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Project-based learning for undergraduate engineering students minoring in textile technology and design

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Abstract. The experience of application of methods of problem-based and project-based learning was described in the training of future engineers for the light industry. Methodological issues are considered, as well as practical recommendations are formulated, for the application of these methods in teaching professionally-oriented disciplines. Examples of project design and their content are given for two specialised disciplines. They are aimed at the development of students' ability to creative thinking and problem-solving when working both independently and in a team. The method effectiveness is illustrated by the formation of students' new competencies, and an increase in their motivation and experience in teamwork. The preferred styles of students' learning were studied for student groups of four different enrolment years. The learning preferences are relatively stable over the four study years. On average, engineering students minoring in textile engineering and design demonstrate a tendency to active, visual, sensing and sequential learning styles. Project-based teaching methods are not universally suitable for students with different learning preferences. Moreover, the success in projecting under the studied conditions correlates with the existing learning preferences of student teams. Student teams succeed in the implementation of projects if they have a balance in the ref-act dimension with a limited preference of the active style. In other words, excessive activity and lack of reflective reflection hindered the successful completion of projects. In the sen-int dimension, the presence of a pronounced sensitive style is also favourable for design and implementation of class projects. Successes in projecting are mostly insensitive to changes in the vis-vrb and seq-glo dimensions. The introduction of the problem and project-based learning methods is useful for engineering students. They acquire new competencies, gain real experience of teamwork, and increase motivation to learn and develop creativity.

1. Introduction
The modern labour market supposes that universities graduate ready to work engineers. The results of a survey of employers, conducted in 2019 and 2020, support such a statement for graduates of Kyiv National University of Technology and Design (KNUTD). About 70% of surveyed companies are mostly satisfied with the professional and social skills of KNUTD bachelor graduates. However, some gaps in the competencies of graduates exist in such areas as the independent acquisition of new knowledge, autonomous work, communication, teamwork and engineering knowledge application to real problem-solving. In this context, the university's role is to provide the best training for future engineers. It can be ensured by the formation of a graduate's adaptive profile that meets the modern requirements of the labour market.

Many factors affect the efficiency and training quality of future engineers. Taking into account the individual characteristics and interests of students is often called among the essential factors ([9], [10], [23]). Several approaches can be used to reckon with these conditions. Attention to the integrated characteristics of students, such as their learning styles, is considered as the correct approach [8].

The learning student preferences for technical specialities are sufficiently studied ([8], [7]). The researcher's data are generally coherent. They allow ones to choose the methods, forms, and means of teaching for the training of a typical engineering student that are the best to meet his requirements. It is generally accepted that problem-based learning (PBL) is the best suited for the training of future engineers ([16], [32]). However, such an approach gained limited application in Ukrainian higher education institutions. The PBL method is mainly used during the writing of course and diploma projects. In contrast, PBL is not traditionally used in teaching fundamental or professionally-oriented disciplines.

Furthermore, the ability to design and manage projects is among the most critical competencies of an engineer. This competency provides for the ability to participate in various aspects of project design and implementation. They include informational, methodological, material, financial and personnel support. It also involves the ability to manage the strategic development of the team in its professional activity. Therefore, activities aimed at the design and management of projects must become a vital component of future engineers training.

However, a contradiction exists between the desired and applied training methods. On the one hand, research methods are based on a student-centred approach. Students learn about a subject by collaborating in teams to solve open-ended problems. Such methods are desirable to meet students' requirements and also necessary to form future specialist competencies. On the other hand, research methods are in limited use, while traditional training methods are mostly used in reality.

Analysis of recent publications shows the growing popularity of problem-based approaches to learning activities ([6], [12], [13], [21], [28]). Researches related to the organisation of learning using a problem-based approach can be divided into two parts. In the first case, learning is based on problem-solving, and this approach is known as PBL. Studies related to PBL are primarily devoted to theoretical and methodological aspects. Their authors mostly specialise in the field of pedagogy ([25], [26], [28]). In the second case, specific examples of the application of the mentioned training technologies are studied in various subject areas for the organisation of project-based learning. This approach is usually called "project-based learning" (PjBL). The researchers are mainly teachers of specialised disciplines in the relevant fields (computer engineering, technology, design, etc.) ([5], [12], [14], [19], [20], [22], [24], [34]).

