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Implementation of Organizational and Pedagogical Conditions for End-to-End Course Project Technology

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To meet the FSES requirements on competence development in the frame of Bachelor's Degree programs in civil construction it is necessary to technologize a training process and use an integrative approach to course project. The solution could be an end-to-end course project (EECP) technology including the following tools: the structural-logic scheme of the EECP content; EECP procedure; graphical description of the process; the diagnostic tools; the mathematical model of learning activity correction, etc.

Key words: *interdisciplinary integration, straight-through instructional designing, technologization training, graphic description of technological process, individual profile of student competencies, mathematical model of the correction of learning activity.*

Nowadays, high development of construction industry requires graduates to be able to solve professional tasks on interdisciplinary level, be aware of a whole design process, be qualified in scientific and technical issues of civil engineering as well as be responsive to changes of social demands. Comparing State Educational Standards (SES) and Federal State Educational Standards (FSES) it is possible to conclude that Bachelors should be trained for the same job positions as Specialists but in a shorter period, which requires a valid "phased acquisition of competences". It needs, in its turn, "systematically organized goal-oriented activity" and specified structure of a training process and content [1].

On the one hand, to increase the efficiency of every training stage it is necessary to technologize a training process or "to manage training, ... starting with diagnostics and up to obtaining planned and sustained outcomes of high quality" [2].

On the other hand, we think that it is impossible to develop competences that are actually interdisciplinary without an integrative approach.

Considering that 70% of all required competences of Bachelor of Civil Engineering are directly or proximately connected with designing and the most practice-oriented training form is a course project, we incorporate interdisciplinary integration into the course project. On analyzing scientific literature, course and curriculum content and basing on our teaching experience we introduce it in the form of end-to-end course project (EECP). Unlike the existing guidance papers devoted to EECP our work is focused on pedagogical designing and implementation of EECP technology. It is explained by the fact that it is technology characterized by the following features [3]: goal-setting, predetermined final outcomes, predictive value, possibility for individual learning path, constant feedback, cohesion and completeness of pedagogical

process. The previous articles were devoted to the conceptual framework and some aspects of the developed technology while the present article deals with its basic tools.

Implementation of EECO technology includes creating a number of organizational and pedagogical conditions (OPC). These conditions are made by means of some approaches: integrative, systems, process, competence-based and learner-centered approaches (Table 1). This choice is determined by the necessity to consider different pedagogical categories.

The first condition is the EECP implementation in a number of courses. We suggest some modules of end-to-end parallel and sequential course projects that contain from 2 to 8 courses with course projects/works (CP/CW). Grouping the learning materials in EECP modules allows using unified didactic methods based on the following [4, p.33, 91]: module objectives (development of set competences of a particular level); the main component; basic content; general development paths; levels and mechanisms of integration (interdisciplinary connections, transfer, information acquisition in combination with project activities); invariant of integration (natural laws, engineering graphics methods, architectural and construction methods).

To organize EECP in training process the following tools were developed. Semantic graphs are the basic notions of the integrated courses including essential connections and interactions between them (Table 1). They help students to analyze basic structure of the main notions of the EECP module, to organize knowledge they have and to integrate new knowledge in CP/CW more effectively. Interdisciplinary tasks in EECP (2 difficulty levels) built an information base for professional activity and practical application skills for notions of complimentary sciences. Structural-logic scheme of EECP content (Table 1) is based on structure analysis of integrated CP/CWs, understanding of interaction between their elements, transformation of requirements depending on the main goal. It makes the process of EECP fulfillment more rational. The scheme presents different objectives of course project: to identify and diagnose (solution choice from a standard set), to evaluate and analyze (evaluation of complicated systems with different variants of solutions), to combine (use of systems approach). Content description of all stages of CP/CWs is accompanied by project schedule and characteristics of inner- and interdisciplinary connections. It should be noted that the observations show that EECP doesn't exceed structural complexity of the learning material and is less time-consuming in comparison to the traditional approach.

The second organizational condition is a process management (operation) of teaching the courses that are parts of EECP. Regarding quality of educational service as a guarantee of competences acquired by a student [5, p.28] we, as many others, think it is necessary to consider different educational activities in universities as processes.

To create this condition at the department level it is necessary:

- to divide the process of a course acquisition into sub-processes – modules, and determine their sequence in the whole teaching process taking into account their interdisciplinary links;
- to determine the assessment criteria for learning outcomes at the beginning and the end of the courses.

To organize the training process according to the technology it is necessary to develop algorithm for staff and student activities based on designing learning situations and teaching process developed in details. Pedagogical design planning,

Apart from other things, also includes a stage of work decomposition for its better management and monitoring etc. [3, p. 177]. It implies dividing the content of a training process into separate functions [6, p. 24, 56]. We distinguish the following functions in teacher-student joint activities: initialization, planning, performance, diagnostics, evaluation and coordination, accomplishment. Purposive approach was used to determine particular objectives solved in the frame of the function by performing particular procedure and to correlate the objectives with the main goal [3, p. 177]. Morphological

approach helped us to choose possibilities to implement objectives of definite functions: 1) resource provision (facilities, data, time, necessary competencies); 2) staff and infrastructure (main participants of training process, facilities); 3) control actions (control data stream: project, design management, restrictions); 4) outcomes (tangible results, data, competencies developed as a result of the project).

