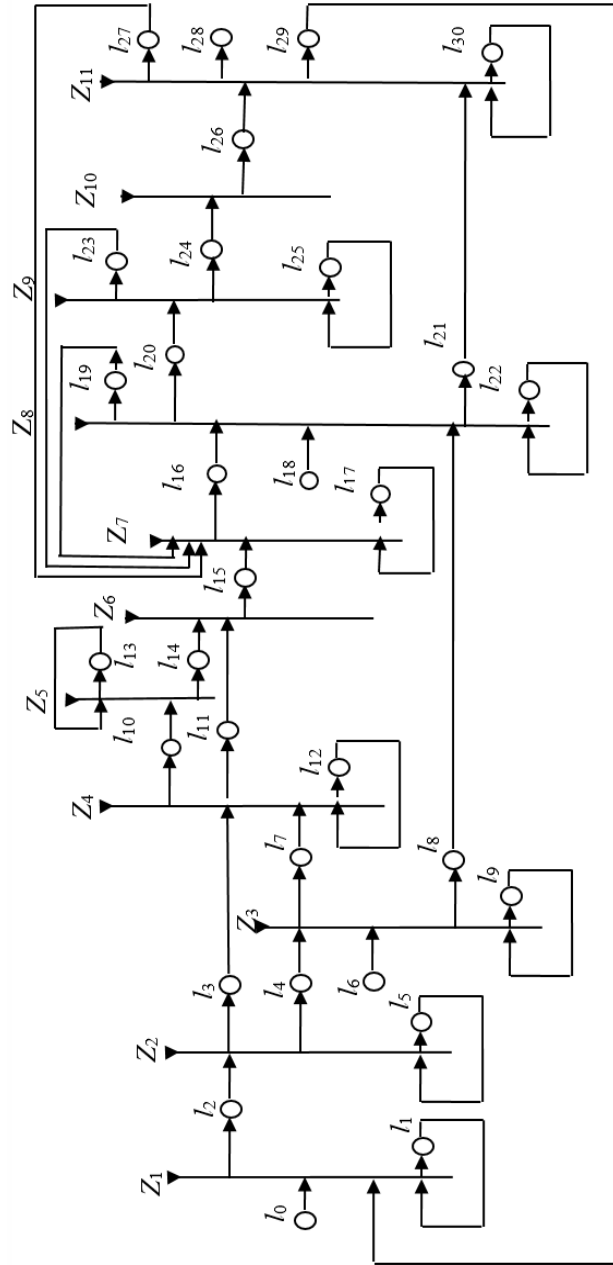
Figure 1. GN model of the process of project-based learning

The GN-model consists of 11 transitions that have the following sense:

Z_1 = Preparation for project-based learning
Z_2 = Start of the particular project-based learning
Z_3 = Forming the project teams of students
Z_4 = Assigning tasks to each project team
Z_5 = Defining the subtasks for each project
Z_6 = Distributing the subtasks to the project team members
Z_7 = Executing the particular project subtask
Z_8 = Executing the overall project
Z_9 = Project completion
Z_{10} = Project presentation and defense
Z_{11} = Projects evaluation

When a new teacher is hired, one β–token enters the net via place l_0 with initial characteristic „*teacher, ID*".

$$Z_1 = \langle \{l_0, l_1, l_{29}\}, \{l_1, l_2\}, r_1 \rangle,$$

$$r_1 = \begin{array}{c|cc} & l_1 & l_2 \\ \hline l_0 & T & F \\ l_1 & T & W_{1,2} \\ l_{29} & T & F \end{array}$$

where *F* and *T* denote *false* and *true*, and the predicates have the following meaning:

- $W_{1,2}$ = "A teacher has decided to implement project-based learning";

The β-token in place l_1 has the characteristic "*List of teachers*". When a teacher decides to implement project-based learning, a β–token enters place l_2 and obtains the characteristic: "*teacher, ID, subject*".

$$Z_2 = \langle \{l_2, l_5\}, \{l_3, l_4, l_5\}, r_2 \rangle,$$

$$r_2 = \begin{array}{c|ccc} & l_3 & l_4 & l_5 \\ \hline l_2 & F & F & T \\ l_5 & W_{5,3} & W_{5,4} & T \end{array}$$

where

- $W_{5,3}$ = "A project task has been formulated";
- $W_{5,4}$ = "A teacher has initiated project-based learning".