Both approaches, namely PjBL and PBL, are similar in the involvement of students in solving real-world problems; they imply collaboration in teams and simulate the professional environment. However, they are based on two different strategies. In PBL, learning issues are considered as problem situations. In PjBL, a student project is considered as an end product. Such a project results from the study of the discipline ([15], [18], [19]). PjBL is usually considered as the development of PBL.

The paper is aimed at the implementation of PBL and PjBL methods in the training of future light industry engineers. The work purpose was realised by incorporating the methods of projecting into the existing curricula of two professionally-oriented disciplines at KNUTD. Appropriate modules of the discipline content were developed and tested. The offered scheme of the training organisation intends two-step mastering of project-based technologies. In the first step, students learn the PBL and PjBL methods under control and with a teacher's aid. In the second step, students developed their creative projects without assistance as parts of the discipline syllabus.

2. Methods

The experiment was conducted at the Fashion Industry Faculty at KNUTD. Students of different enrolment years from 2014 to 2017 participated in it. The number of students in a group varied from 15 to 25 people. Students studied in two educational programs focused on training of engineering-pedagogical specialists for the light industry. One part of students minored in textile technology and the other one in textile design.

Student learning preferences were identified by R. Felder – B. Soloman method. The instrument, known as the Index of Learning Style [11], was used. All respondents answered 44 questions. The processing of responses allowed ones to estimate available preferences in four complementary dimensions. Perception of information was studied through the prism of either sensing (sen in short) or intuition (int). The input of information occurred via visual (vis) or verbal (vrb) channels. Either active (act) action or reflexive (ref) reflection determined the data processing type. Understanding of information took place by the use of a sequential (seq) or global (glo) approach. In other words, each of the four dimensions consists of a style and anti-style pair or two contrasting styles. An 11-point scale was used to quantify students' preferences for each dimension.

An individual style was considered as predominant when the calculated score in the person's answers ranged from 6 to 11 points. The preferred learning styles for a student group were assessed in two ways. In the first case, the shares of students that scored either 6 to 11 or 0 to 5 points were calculated. The learning preference was expressed as the percentage of students who scored from 6 to 11 points. Such an approach illustrated the distribution of student preferences between style and anti-style for each dimension.

Nevertheless, the first approach did not reflect the strength of the existing preference within a styling pair. The second method implies the calculation of the average score of learning preferences instead of the relative number of students in a group. The average score reflected not only the relative number of students with individual preferences but also depended on the preference strength.

Based on the individual data of each person, average data for groups were obtained. The groups were considered both formal, divided by enrolment year or educational program, and informal. In the latter case, these were student communities formed during the project activity. In the process of project implementation, students formed groups independently, based on their motives and interests.

The method of problem situation development (PBL) and the technology of project-based method (PjBL) application are described in many papers ([4], [30]). The development of problem situation involved three stages. The first stage includes the selection of issues in the educational material that could be a subject for the creation of a problem situation. The second stage is aimed at the identification of the knowledge array needed to develop a problem situation. It involves determining the necessary factual material and appropriate information resources. A methodological analysis of the emergence and resolution of contradictions was carried out at the final, third stage.

The general scheme of PjBL application in learning consists of five stages. The first is a problem-target stage, and the second includes the development of requirements specification. The third stage is devoted to practical work. The fourth and fifth are the stages of preliminary and final defence of the developed project ([17], [21], [27]).

The effectiveness of the application of PBL and PjBL was studied in the course of teaching two disciplines. The first discipline was used to practice the skills of working on individual elements of the PBL and PjBL methods under teacher guidance. The second one was used for independent creation of student projects by PjBL. Thus, two stages, namely the initial stage of mastering the components of both methods and the final stage of independent project creation, were present in the project activity. Both disciplines were taught during the seventh and eighth semesters and consisted of two modules.

