

Project Based Learning - Strategy for Professional Competence Development in Higher Education

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ABSTRACT

The experience we present in this article shows a project-based learning as a strategy and a didactical guarantee for the development of basic skills of competence. In our opinion the project-based learning is an opportunity for effective learning activities and assists students in their attempt to reach a desirable level of academic knowledge and skills, to develop self-control over their own performance. The implementation of the experimental training model on content that is fundamental for different academic programs showed dynamics in individual progress and opportunities for the development of core competences through teaching and learning in non-traditional task environment. Different trends emerge from students' evaluation of their progress and the dynamics in the learning process, but the leading one is the demand for support to develop skills, to find and use all the components of the environment, to improve their own learning and to form significant competences for modern professions in response of the requirements for competence profile of specialists according to the European Qualifications Framework.

Keywords: bioscience in engineering education, project-based learning, student-centered learning, independent learning, self-assessment, peer evaluation.

INTRODUCTION

Reforms in higher education are increasingly determined by the requirements of professions that dynamically develop and require training to adapt to the challenges of a knowledge society. Today, students need to form knowledge that will allow them to find their place in society, to be able to use and develop abilities and to be ready to learn lifelong. This directs the processes, related to the

modernization of training, to particular results (development of knowledge, skills and competences) in response to the needs of employers. Learning Outcomes are systematized in documents such as the European Qualifications Framework (EQF) and National Qualifications Frameworks, but each higher education institution has specific tasks in its priorities in order to achieve the expected results for the respective EQF levels.

The primary task of the reforms in this di-

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rection is overcoming the traditional paradigm, focused on the transfer of content by the teacher. Pedagogical approaches are increasingly being implemented, based on the idea that students should be in the center of training and on the key concept of student-centered learning (SCL). This changes the roles of teachers and students and shows the student as an active and creative participant in the learning process, and teachers as assistants who support students in their autonomous learning and in the process of building transferrable and professional competences.

Theoretical concepts of pedagogy of higher education and student learning outline the framework of methodological innovations in an academic environment. The leading goal for bringing educational goals with those of business together brings out one more direction for development - the goals for a greater share of STEM (Science Technology Engineering Mathematics Education) skills of learners as a result of training at all levels. For Higher education graduates, this is a perspective that guarantees the success of individual careers in most professions. Therefore, there is a need for innovative curricula in which students expand their experience and can transfer knowledge into non-standard academic activities and which arouse excitement and additional motivation to learn [1].

The trends for increasing the requirements to the higher education are placed in documents such as EQF and accreditation standards, but this does not guarantee automatic good curriculum and teaching. At a traditional university, teachers have little knowledge of educational principles and “teach as they are taught. And in this sense, “innovativeness” means “new” and “old” teachers to know the best educational practices”. In [2] the author identifies specific areas of innovation in the curriculum: problem-based learning, group work, self-assessment and peer evaluation, cooperative training, towards the achievement of learning outcomes in various disciplines of university programs. The unifying content and

structure of the model is a reason to explore feasibility in different majors and to establish the ability to contribute to the development of core competencies through teaching and learning in a non-traditional task environment. The topics include application versions of project tasks on topics from the first-year medical students’ subject “Parasitology of Human Biology and Instrumental Methods for Separation” and from “Analysis of Bioproducts”, studied by fourth-year biotech and biomedical engineering students.

MATERIALS AND METHODS

Project-Based Learning (PBL) - Characteristics

By its nature, PBL begins with the idea that students can learn by researching, applying available experiences, exercising skills and this is related to problem solving. Often the definitions of PBL methods are mainly associated with solving problems. Although there are several authors who claim that project methods are described, there is neither theoretical justification nor practical details [3, 4]. Theoretical grounds can be traced from the promotion of the idea of “learning by doing” by John Dewey. Research in education improves this concept of teaching and learning in a methodology known as “project-based” learning. Today, a number of scientists show that learners in PBL classes receive higher outcomes than students in the traditional system [5 - 7].

PBL is a good opportunity to improve the quality of academic work if it manages to make its priority not the transfer of knowledge, but the students’ assistance to achieve individual control over the development of their own knowledge, to stimulate their cognitive and professional interests and make them active in their own development [8].

In practice, PBL assists students along with mastering academic knowledge to carry out their skills in communication, sharing experiences and managing information, managing time, and ultimately developing self-control over their own performance. This makes it possible to orient the

training towards the development of a broader range of competences and to meet the expectations of the professional practices for the competency profile of the specialists from the respective level of education of the EQF.

