

## PROJECT-BASED LEARNING IN THE LABORATORY OF COMMUNICATION AND NAVIGATION SYSTEMS

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**Abstract.** This report deals with the project-based learning used by the communication and navigation systems laboratory in teaching aviation engineers.

**Keywords:** project-based learning, aviation engineer, radio measurements, communication and navigation systems, laboratory work, computer-controlled experiment.

### 1. Introduction

The Estonian Aviation Academy (EAVA, former Tartu Aviation College) was founded in 1993 with the purpose of training aviation specialists for the Republic of Estonia.

A peculiarity of EAVA is that it has only a small number of regular full-time members of the teaching

staff. The majority of the teachers/instructors are experienced specialists from aviation enterprises and institutions of higher education working at the Academy on a contractual basis. It has assured the permanent high quality of the teaching process and its compliance with international requirements.

The full course of all the specialities taught at the Academy lasts four years. The major specialities taught at the Academy are:

- 1) Air Traffic Management (Air Traffic Service, Management of Communication and Navigation Systems);
- 2) Aircraft Piloting (Aeroplane Piloting, Helicopter Piloting);
- 3) Aviation Management (Aviation Company Management, Aircraft Maintenance);
- 4) in the form of open studies, aviation specialists (and other people interested in aviation) can obtain a diploma of professional higher education in Aviation Administration.

In cooperation with the Estonian National Defence College, the Academy prepares Radar and Communications Officers and Aerodrome Officers for the Estonian Air Force.

In the autumn of 2011, a new Estonian Aviation Academy building was completed near Tartu Airport. The new lecture rooms and laboratories have been equipped with modern IT equipment, which offers perfect technical support for conducting teaching.

To assure the quality of training of future specialists, the Academy pays much attention to training and developing its staff. That enables it to introduce and apply new teaching/learning methods supported by the modern teaching technology the Academy has recently obtained.

In 2002 the Estonian higher education system underwent reform (i.e. the transition to a higher education structure of 3+2 years was introduced) resulting from the creation of the common European higher education area – a consequence of the Bologna process, the objective of which is to achieve coherence of educational systems and implementation of a system of comparable degrees in European member states. In higher education, the teaching process has shifted from teacher-centred teaching, the prevailing approach so common in Estonia previously, to student-centred learning. That is why learner-centred methods like project-based learning have been adopted in conducting laboratory practice at the Academy. The core idea of this method is that the students acquire knowledge and skills through independently planning and solving the problems that might occur in a real life working environment.

## 2. Project-based learning

The theoretical foundations of project-based learning proceed from the constructivist learning theory developed by Jean Piaget, Lev Vygotski, Jerome Bruner, John Dewey, among others. According to constructivism, the learner builds up new knowledge him-/herself, proceeding from the different aspects of the topic covered and from their prior knowledge and experience.

The newly acquired and the prior knowledge then form a certain system. The opposite of constructivism is reception, the most characteristic feature of which in pedagogy is a passive transmission of knowledge from one person to another (teacher-centred teaching).

The main theses of constructivist learning theory one has to proceed from when organising learner-centred learning process are as follows:

- 1) the learner is an active participator in the learning process who independently builds up his/her knowledge and does not copy or take it from any textbook or get it from his/her teacher;
- 2) there can be several correct solutions or answers;
- 3) the learning process has to take place in a real-life, authentic environment;
- 4) the learner guides the learning process him-/herself and sets the pace and aims of his/her activities him-/herself;
- 5) learning is a social activity that takes place in cooperation with other learners.

Acquiring a certain specialisation following the constructivist learning method means learner's active participation in solving real-life speciality-related problems in their learning process, which also involves critical thinking. This kind of activity is quite similar to the activities of a specialist-to-be in their future work place, and that is why learning is interesting and motivated. The learners themselves determine their concrete activities and the pace of work, construct their knowledge themselves proceeding from their prior experience, the sources of information, and the equipment for carrying out experiments at their disposal in their learning environment. Project-based learning ends with a concrete result, though it should be mentioned that more important than the final result is the whole process of how the learners reached it (Mergendoller, Thomas 2012).

Quite close to project-based learning is the problem-based learning method that came into use in the 1970s. The main difference between problem-based learning and project-based learning is that in problem-based learning the problems/tasks the learners have to solve are artificial, set by the teacher. In project-based learning, real life problems emanate when solving practical speciality-related problems in the learning environment, which is close to a real working environment.

When a problematic situation appears in both project-based learning and problem-based learning, the learner perceives that the knowledge they have is not enough to solve the problem and they have to find new approaches, try them out, and check the solutions. Both of these methods are learner-centred and new knowledge builds up as a result of the thinking process. Such a way of acquiring knowledge and skills is much more effective than teacher- and textbook-centred teaching processes. To assess the organisation of project-based learning, N. Kraft has elaborated 17 criteria that enable the teacher to

determine the quality of the designed study process and find possibilities for improving it (Kraft 2012).

### 3. Project-based learning in laboratory tasks for the course entitled Radio Measuring in Aviation

At EAVA the project-based teaching method was introduced in 2008 to run the laboratory tasks of the course entitled Radio Measuring in Aviation for the students of the Communication and Navigation Systems speciality. The initial results of introducing this method were presented at the AVIATION 2009 international conference in Vilnius on 16 July 2009 (Märtens, Umborg 2009).