The first discipline is named "Creative learning technologies". It has a volume of 180 hours (6 ECTS credits). In-class learning hours include lectures (54 hours) and practical works (76 hours). The discipline syllabus was supplemented with three new lectures and three practical classes to master the main components of PBL and PjBL methods. Students mastered the PBL and PjBL methods, as well as performed a cycle of works focused on the development of creative abilities and creative thinking. Finally, the PjBL method was used for independent development of webinars, which were conducted by students under teacher guidance.

The second discipline is "Fundamentals of engineering and pedagogical creativity". Its volume is 270 hours (9 ECTS credits). In-class learning hours include lectures (44 hours) and practical works (66 hours). The course consists of the following modules: "Fundamentals of engineering and pedagogical creativity" and "Fundamentals of project activities." Mandatory development of a project was included in the curriculum of the discipline as an individual research task. Students began to develop real projects in the eighth semester and had been making them for eight weeks. Five new lectures and five practical works on project development were introduced into the module "Fundamentals of project activity". During the practical work in the classroom, students worked in groups. They developed the following elements of projects: "tree of problems", "tree of solutions", a logical-structural matrix of the project, etc. During the independent work, students developed the same elements by chosen topics. Subsequently, the developed essential elements were supplemented and combined into a project.

Students independently selected topics of projects. Teachers played mainly advisory roles in the process of project design and implementation. External experts were involved in assessing the significance of the projects. Students participated in evaluating the effectiveness of each member of project teams. Their assessments were constituents of the teacher's evaluation criteria for the completed project.

In parallel with the project activity, practical classes of the course "Fundamentals of engineering and pedagogical creativity" were given. They were aimed to intensify creative processes and used several standard techniques. In particular, the self-questioning techniques by A.F. Osborne and B. Eberly, known as SCAMPER, were used to expand a view on the problem's environment and develop solutions [31]. The method of F. Kunze, improved and renamed to Method of Focal Objects (MFO) by C. Whiting, was applied for problem-solving and creative thinking enhancement [35]. This method allows synthesising seemingly non-matching characteristics of different random objects into something new. It serves as a means of entering into a creative state and developing imagination and associative, non-standard thinking. Some components of the Theory of Inventive Problem Solving (TRIZ) by G.S. Altshuller were utilised. They focus on provoking a breakthrough in students' thinking patterns and the way they approach problem-solving [2]. Besides, some elements of the creative training system CARUS by V.A. Moliako [29] were also used in teaching. They focus on stimulating creative thinking and developing skills to solve new problems in engineering activity.

3. Results

3.1. Preferred learning styles

Figure 1 illustrates the results of the learning preferences study for groups of KNUTD students of different enrolment years. The existing learning preferences remain valid for all studied years. However, some variation is observed in the relative number of students with different preferences for groups of different enrolment years. This variability may be caused by the fact that the number of students in each group was relatively small. Therefore, the impact of individual profiles was more significant for groups with a lower student number. Nevertheless, it can be argued that the contour of the profiles remained unchanged, at least in qualitative terms.

Visual learning style has the most significant advantage over verbal style among all four dimensions. In the vis-vrb dimension, the vis style in different years accounts for 83-89% of students. In comparison, only 11-17% of participants prefer the vrb style. The predominance of styles active and sequential is also convincing in the pairs act-ref and seq-glo, respectively. Indicators of these two predominant styles vary between 65-89% of surveyed students. In dimension sensing – intuitive, about 55-67% of students prefer sen style, while the rest 33-45% have a preferred int style. The students demonstrated a high degree of activity, visuality, sequentiality and sensing. These characteristics are almost independent of their enrolment year. The obtained results well fit with other published data for engineering students ([7], [8], [9]).

Figure 2 illustrates averaged learning profiles separately for students minoring in textile technology and design and for groups of 2014 and 2016 enrolment year. The existing preferences in the profiles of the technologists and designers almost coincide in the dimensions act-ref and seq-glo. However, they

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are somewhat different in the other two dimensions. Students-designers differ noticeably in higher visuality (95-100% among designers versus 73-80% among technologists). Besides, designers are characterised by a slightly higher sensitivity rate (56-71% versus 50-55%).