Some of the basic principles of project training outlined by Kolmos provide a basis for comparison with direct teaching and present the best opportunities for teaching and learning the curriculum's content:

- Training is based on the formulation of a problem as a starting point for the learning process and the main question is how this problem dictates the direction into which the learning process should go, and places greater importance on asking questions than finding answers.
- The experience of the learners is implicitly part of the learning process, and the connection of the problems with the individual experience brings along additional motivation.
- Learning based on tasks is in the center of the learning process and results are achieved by seeking information and making decisions.
- Learners learn to associate specific or empirical experiences with theory, which is a vital issue in terms of applying knowledge and, above all, the ability to analyze information.
- Active learning by working in groups, which is part of PBL, leads to the development of personal competences related to the management of cooperation processes.

Project-based training is closely linked to problem-based learning [9] and sometimes the term “mutually interchangeable” is used [10]. Although different authors have different opinions about the strategy, initially Larmer and Mergendoller [11] refer to problem-based learning as a “precursor to project learning”. Problem-based learning is defined as solving problems that provide a context for learning, while project-based learning refers to a large-scale project, planned and developed by students over a period of time and require high level of self-targeting [12].

In terms of learning methodology, distinc-

tions between problem-based and traditional are subject to a description by structuring learning levels which reflect the sequencing of learning and are as follows:

- Traditional learning: Functional-applied – contextual
- Constructive learning: Contextual-applied-functional

Different methodologies are in fact different according to where the emphasis is placed in the process. The traditional didactic approach focuses on the transmission of two functional components - “procedures” and „information“ (usually through material handout), and cognitive components are provided by the learner. There are very clearly stated benefits of this approach such as the organizing functions of teaching. Of particular importance are the expected constraints (knowledge frame and depth of view), which are specifically defined by the teacher, and this gives a high degree of confidence to the learners in their actions [13].

The Application of PBL makes it possible to develop and promote several skills that are useful in real life [11]. These are time management, collaboration and teamwork, communication [14, 15]. Most project-related skills include critical thinking, negotiating skills, and taking responsibility for own learning, independent learning, and managing incomplete or poorly structured problems [16].

The skills associated with project-based learning are also seen in the field of democratic education objectives in contrast to conventional university teaching, which is characterized by increased scrutiny. In the classic example, when a professor conducts a lecture, he controls the process because of directional communication, and students are in the role of perceiving and learning. The main question for students' learning is to find and understand what is right and what is not well done, and the professor has the right answers.

The instructor, regardless of the subject area, presents the knowledge, conveys his insight into

the topics, understandings, ideas, perspectives or concepts and controls even the way of communicating with the group. He may not discuss problematic spheres, not present any arguments for and against, or this follows from his traditional role, pedagogical authority and proven knowledge and expertise. Teaching with such characteristics is rather authoritarian or elitist and in rare situations gives students the opportunity to seek alternative knowledge compared to the knowledge the professor presents.

In the opposite direction, the PBL can be understood as a way to introduce into the system of teaching with democratic elements. It is a system in which decisions, processes and behaviors, related to learning, are established through argumentation (discussion) or negotiation (dialogue), voting or consensus (independent or in combination) between them, influenced by the decision at the same time as achievement of learning outcomes, technical and professional knowledge and insights. Participants should in principle be equal with equal rights and feel committed to the values of rationality and impartiality [17].

PBL very successfully finds application in disciplines in engineering training. This has given reasons to the authors of the experimental and innovative methods of PBL to summarize the main characteristics and approaches for its implementation. The key points of this training are:

- PBL is a pedagogical strategy in which in the learning process learners achieve a product, related to a topic.

- The PBL base consists of the authenticity or actual application of the study and is considered an alternative to learning to remember – training, based on the transfer of information from a lecturer and sources.

- In the process of learning students independently collect resources and information to create a project and/or product.

- Teaching presents and defines students' goals, and then allows the learner to study the subject and create their project.

- PBL implements a student-centered approach where the teacher is a facilitator, provides the basic activity scheme and provides guidance when needed.

- PBL provides opportunities for everyone to join individually or as a group.

When a student uses the PBL environment as a means of communicating with others, there is an opportunity to take a more active role compared to that of learning through the retransferring of information from a teacher, book or other source. It is in this role that he continually makes choices about how to receive, submit, or manipulate/process information. PBL application technologies enable students to think actively about the choices they make and the activities they perform.

The role of the teacher in PBL is more like an instructor and facilitator. This is essentially not a denial of the control of working together in class and with students, but rather striving to develop an atmosphere of shared responsibility. The instructor must structure the proposed issue to direct the training of students to materials and activities related to the content. It then needs to regulate progress against the set goals to ensure that students' projects remain focused on the specific topics and tasks.

Supporters of project learning point to numerous benefits from this strategy, including greater depth of understanding of concepts, a broader knowledge base, improved communication and interpersonal/social skills, increased leadership skills, increased creativity and improved writing skills.

