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Abstract. *The article deals with horizontal connections in the teaching of fundamental engineering disciplines at ETU "LETI". It is this combination of traditions and innovations that can be offered for international cooperation. The organization of education at the university is carried out meaningfully through a vertical structure that leads the student from the school level to the engineer level. Horizontal links are the opposite of organizational administrative hierarchical links, but complement the content vertical.*

Keywords: Horizontal linkages; digital technologies; learning through teaching; non-invasive monitoring; in demand training

The organization of education in higher educational institutions is carried out along a vertical trajectory that leads the student from the school level to the level of an engineer. However, while studying, students interact with different teachers and other students. Each of these people – professors, scientists, specialists, students – is the owner of new ideas. People are willing to share these ideas at no extra charge. It is proposed to supplement administrative hierarchical links with informal horizontal links [1, 2]. Horizontal structures ensure the creation of local information spaces for such communities of practice. Important pedagogical theories for the development of horizontal connections are: the concept of "in demand" training; the concept of “learning by teaching”; the concept of “non-invasive monitoring”.

Horizontal structures maintained by the Department of Algorithmic Mathematics ETU: Community of Mathematics Educators; Alternative exam; Student Research Laboratories; Scientific seminars; Student project conferences; Student scientific journal; Student University IT-LETI; the system of student mutual assistance in teaching "Smart listeners".

Let us consider in more detail the horizontal connections of this structure.

Suggestion of different types of project activities – alternative exam:

- Learning new material and solving problems (the latter so that students themselves can evaluate the effectiveness of their activities).
- Listening to more complex online courses and passing an oral exam on them, or certification on the resource itself (this form is chosen by about 30%).
- Creation of software modules according to the studied algorithms (this form is chosen by about 40%).
- Research task (30%, usually research work is combined with the previous forms).

Using various resources and search tools, the lecturer can easily compile a list of actual articles, some of which will be available for students to study. Moreover, according to these articles, it is easy to pose additional questions that help to understand the subject of the article: analyze special cases, illustrate with examples, study the ideas underlying the article, implement the algorithms described in the article. Usually,

in the course of lecturing, interesting problems and topics for research or software implementation arise. Thus, it is possible not only to ensure the originality of topics every year, but also continuity: there is no point in hiding from the next generations of students what was done by previous generations.

Use the power of all teachers to communicate with (potentially) all students. The lecturers of the department suggest projects of interest to them and supervise the work on these projects. Practice has shown that it is most effective when 2-3 people work on a project. The project is given for the team. The students themselves strive for team activities that correspond to the organization of modern work in the field of information technology [3].

The purpose of the transition from the Alternative exam to Student Labs: continue work on topics of interest under the guidance of teachers; ensure the continuity of work on topics of interest to the teacher. Types of student laboratories have emerged: student-initiated, laboratories opened at the initiative of teachers. Let's consider examples of student laboratories working at the department of AM.

Example 1. Laboratory of Neural Networks and Tropical Mathematics [4]. It is based on a student seminar on the topic of the same name. The seminar is led by a student who is interested in this topic, who was offered assistance in organizing the seminar, provided that he himself will be the organizer. Study articles were submitted by renowned scientists in the field of tropical mathematics. During the year, students dealt with the material and explained to other students. The following problem arose: the mathematical apparatus turned out to be too complicated for the students. Part of the knowledge turned out to be formal. The next year, the teacher of the department joined the seminar, who explained the missing material. The result was an interest in upcoming mathematics courses, which supported the applications of interest. Parallel to this, at the seminar, the algorithms necessary for the design of neural networks were studied, software modules were written that implement these algorithms, a course was delivered for students who joined the seminar in the second year, and a course on text processing with artificial neural networks was delivered. A nucleus of 8-10 people was formed who are interested in the topic of the seminar and continue to work in it.

Example 2. Laboratory of Mathematical Modeling [5]. The laboratory was born with the arrival of a qualified specialist, a young scientist who combines the work of a programmer with teaching mathematics: students were offered several projects for passing the exam in an alternative form on the subject of the laboratory; the second step was to create a team with a core of these students who performed (successfully) in an international modeling competition; the third stage was the invitation of these students to work on real projects related to orders from companies developing high-tech technologies.

Example 3. Combinatorial Computing Laboratory [6]. The laboratory arose in the process of preparing a Ph.D. thesis by the teacher. The teacher fascinated students with his topic, who developed algorithms for solving various specific problems in the direction of the laboratory. Regular meetings are held, through which new students naturally enter the subject of the laboratory. Many laboratory participants choose the topic of the laboratory for their final work and continue to work on it in the master's degree. Based on the results of the work, articles and speeches at scientific conferences are prepared.

ETU is a university with many faculties, where there are self-motivated students who independently master modern IT technologies. Not all of these technologies are included in the program of the first two courses, and students become familiar with some technologies already when they become graduates. The goal of the Student University IT-LETI [7] is to help students master the IT technologies they are interested in, using the student community, as well as specialists from departments and IT companies involved in the project, already in the first years of the university. The courses consist of approximately 10 sessions, which are mainly related to the development of practical techniques. Students of any course who wish to share their knowledge with other students, as well as teachers and specialists from the IT field, are invited as course leaders.

The classroom system for organizing training, when students are tied to "their" groups and cohorts, and teachers, for their part, to the groups and streams assigned to them, limits students and teachers in the breadth of contacts. This problem can be solved by adding various forms of “horizontal” interaction of both

teachers and students, and students with students. The development of such forms as project activities, student laboratories, student university increases the motivation to study and to study mathematics, if it is organized by mathematics teachers.

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Горизонтальные связи в преподавании математики

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Аннотация. *В статье рассматриваются горизонтальные связи в преподавании фундаментальных инженерных дисциплин в СПБГЭТУ "ЛЭТИ". Именно такая комбинация традиций и инноваций может быть предложена для международного сотрудничества. Организация образования в университете содержательно осуществляется через вертикальную структуру, которая ведет студента от уровня школы к уровню инженера. Горизонтальные связи противоположны организационным административным иерархическим связям, но дополняют содержательную вертикаль.*

Ключевые слова: горизонтальные связи; цифровые технологии; обучение через преподавание; неинвазивный мониторинг; востребованное обучение