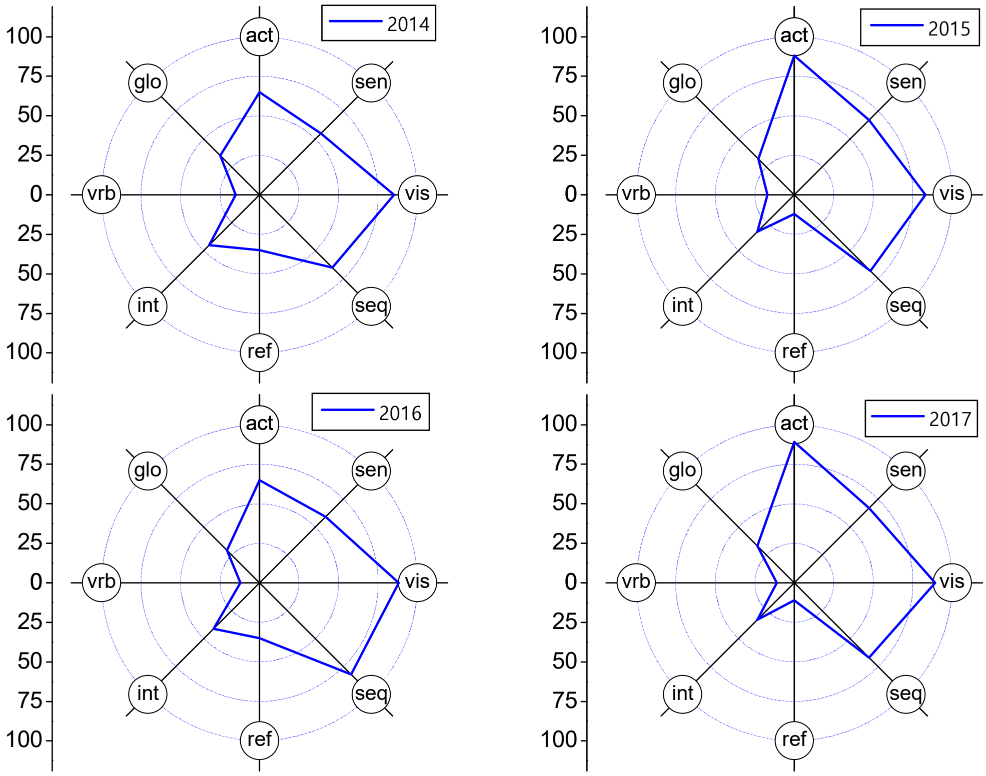

Figure 1. Profiles of learning preferences averaged for all surveyed students depending on the enrolment year.

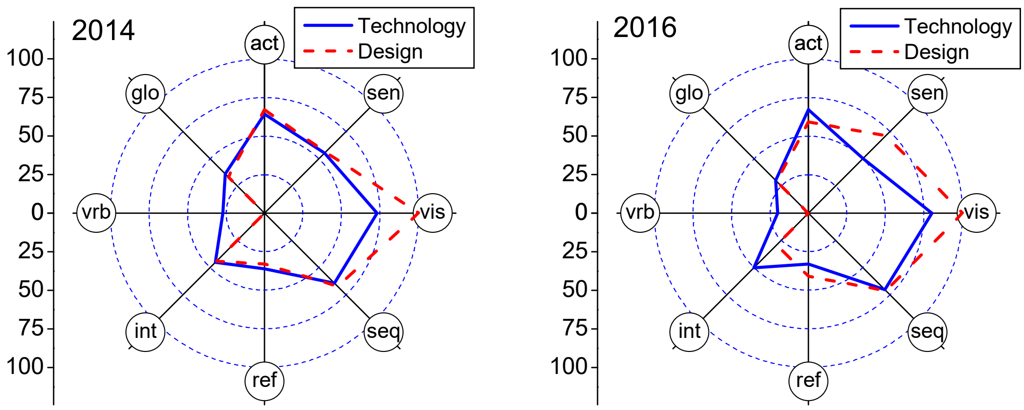

Figure 2. Learning preferences of two student groups minoring in technology and design and for 2014 and 2016 enrolment years.