However, project-based learning is not without opponents. According to some authors, the entry into the field of a mixed team learning, based on projects and peer evaluation raises the question: What do learners know? If in practice there is a lack of compliance with the set norms by all participants, then this is an obvious negative aspect of collaborative learning. Social rejection for some may include insufficient representation of team members, as well as lowering the expected

performance standards from the group as a whole in order to maintain a consistent assessment between members. In cases where only the final product is assessed, the social dynamics processes can also lead to warnings that are observed when applied at lower levels of education [18].

Research model

The design of the fundamental academic course of Human Biology, part “Parasitology and Instrumental Methods for Separation and Analysis of Bioproducts” allows to create a learning model that integrates activities for accumulation of course knowledge and methods for implementing that knowledge in professionally oriented activities, including such activities that support the improvement of personal and interpersonal skills. The application of such a design will provide learning outcomes measurable as: technical/chemical, personality competences and gained experience.

The objectives of the PBL model are:

- Putting emphasis on authenticity and autonomy in learning;
- Stimulating the initiative of the student or group of students, which follows from the requirement for a variety of educational activities;
- Increasing the share of activities that result in a visible outcome or end product;
- Organizing the duration of the activity to develop time and resource management skills;
- Change in the role of the teaching staff, which becomes consultative at all stages of learning.

Construction of the model integrates the following three approaches:

Learning approach which refers to three aspects: learning is organized around (a) problems, because the formulation allows the content of learning to be linked to (b) context and in the learning process; (c) experiences are particularly important in relation to which problems the student is attracted to in his own understanding and interests.

Meaningful approach also refers to three aspects:

- (a) *Interdisciplinary learning*. It refers to the

knowledge dimension as a solution to the formulation of the problem, which can encompass traditional thematic boundaries and methods. This principle is crucial to the organization of teaching, because teachers often consider goals within the familiar thematic-oriented framework than problems or situations.

(b) *Exemplary practice*. It deals with ensuring that students’ learning outcomes are aligned with the goal framework. This is an extremely central principle because the student must be involved in a deeper understanding of the chosen complex problem.

(c) *Theory-practice*. This means that students acquire the skills to analyze problems by using theories. During the whole learning process, they learn the art of analysis as it is necessary for analyzing problems, analyzing solutions, developing solutions and analyzing the impact of given solutions.

The main idea of the PBL is to apply the problems of the real professional practice, which will fall within the scope of academic objectives and interests. This provokes serious thinking, as students acquire and apply new knowledge in the context of problem solving. The instructor plays the role of a teacher-facilitator, working with students to form useful questions, structuring meaningful tasks, training and development of knowledge and social skills, and careful assessment of what the students have learned from the experience.

The third - social approach - refers to team learning, which means that most of the processes in the learning take place in groups and teams. This underpins the learning process as a social interaction where learning is done through dialogue and communication. Learners not only learn from each other – they also learn to share knowledge and organize the process of cooperation in the study of new knowledge and experience, including cooperation.

In the design of the disciplines in which the model is applied, laboratory activities remain an important component for demonstrating theoretic-

cal concepts, but with a focus on using Internet-accessible materials and experiments, computer simulations enabling them to be performed without limitation of schedules.

Learning theories also have „threshold“ concepts to improve learning. These educational approaches and instruments transform and professionalize the academic role of teacher as an entity in the process of organizing and managing the educational process in engineering education.

The pedagogical bases of the developed model are to be found in the ideas of Constructivism [19]. Constructive alignment, as a conceptual framework, has a significant influence on modern educational theory and practice and this is widely reflected in the literature [20]. It influences learning in higher education and provides a qualitative measure for a good educational program. The key is that all the components in the teaching-curriculum system and the planned outcomes, teaching methods used evaluation tasks – are constructively aligned to each other. The learning activities are addressed in the context of the desired learning outcomes [21].

In the realization of the methodology of the PBL is applied 3P model of Biggs: Prediction – Process – Product, which expresses the interaction between teachers and students in terms of expectations from the learning process and teaching creates a learning environment that supports learning activities towards achieving the desired learning outcomes.

The benefits of constructive alignment for students (who implement projects) will be available if the curriculum developers outline the importance of determining the objectives and the similarity between the stated objectives and the activity in which the students participate [22].

Although the theoretical framework is proven true, constructive alignment can be difficult to achieve [23]. However, it is useful as a method of approaching the target as a qualitative measure of the integrity of the stated learning objectives with the environment, activities, presentation, roles and evaluation tools [22]. The very process

of coordinating some of the components in the curricula in a common system shall be achieved by the following:

- The indication of learning objectives as to the nature and level of learning outcomes is necessary;
- Selection of appropriate learning and teaching activities exactly in the form of the desired training;
- Alignment of the assessment to make judgments about the achievement of the objectives and to confirm for the students what is necessary for the learning progress.