An *α*–token enters place l_3 with the characteristic: „*Specification of the project task*". The *β*–token from place l_5 has the characteristic „*List of teachers, implementing project-based learning*".

When the transition gets activated, the *β*–token from place l_5 splits into two tokens, one of which remaining in place l_5, and the other transferring to place l_4 with the characteristic „*Teacher – Project-based learning leader*".

$$Z_3 = \langle \{l_4, l_6, l_9\}, \{l_7, l_8, l_9\}, r_3 \rangle,$$

$$r_3 = \begin{array}{c|ccc} & l_7 & l_8 & l_9 \\ \hline l_4 & F & T & F \\ l_6 & F & F & T \\ l_9 & W_{9,7} & F & T \end{array}$$

where

• $W_{9,7}$ = "A student has been selected for member of a project team".

In the input place l_6 enters a *γ*–token with initial characteristic: „*Student – participant in the project-based learning, Student ID*". A *γ*–token stays in place l_9 with the characteristic „*List of students – participants in the project-based learning*". When activating the transition, a *γ*–token enters place l_7 with the characteristic „*Student, Student ID, Project team ID*". The *β*–token from place l_4 transfers to place l_8 keeping its characteristic: „*Teacher – Project-based learning leader*".

$$Z_4 = \langle \{l_3, l_7, l_{12}\}, \{l_{10}, l_{11}, l_{12}\}, r_4 \rangle,$$

$$r_4 = \begin{array}{c|ccc} & l_{10} & l_{11} & l_{12} \\ \hline l_3 & W_{3,10} & F & F \\ l_7 & F & F & T \\ l_{12} & F & W_{12,11} & T \end{array}$$

where

• $W_{3,10}$ = "Each project team has been assigned a particular project task";

• $W_{12,11}$ = "A student has been selected for member of a project team".

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At this transition, the α–token from place l_3 moves to place l_{10} with the characteristic: „*Specification of the particular project task, Project team ID*". In place l_{12}, a γ–token is staying with the characteristic: „*List of students – members of a project team*". At the moment of activation of the transition, the γ–token from place l_{12} splits into γ_i tokens, representing each individual project team member.

During the GN functioning, each γ_i token enters place l_{11} and obtains there the characteristic: „*Student ID, Project team ID*".

$$Z_5 = \langle \{l_{10}, l_{13}\}, \{l_{13}, l_{14}\}, r_5 \rangle,$$

$$r_5 = \begin{array}{c|cc} & l_{13} & l_{14} \\ \hline l_{10} & W_{10,13} & F \\ l_{13} & T & W_{13,14} \end{array}$$

where

- $W_{10,13}$ = "Subtask of the particular project has been defined";
- $W_{13,14}$ = "Subtask of the particular project has been selected".

At the transition, the α–token from place l_{13} obtains the characteristic: „*Project team ID, Project subtasks*". The α–token from place l_{13} splits into α_i tokens for each project subtask and during the GN functioning each of the α_i tokens enters place l_{14} with the characteristic: „*Project team ID, Subtask title*".

$$Z_6 = \langle \{l_{11}, l_{14}\}, \{l_{15}\}, r_6 \rangle,$$

$$r_6 = \begin{array}{c|c} & l_{15} \\ \hline l_{11} & T \\ l_{14} & T \end{array}$$

During the transition, the γ_i –token, coming from place l_{11} with characteristic „*Student ID, Project team ID*" merges with a α_i –token, coming from place l_{14} with characteristic „*Project team ID, Subtask title*" and the emergent token enters place l_{15} with the characteristic „*Student γ_i, Subtask title α_i*".

$$Z_7 = \langle \{l_{15}, l_{17}, l_{19}, l_{23}, l_{27}\}, \{l_{16}, l_{17}\}, r_7 \rangle,$$

$$r_7 = \begin{array}{c|cc} & l_{16} & l_{17} \\ \hline l_{15} & F & T \\ l_{17} & W_{17,16} & W_{17,17} \\ l_{19} & F & T \\ l_{23} & F & T \\ l_{27} & F & T \end{array}$$

where

- $W_{17,16}$ = "Student γ_i has completed Subtask α_i";
- $W_{17,17} = \neg W_{17,16}$;

where $\neg P$ is the negation of the predicate P.