Thus, the profiles of learning preferences in groups remain qualitatively stable both by enrolment years and specialisation. Such stability allows us to build a specific strategy for students' training, regardless of an enrolment year but focusing on the integrated characteristics of their learning preferences and time horizon of their changes.

3.2. Mastering of PBL and PjBL methods

PBL and PjBL methods were implemented during the study of two professionally-oriented disciplines. Development of students' ability to independent creative and project activities was carried out consistently, from simple to complex. As mentioned above, students first mastered some elements of the PBL and PJBL methods. Then gradually, the tasks became more complicated and ended with the independent development of projects. Teachers encouraged students to ask questions and reveal contradictions in classroom activities to develop a creative approach to problem-solving. The necessary knowledge and skills were gradually developed during the performance of three practical works. The characteristics of corresponding steps are given in table 1.

Table 1. List of activity types which are necessary to master PBL and PjBL methods at the initial stage of the experiment.

Activity type	Description of student activity	Aim
	Mastering of PBL	
Identification of issues that could form the subject for problem situation creating.	Students independently formulate a problem that is taken from real life and significant for them. To solve the problem, one needs to use both already acquired knowledge and new ones that have yet to be acquired.	To improve creative activity. Creative comprehension of the material can improve learning and understanding of the subject.
Creation of a knowledge base.	Students analyse what knowledge is needed to solve a problem situation and build a shared knowledge base.	To improve knowledge acquisition. Analysis of the material and the need to make explanations within a team can enhance learning and understanding.
Resolving of contradictions.	Students are responsible for solving the problem situation. They become experts on various topics.	The methodological analysis of contradictions and ways to solve the problem situation.
	Mastering of PjBL	
Definition of project problems.	Students work in pairs, acting in turns as a student and teacher. As a student, they describe the problem and formulate a project topic that is important to them. Then they exchange topics and develop project implementation plans as their teachers.	To formulate the topic, goal, tasks and forms of the final product resulted from the project. To determine the range of users, compose the project team and divide responsibilities. To write a short annotation to the project.
Development of a project plan.	Students develop a project plan and describe the main stages of work organisation by PjBL. They try the role of a teacher of professionally-oriented discipline.	To learn planning and align tasks with project goals by highlighting all project aspects (goal, scope, tasks, team, resources, time and results).
Development of a requirement specification and project schedule.	Students prepare detailed requirement specification, assess the necessary time and distribute roles among project participants.	To ensure constant feedback from the supervisor and even work distribution between students.
Regular written reporting.	Students describe their work, explain how participants coordinate their activity and continuously monitor the progress and timing of the work. They select the necessary literature.	To ensure feedback with the head and even work distribution between team members. To master the skills of writing short reports.
Presentation of the report.	Students report on the project results. The report lists all the main paragraphs and briefly explains their most relevant content.	To structure and think over the report content. To write a report.

Several complications were experimentally identified at the beginning of the problem situation development. It was difficult for students to formulate independent ideas. If a student is not accustomed to questions and active communication with a teacher in class, he will not be able to develop problem situations. Here are the keys to the development of creative activity.

Students were invited to develop a webinar to consolidate the skills of working on the method of projects. The webinars were developed under teacher guidance. Students independently formulated a real-life problem which was significant for them. During the development and conducting the webinar on a selected topic, they consolidated in practice all the stages of projecting. An external audience was involved in the webinar conducting. It included a lecturer, academic group members as experts in the field, as well as all other people wishing to visit webinar.

A report on the achieved results was prepared at the end. Students participated in the assessment of work results. They acted as opponents in the webinar presentation by another group, provided open feedback, and independently assessed the effectiveness of each team member. The use of student's opinions allowed us to increase the objectivity of the teacher's assessment.