The PBL model implements a direct project method. Its main objectives are competent use of knowledge, processes, decision making and analysis/synthesis of content under supervision. By its very nature, this method applies to problems whose content does not require a significant change in a possible process/form/theme, but generally has an open-ended structure or open-ended result/finish. The experimental design of STEM PBL Human Biology has created opportunities for project work, which is divided into three stages with interim reports, self-assessment and peer/group evaluation. The topics of the project assignments are in the field of “Investigation of the causative agents, the distribution and treatment of certain parasitic and transmissible diseases in man”. It is essentially an authentic task, contextually rich and allows variations in the field of learning outcomes in medical majors. It includes basic knowledge, it is studied in first year for medical majors, and for Bioengineering it is part of the specialized training, which builds on basic engineering training. The structure of the project allows students to interpret it in various activities and formulate individual solutions based on knowledge and information.

Running Time: 6 weeks (between the 8th and the 13th week of the 15-week semester)

Content: Content focuses on a subject and a process provided before or during project development.

The Organization provides work in small

groups for cooperative activities and cooperation with changing responsibilities in different activities for each stage.

The work environment is formally divided into two spaces. The first is the contact classes with a clear supervision and minimal control by a teacher on the group activity, individual peer discussions to review progress, presentations of interim results and formation of group evaluations. The second is created in Google Drive common space, where: the teacher uploads general information needed for all participants in the project; each participant has an individual folder to upload their finished materials for each activity and in each stage; it is possible to account for and monitor compliance with the specified deadlines.

The resources are informational and research and are entirely within the material security of the disciplines in the traditional methods of training in medical and bioengineering majors. The informational attitude achieves a significant enrichment of the fund from materials related to the content, as individual project tasks give directions of searching and processing of a much broader range of scientific information, as well as specific data on the subjects surveyed. In

practice, this is reflected in the PBL product, and the presentation of the result is the stage at which students qualitatively enrich their knowledge on the content of the discipline.

Together with the wider knowledge of the studied objects, the development of skills and the connection of the prescribed activities and processes in a larger result are achieved.

By its nature, the process of implementation is based upon prescribed steps and structures, but at the level of interpersonal communication in the groups and between them, as well as in the reflection of the progress of others in the space of Google Drive dynamics is achieved, which has a significant influence on progress in implementation.

RESULTS AND DISCUSSION

The results of the implementation are measured as a formal assessment of academic progress, effects on the development of professional and learning skills. For this purpose, a student feedback is received through a survey. Students' self-assessment of PBL performance produces a rich picture of the organization of learning, the

PBL should be continued in other disciplines throughout the training course

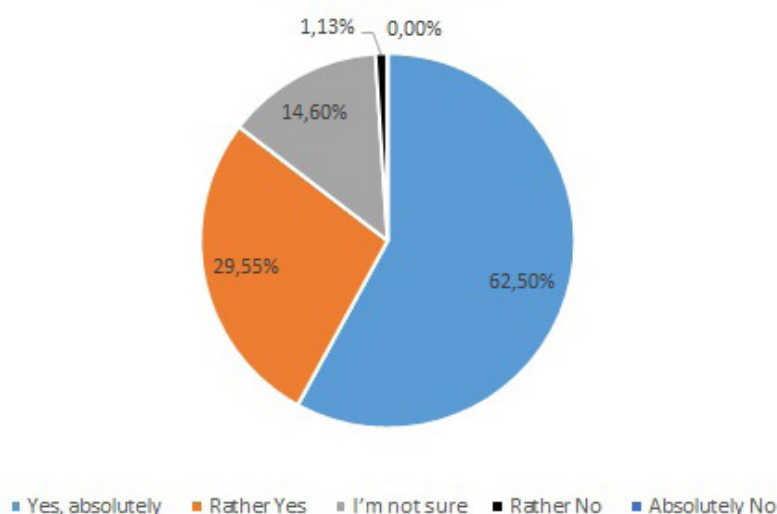


Fig. 1. Distribution of answers of the question 1.