The algorithm (Table 1) of the procedures performed by teachers and students in the frame of every function is a sequence of 26 activities including incoming and outcoming documents, alternative solutions, correcting and controlling actions. Graphic description of the technological process of EECP (Table 1) shows the implementation of the above mentioned functions with regard to resources, participants and control actions. It is developed in IDEF0 notation [6], because it is the suitable for description of integration processes, in particular, education area from a department to federal levels. Thus, management of EECP process takes into account initial competence level, the chain of interlinked and cyclically connected functions that ensure feedback for better forecasting, achievement and evaluation of the outcomes.

The conditions for competence and student-centered approaches are regarded as pedagogical ones.

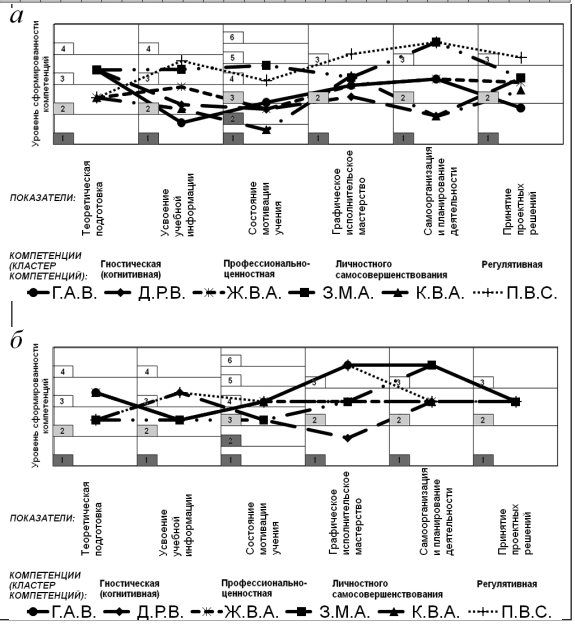
In their learning process students should develop competences of different nature: knowledge gaining, activity, motivation, personal development. They can be fully developed only in the process of quasi-professional activity. EECP stimulates students' interest and independence since they discover many sides of the projected object and are involved in interdisciplinary relations. This fact is also very important for implementation of the competence ap-

Table 1. Technological means (tools) of EECP

<table>
<tr><th colspan="2">Approaches</th><th>OPC</th><th>Short description of the stages and general view of some tools</th></tr>
<tr><td rowspan="2">Systems</td><td>Integrative</td><td>EECP implementation</td><td>- Structural-logic scheme of EECP content
elements of projects of integrated disciplines
interdisciplinary connections
inside interdisciplinary connections
- Didactic tools of EECP (interdisciplinary tasks, semantic graph (Fig.) etc.)</td></tr>
<tr><td>Process</td><td>Process management of teaching</td><td>- EECP procedure algorithm (fragment in Fig.)
- Graphical description of EECP technological process (notation IDEF0) at the interim stage of Bachelor's Degree programs in civil construction</td></tr>
</table>

Table 1 Continued

<table>
<tr><th colspan="2">Approaches</th><th>OPC</th><th>Short description of the stages and general view of some tools</th></tr>
<tr><td rowspan="2">Systems</td><td>Competence-based</td><td>Reliance on quasi-professional activity of EECP and encouragement of student's independence of developing necessary competencies</td><td>
Стадии разработки курсового проекта и форма участия преподавателей смежных дисциплин
<table>
<tr><th>Смежные дисциплины</th><th>1 неделя</th><th>2 неделя</th><th>3-4 неделя</th><th>5-7 неделя</th><th>7-8 неделя</th></tr>
<tr><td></td><td>Выбор междисциплинарного задания, программа СКП</td><td>Теплотехнический расчет ограждающей конструкции, функциональное зонирование квартир</td><td>Разработка эскизов рабочих чертежей, расчет потерь тепла по помещениям</td><td>Выполнение архитектурно-строительных рабочих чертежей, выбор и расчет нагревательных приборов</td><td>Размещение на планах элементов системы отопления, технико-экономическая оценка проектных решений жилого здания</td></tr>
<tr><td>ОПД.Ф.01.02 Инженерная графика (2 сем.)</td><td></td><td></td><td></td><td>Консультация</td><td></td></tr>
<tr><td>ЕН.Р.01 Системы автоматизированного проектирования в строительстве (3 семестр)</td><td></td><td></td><td>Консультация</td><td>Консультация</td><td></td></tr>
<tr><td>ОПД.Ф.10 Строительная физика (4 сем.) ОПД.В.02.01 Основы нормативно-проектной документации в строительстве (5 семестр)</td><td></td><td>Консультация</td><td></td><td>Консультация</td><td></td></tr>
<tr><td>ОПД.Ф.11.01 Теплогазоснабжение и вентиляция (5 семестр) СД.01 Архитектура гражданских и промышленных зданий и сооружений (5, 6 семестр)</td><td>Вводная лекция с использованием междисциплинарного семантического графа</td><td>Консультация</td><td>Руководство КР Консультации Руководство КП Консультации</td><td>Консультации Консультации</td><td>Консультации Консультации</td></tr>
</table>
- technological map (fragment in Fig.);
- diagnostic tools
(competence skills, description of indicator scales for every competence;
competence profile of students, which based on the above mentioned scale);
- diagnostic procedures;
- actual individual competence profile (example in Fig.)