During the transition, the γ–token, coming from place l_{16} obtains the characteristic: „Student γ_i has completed Subtask α_i", while the γ–token in place l_{17} obtains the characteristic „*Student γ_i, Subtask title α_i*".

$$Z_8 = \langle \{l_8, l_{16}, l_{18}, l_{22}\}, \{l_{19}, l_{20}, l_{21}, l_{22}\}, r_8 \rangle,$$

$$r_8 = \begin{array}{c|cccc} & l_{19} & l_{20} & l_{21} & l_{22} \\ \hline l_8 & F & F & T & F \\ l_{16} & W_{16,19} & W_{16,20} & F & F \\ l_{18} & F & F & F & T \\ l_{22} & F & F & F & T \end{array}$$

where

- $W_{16,19}$ = "The subtask needs to be finalized";
- $W_{16,20}$ = "The subtask has been completed".

During the transition, the α–token in place l_{19} obtains the characteristic: „*The subtask needs to be finalized*", while in place l_{20} this becomes „*The subtask has been completed*".

Via the input place l_{18} a δ–token enters with the characteristic: „*New criterion for project evaluations*". In place l_{22} a δ–token loops with the characteristic: „*List of criteria for projects evaluation*".

During the transition, the δ–token from place l_{22} splits into two token; one remains to loop within place l_{22}, and the second one merges with the β–

token, coming from place l_8, and the emergent token transfers as a β–token into place l_{21} with the characteristic: „*Teacher, List of criteria for projects evaluation*".

$$Z_9 = \langle \{l_{20}, l_{25}\}, \{l_{23}, l_{24}, l_{25}\}, r_9 \rangle,$$

$$r_9 = \begin{array}{c|ccc} & l_{23} & l_{24} & l_{25} \\ \hline l_{20} & W_{20,23} & W_{20,24} & W_{20,25} \\ l_{25} & F & W_{25,24} & T \end{array}$$

where

- $W_{20,23}$ = "The students has started working on a new subtask";
- $W_{20,24}$ = "The project has been completed (with all subtasks being done)";
- $W_{20,25}$ = "The student is waiting for the rest project team members to complete their subtasks";
- $W_{25,24}$ = $W_{20,24}$.

During the transition, the α–token, coming from place l_{23} obtains the characteristic: „*Student γ_i , Subtask title α_i* ", and in place l_{25} the characteristic „*The student is waiting for the rest project team members to complete their subtasks*", while the α–token in place l_{24} obtains the characteristic: „*Completed project task*".

$$Z_{10} = \langle \{l_{24}\}, \{l_{26}\}, r_{10} \rangle,$$

$$r_{10} = \begin{array}{c|c} & l_{26} \\ \hline l_{24} & W_{24,26} \end{array}$$

where

- $W_{24,26}$ = "The project has been presented at a public defense".

During the transition, the α–token coming from place l_{26} obtains the characteristic: „*Project team ID, Project defense*".

$$Z_{11} = \langle \{l_{21}, l_{26}, l_{30}\}, \{l_{27}, l_{28}, l_{29}, l_{30}\}, r_{11} \rangle,$$

$$r_{11} = \begin{array}{c|cccc} & l_{27} & l_{28} & l_{29} & l_{30} \\ \hline l_{21} & F & F & T & F \\ l_{26} & W_{26,27} & W_{26,28} & F & T \\ l_{30} & F & F & F & T \end{array}$$

where

- $W_{26,27}$ = "The project is negatively evaluated";
- $W_{26,28}$ = "The project is positively evaluated".

During the transition, the β–token from place l_{21} merges with the α–token from place l_{26} and the emergent token enters either place l_{27} with the characteristic: "*Project team ID, negative evaluation of the project*", or place l_{28} with the characteristic: "*Project team ID, positive evaluation of the project*".

The β–token in place l_{29} does not obtain any new characteristic. The α–token in place l_{30} obtains the characteristic: "*Students' evaluations of their performance in the project-based learning*".

4   Conclusion

The integration of the project-based learning with the opportunities of the electronic and web-based learning make the process of learning more diverse and more attractive for the students. The interest of young people in the new, their curiosity and communicativeness successfully apply to the process of their training.

The so constructed GN model gives the possibility for tracking the processes of personalization and usage of different intelligent tools for project-based learning. Information can be thus derived regarding the trainees' preferences and the results of their training. On the basis of the GN model and accumulated statistics of real data, evaluations can be made and trends can be discovered about the development of processes, related to project-based learning and its servicing. Extra model parameters and additional tokens' characteristic can be introduced, while considering factors influencing the process of education, aiming at optimization with regards to a certain goal.

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