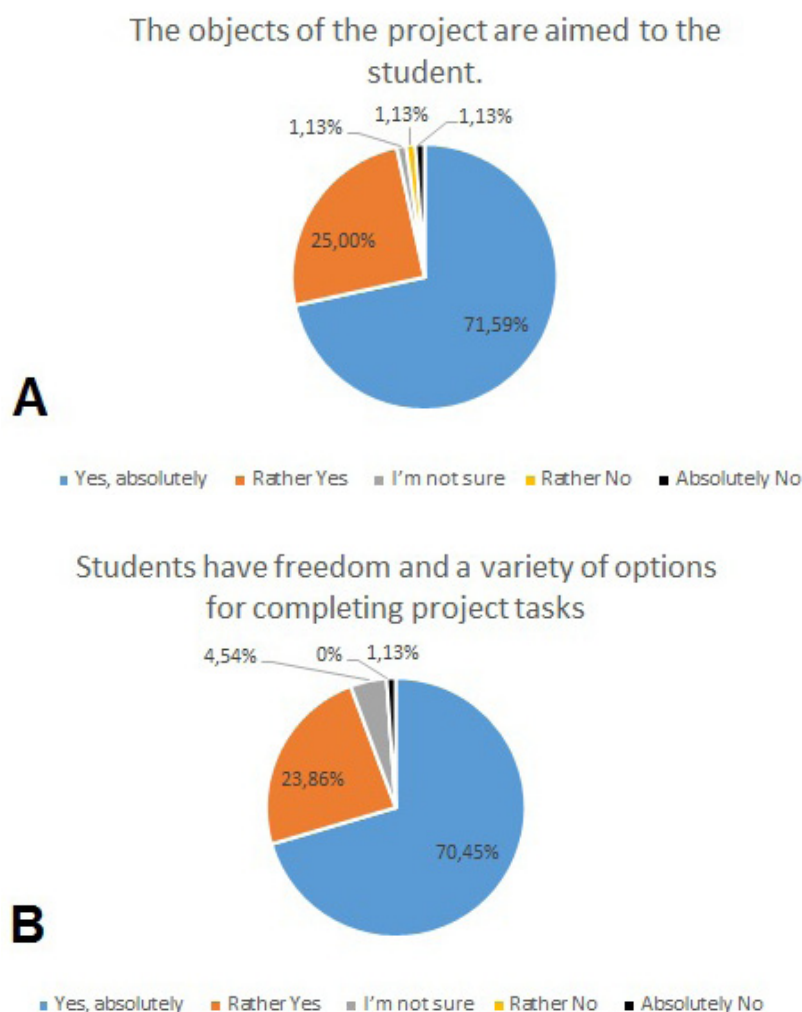


Fig. 2. Distribution of answers for A. the question 5, B. the question 9.

dynamics of individual progress and the satisfaction of applying this methodology.

One of the evaluation guidelines that we will discuss in this analysis is how students are self-evaluating as learners in this environment. This is measured by a series of questions, and some of them are addressed to specific learning outcomes. They are subject to other analyses related to the specific educational content. The scope of this discussion covers issues directly aimed at evaluating the experimented learning model. The received results of the 88 surveyed respondents show a picture that is positive, but there are some fluctuations. The analysis of students' self-evaluations in the first year of study shows the following:

- A positive feature of the PBL model is the clear understanding of the learning objectives – over 89 % affirmative responses (question #1 presented on Fig. 1)

- 90 % believe that the results correspond to the objectives set (question #5 presented on Fig. 2A) and 96 % are convinced that PBL is a student-oriented learning (question #9 presented on Fig. 2B). The allegations that “the Goals of the PBL are aimed at the student” (question 5) and “students are given freedom and variety of options in the execution of project tasks” (question 9). Nearly 94 % affirmative responses receive as 70 % of them are “yes, completely” and to “rather positive” (Figs. 2A and 2B).

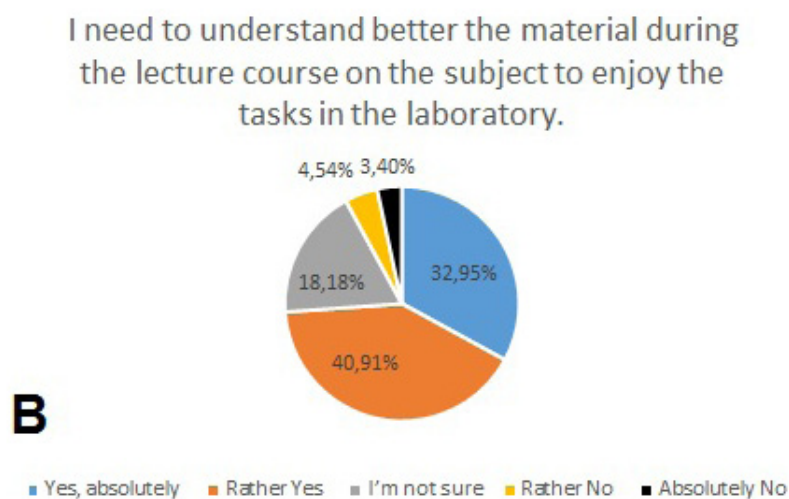
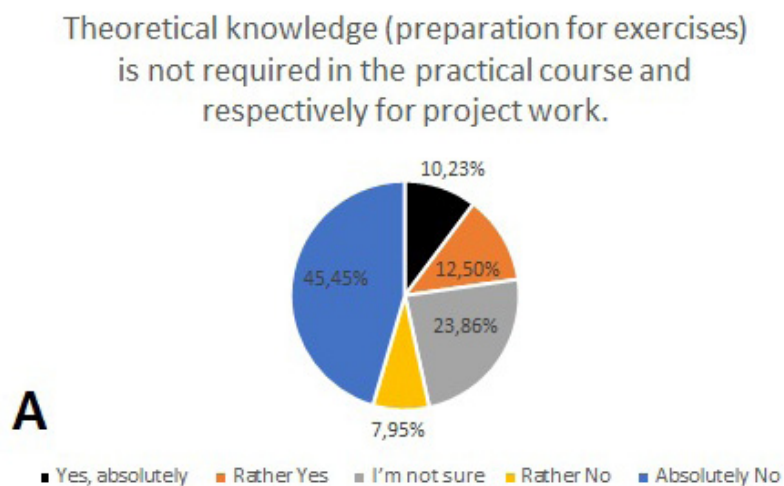