</td></tr>
<tr><td>learner-centered</td><td>Facilitation based on the difference in competence levels, living conditions of students and forecasting their learning success</td><td>Math model of learning activity correction in the EECP process, which allows to predict individual competence profiles of students
(а) at the beginning of a semester;
(б) actual individual competence profile of students at the end of a semester (empirical evidence)


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</table>

proach as it implies the use of complex procedure. That is why the third condition is the reliance on quasi-professional activity of EECP and encouragement of student's independence of developing necessary competencies.

To ensure this condition it is necessary to agree teaching process of allied subjects (courses) in the following aspects: 1) discovering interdisciplinary links of the material for the students; 2) giving information on competence diagnostics.

It is very important to use the time for independent student's work in the most effective way. A technological map (Table) is designed for this purpose as well as for the agreement of EECP design solutions, correlation and distribution of interdisciplinary consultations and further use of the project materials. It is necessary for students to be acquainted with requirements to the learning outcomes and to know what competencies are developed by this or that course, which contributes to student's active and independent position [7]. The use of graphic scheme showing the course's interconnection, current and final learning outcomes and importance of the developed competencies contributes to student's learning motivation and this is important element for student competence evaluation criterion.

Diagnostic tools were developed with the use of psychology and pedagogic science and famous approaches to the competence models used in personnel management that we adapted for students. They increase objectivity in competence evaluation by instructors of allied course. Experimental work includes 6 competence-markers with special indicator scales of development degree level for each competence. These scales constitute a competence profile (Table 1) that demonstrates learning objectives and outcomes[1].

The next condition is facilitation based on different levels of competence development, student's living conditions and forecasting their individual success. In other words, this is the activity focused on encouragement of considered study and help with person's self-development [8, p. 37].

To implement this condition it is necessary to: 1) take into account particular features of acquisition of learning materials of integrated courses, give individual current help to student's with their EECP (especially parallel one); 2) show different project variants for student's independent decision making. Student's challenge in more complicated EECP gradually makes them structure their own experience and be more independent; 3) give adequate difficulty level of a task based on individual approach; 4) distinguish the most independent and challenged students as well as students dependent on opinions of others [8].

Teacher's awareness about student's level of competence development at the beginning of the course (which is necessary for phased competence development and interdisciplinary process management) helps to evaluate the increment of student's skills and competencies at the end of the course. Having this value as well as the desired final competence level it is possible to activate goal-oriented learning and teaching process well-timed. The necessity to take into account a great amount of factors can cause difficulty in forecasting. It can be solved by means of math modeling. Considering I.P. Podlasyy's recommendations we collected data according to 70 productgenic factors and 10 characteristics of learning outcomes for each student of the experimental sample. Math model of learning activity correction in the EECP process is multiple regression equations of the indices showing the

[1] *We think that such scales should be developed for the whole competence model of graduates in specialty civil construction including 13 social and cultural and 23 professional competencies. For correlation with the management models with the optimal number of competencies 8–12 and for better understanding (by staff, outer experts and students) we suggest dividing these 36 competencies into clusters: gnostical, regulatory, communicative, status-reflexive, normative, professionally valuable, personal development and integrative. The requirements to the learning outcomes in different courses (study stages) could be different depending on what competence and to what degree should be developed.*

competence level developed due to the productgenic factors. They are used making forecasting individual profiles of student's competence (Table 1) at the beginning of a term (unlike the learning outcomes at the end of the course, these profiles are not shown to the students). The model scalability is connected with distinguishing factors of successful competence development during EECP and allows coordinating correction activities of instructors delivering allied courses.

Correlating our own experience with the training management principle suggested by N.V. Sosnin [1] (that we consider to be correct) we think that the EECP modules can function as "structure units ... of the super-disciplinary, system-activity type" concentrating "interdisciplinary content, student's personal experience and faculty's activity for organizing training process for development of a need competence". Implementation of EECP technology in a training process will unite instructors of allied courses into a team of the courses content developers who decide together what competencies should be developed and how to do it. The suggested method of diagnostic tools development will help to solve the issues of competence development process rulemaking, learning outcomes registration and correction of student's learning path in the process of competence development.

The experimental work that has been conducted for some years proves high efficiency of the EECP technology in developing design (project) competencies of students and meets the requirements of Bachelor of Civil Engineering training.

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