When developing the project-based laboratory work task, two aims for the work are set beforehand:

- 1) the technical aim of the whole project on radio measuring conducted by the students, which has to be achieved during practical work;
- 2) the didactic aim of the work that specifies which of the knowledge, skills and experiences prescribed by the curriculum the students acquire as the outcome of the project.

When using this method, the teacher does not guide the students' thinking but creates opportunities necessary for learning, ensures access to information, and facilitates the development of a creative environment favourable to learning. The learning environment, the laboratory, is equipped in such a way that it resembles the student's future working environment. The laboratory is equipped with the measuring devices in use in Estonian aviation enterprises:

- 1) AM300 dual arbitrary generator (Rohde & Schwarz);
- 2) SMBV100A vector signal generator (Rohde & Schwarz);
- 3) SM300 RF signal generator (Rohde & Schwarz);
- 4) FSV, FS300 and FSH3 spectrum analysers (all Rohde & Schwarz);
- 5) TD2001 (Tektronix) and HM03522 (Hameg) digital oscilloscopes;
- 6) NRP-Z81 power sensor (Rohde & Schwarz), etc.

Each project team position is equipped with a PC with embedded audio card and two 22-inch monitors. Two large monitors are necessary to ensure that each project team member (3–5) can see what is going on and can thus actively participate in team work. All PCs are equipped with a NI LabVIEW licence.

The manuals of measuring devices used in the laboratory and other project-related information is accessible on the intranet of the lab.

Laboratory work focuses on acquiring and developing the following specific skills and capabilities:

- a) measuring radio receiver and transmitter parameters;
- b) measuring RF filter characteristics;
- c) measuring coaxial cable losses, distance to fault, and antenna matching;

- d) simulating and measuring DME, VOR, ILS, and ADS(B) signals;
- e) simulating and measuring pulsed radar signals.

In the problem-driving phase, the students find out what basic measurements are necessary for normal operation of communication and navigation equipment. Different measurement methods and applicable measurement instruments are analysed.

An example:

Problem: evaluation of radio frequency power.

Possible measurement methods:

- a) using power sensor;
- b) using spectrum analyser with special application software (internal or external).

In the problem-solving phase, the students select the measurement method after taking into consideration the equipment available.

An example:

Problem: evaluation of coaxial cable loss.

Possible measurement methods to select:

- a) using signal generator and power meter;
- b) using signal generator and spectrum analyser;
- c) using spectrum analyser with embedded tracking generator;
- d) using spectrum analyser with embedded tracking generator and WSWR bridge (measurements from one end of the cable only).

In the experimental phase, the student drafts the measurement scheme, connects the device being tested with measurement equipment, prepares the test routine using PC control tools to a maximum extent, and carries out the experimental part of the job. National Instruments LabView software is used as the basic tool for PC control for test routines.

Recording of experimental results and reporting is carried out on the PC used for controlling test routines.

An example:

Problem: PC-controlled evaluation of the sensitivity of a radio receiver.

Solution: the radio receiver being tested, a remotely controlled RF signal generator, and an audio card embedded in the control PC with the LabView software suite pre-installed is used. The radio receiver sensitivity measurement test procedure is well known. Using this knowledge, students create automatic test routines in the form of a LabView application file. The test routines created should be documented and an automated test process should be performed.

In the verification phase, the student analyses the results received in the experimental phase based on the following options:

- a) using different measurement methods (for example, the radio frequency power measurements described above);
- b) control measurements of any simulated signals; example: using oscilloscope for DME (Distance

Measuring Equipment) simulation measurements;

- c) verification with technical specifications of equipment with test provided by producer/supplier.

There is no need to instruct students in detail; basically they manage their work themselves. Work is done in small groups (3–5 students), which offers an excellent opportunity for developing the students' communication skills and culture of cooperation. Brainstorming is used to solve problems and plan the activities. The basic fields such laboratory tasks develop are radio measurement, radio communication and navigation systems, and PC-controlled experiments.

Students present their results in standard MS Office document and presentation formats. All the measurement data gained from LabVIEW PC-controlled software and from equipment-specific software are copied directly to the reporting documentation. The report is presented in an electronic format.

#### 4. Conclusion

Project based learning offers opportunities for creating cross-curricular links. In addition to developing speciality-related knowledge and skills, the students gain experience in planning and carrying out work and project management. This kind of experience becomes necessary for specialists-to-be who have to adjust themselves to the complicated present-day socio-economic situation or create a company or a job themselves where they can use the speciality obtained at the Academy. During the work on the speciality, a foreign language is learned as well. Reading and writing skills are also essential skills developed by project-based learning.

When starting with the project based-method, the teachers initially feared that if the students were given the opportunity to plan their learning activities themselves, they might choose easier options for achieving the aims of the work and didactic aims would not be reached. But as can be drawn from our own experience, such a fear proved to be ungrounded. Very often students offer new non-standard solutions that show the effectiveness of the given method. One of the most important advantages of project-based learning is that it encourages students' creativity.

In conclusion it can be said that students successfully achieve the aims of the project, even though it has become more difficult for them to record their activities and outcomes. Annual student surveys indicate that in laboratory work students prefer the project-based method to the traditional one.

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