Fig. 3. Distribution of answers for A. the question 6, B. the question 8.

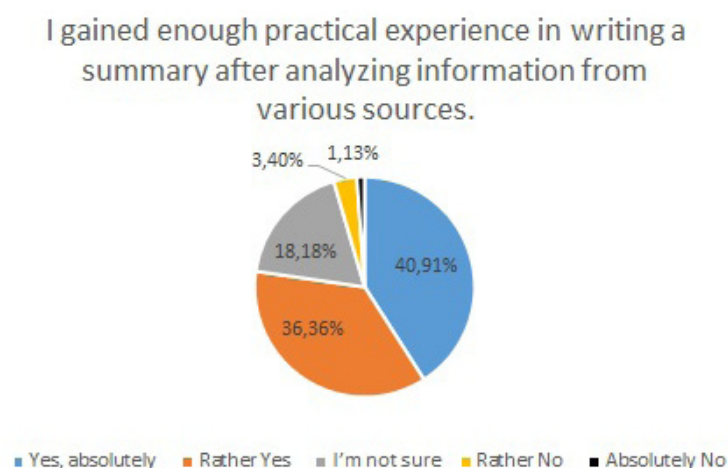


Fig. 4. Distribution of answers of the question 7.

A major discrepancy between the classic teaching concepts of academic education and PBL students are seen in the opinions on „Theoretical lessons are necessary in order to work on authentic practical tasks“ (question 6), about which 53 % say „completely not“ and „not enough“ while the question „I need to better understand the material during the course in order to enjoy performing the tasks in the laboratory“ (question 8) just under 73 % give a positive response. This shows that more than 1/3 of students do not clearly see the relationship between the classes for theoretical knowledge and the practical or project activities aimed at some result in the field of learning from the course (Figs. 3A and B).

An important feature of the experience gained in the context of future academic training and

professional conversions is the self-assessment of obtaining sufficient experience in writing short scientific texts after analysis of information from various sources, (question 7) with 77 % being confident in their progress. But the fact that more than 20 % do not find this for themselves after the execution of the project task is an indication for further discussions and changes in the model and in the approaches in the overall design of the course in the disciplines in order to develop skills for self-observation (Fig. 4).

One of the possible reasons for differences in individual progress assessments can be sought in the levels of development of self-monitoring skills (question 12). On survey data, 26 % of students do not have the skills to self-monitor their own learning. This fact at the initial stage of academic

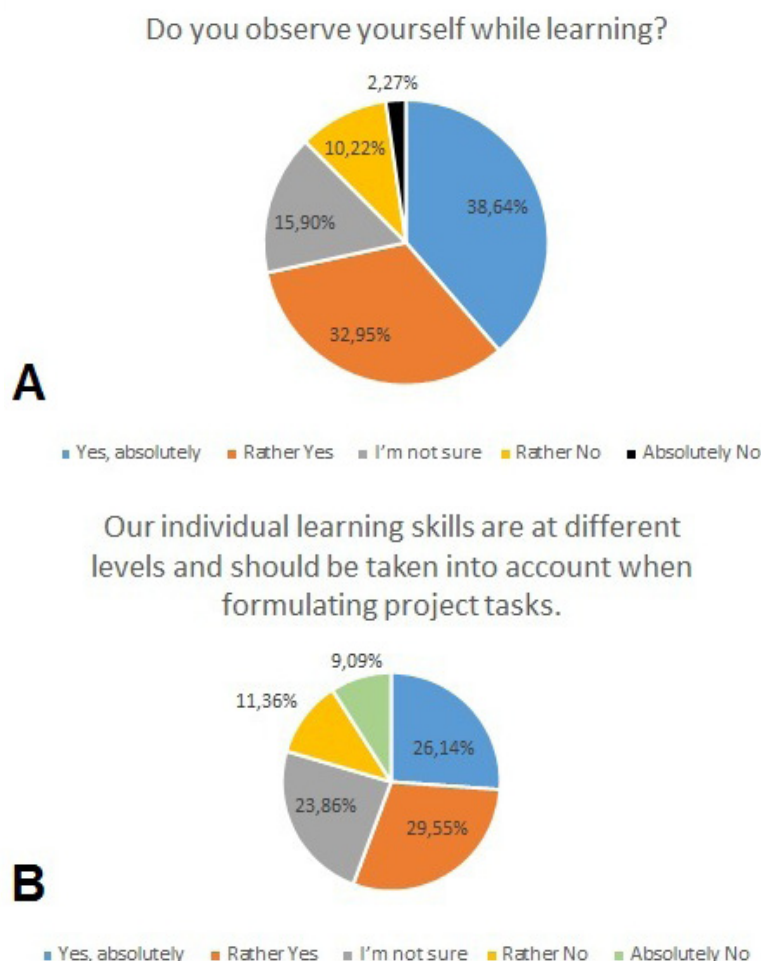


Fig. 5. Distribution of answers for A. the question 12, B. the question 13.

education is a serious signal for the direction of development of the training towards the formation of skills for self-regulated learning, which is a key for the next professional implementations and for readiness for lifelong learning. In support of this are the answers to the question: “Our individual learning skills in the group are at a different level and should be taken into account when formulating the project tasks” (question 13). Here 55 % give affirmative answers and the others do not have opinion - 23 % or do not support the statement (Figs. 5A and 5B).

At the same time, students almost unanimously, nearly 89 %, give a positive answer to the question 20: “Does working with authentic practical tasks stimulate your active participation in the

learning process?“, i.e. this shows that there is a change in activity and this is reflected to a large extent. In the same direction are the statements that „Project work stimulates students to take responsibility for their own development“ (question 21), which data is close to 86 % support (Figs. 6A and 6B). This is an indicator of PBL’s potential to develop academic and personal competences, set out in the EQF for relevant levels of university vocational education.

Project work can be carried out in different courses and between related preclinical and clinical disciplines throughout the course of study. The PBL should be continued in other disciplines throughout the course of training (6 years). More than 90 % of participants attach great importance

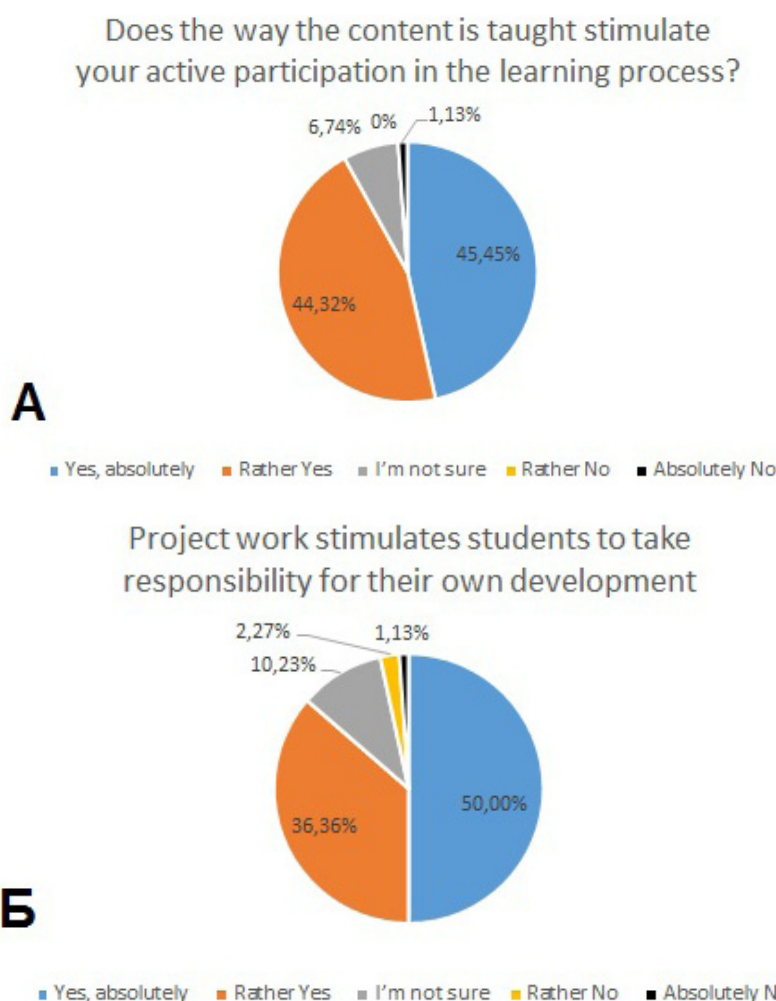


Fig. 6. Distribution of answers for A. the question 20, B. the question 21.

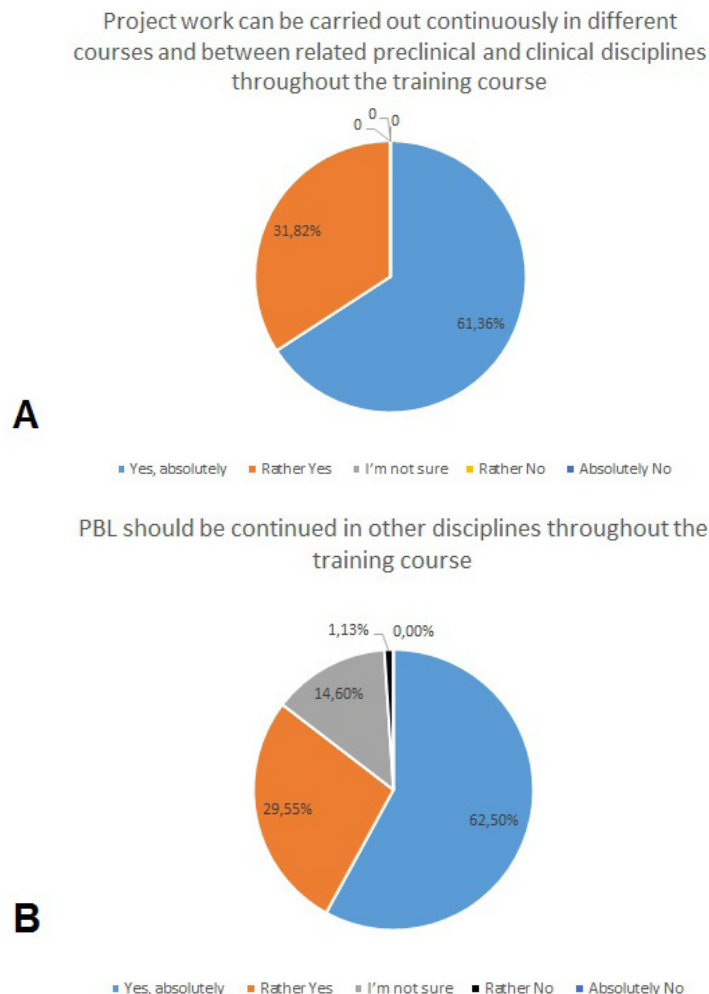


Fig. 7. Distribution of answers for A. the question 26, B. the question 25.

to project-based learning in an academic environment. 98 % think that “Project work can be carried out continuously in different courses and between related preclinical and clinical disciplines throughout the training course” (question 26). 62 % of those 98 % answer „completely YES“ and around 30 % answer „rather, YES“. Similar answers - 93 % positive responses are given to the question „PBL should be continued in other disciplines throughout the training course (6 years)“ (question 25) : „completely YES“ - 61 % and „rather, YES“ - 31 %. (Figs. 7A and 7B, respectively).

The analyses of this level of empirical data from the application of the created model support the ideas that PBL is the integration of knowledge and practice. At the same time, there are indicators

on the quality of student learning, which show the need for follow-up activities to support students in developing skills to use all components of the environment in the direction of improvement of their own learning and the formation of skills and competences relevant to the modern professions. These are the skills that are not easy to register, report and evaluate, but society “rewards them as intangible assets, such as attitudes and aspirations, passion, creativity, empathy and flexibility and cannot be taught by a textbook, but can be activated through experience” [24].

Positive attitudes towards learning based on authentic tasks support the ideas that this is one way to follow structured academic training and to respond to the change required by modern world. Moreover,

in meaningful terms, university disciplines allow for a very easy integration of interdisciplinary knowledge and experience, which corresponds to the goals of higher education today - to prepare students for realization in the global economy.

CONCLUSIONS

PBL provide student-centered and independent learning. Students that have achieved a certain level of independency in learning would in turn acquire the skills needed to become much better professionals in future.

PBL should not be understood as strategies for replacing all lectures with discussion groups or lessons, according to Armstrong [25], they would only replace one-sided system with another. Moreover, offering only one way of training can aggravate the learning outcomes of some students and others would drop out. A hybrid curriculum, successfully introduced by several institutions, combines traditional learning strategies (lectures, practical exercises) and PBL, offering learners a variety of learning styles.

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