The applied approach allowed us to reach 93% of the successful completion of educational tasks. Students learned to plan their work, coordinate tasks with the goal, distribute the work types and load and gained teamwork skills. Students have mastered ways of receiving and processing feedback to improve the resulting quality. The involvement of external experts enforced some pressure to achieve a good final result. As follows from the survey results, students' motivation to study was increased. Their responsibility towards each other was enhanced. Reflection after each stage of projecting, based on students' questions and curiosities, allowed ones to make projects more relevant and students more interested.

3.3. Application of PjBL method

After mastering the basic elements of the PBL and PjBL methods, students began to develop real projects. The activities that students carried out are described in table 2.

Students independently determined topics of their projects. The topic choice depended on the importance of a particular activity area for them. So, topics related to the future field of professional activity dominated among other problems. It can be a response to the demands of potential employers – about 80% of projects referred to this area. Social projects accounted for another 10%. The rest 10% concerned cultural self-identification. Analysis of the typology of developed projects revealed that they mainly belong to short-term mono-projects.

As follows from the analysis of the student activity results, project design improved students' attitudes toward learning and enhanced their creativity. However, only 77% of students were able to complete their projects fully and report the obtained results. The rest 23% of students had difficulties with completing the task. Table 3 illustrates the indices of learning preferences by groups. Students of group 1 successfully developed and completed projects. Students of group 2 were not able to complete all project stages.

The available learning preferences shown in table 3 were assessed in two ways, as was described in Methods. In the first case, the share of students in the group with particular learning preferences was calculated by analogy with figure 1 and figure 2. In the second case, the average indices of learning styles for each dimension were calculated for groups 1 and 2 on the base of individual data. The main difference between students in groups is reduced to two dimensions, namely act-ref and sen-int. For other dimensions, such as vis-ver and seq-glo, students were more visual and sequential regardless of the group.

The most severe difficulties, according to the student survey, occurred in the following types of activity: formulation of the purpose and identification of project tasks; creation of logical framework (logframe) matrix; and budget calculation. Financial calculations were complicated although they were simplified in projecting and included only two budgeting components, namely the team's salary and resource costs. Such difficulty was probably caused by a lack of necessary knowledge in economics. It may indicate the need to move to the implementation of interdisciplinary projects in the future. Such a transition will provide an opportunity to involve teachers of economic disciplines as supervisors or project consultants. All of the above requires finding out the reasons for students' lack of success in designing real projects. Solving this problem will improve the training methods for future professionals to carry out creative activities.

Table 2. List of activity types while mastering the method PjBL at the final stage of the experiment (independent project development).

Activity type	Description of student activity	Aim
Introduction to classifications and life cycle of projects.	Individual work on information processing — execution of tasks on classification and definition of project stages.	To form the ability to classify projects and specify stages of the project life cycle.
Implementation of methods for project idea generation and their assessment (ranking).	Group work: brainstorming or brainwriting, generating the maximum number of ideas. Individual work as experts: evaluation of other student ideas by specific criteria & ranking.	To promote the development of creative thinking and form a "bank of ideas" for further project development.
Introduction to methods of problem analysis and identification of causal effects (lean-analysis).	Group work: analysis of problem situations, determination of the target audience and project stakeholders, construction of a "problem tree" (causes -problem -consequences).	To develop the ability to establish causal effects in project development.
Definition of the project team, schedule, and purpose and objectives by SMART-criteria.	Individual work: case analysis, construction of "tree of goals" (task-goal-effect), the definition of the goal, tasks, team and project schedule, specification by SMART-criteria.	To develop the ability to identify the project purpose and tasks using SMART-criteria.
Creation of project log frame.	Introduction to the main elements of logframe (general and specific goals, results, actions, milestones, verification, assumptions/risks). Group work: case analysis & development of logframe.	To form the ability to develop a project logframe.
Planning of project results.	Acquaintance with quantitative and qualitative project results, tools of their estimation. Individual work: a study of the algorithm, examples and implementation of SWOT-analysis.	To form the ability to identify quantitative and qualitative indicators of project results and use a SWOT analysis.
Evaluation of project effectiveness. Analysis of the process for project management.	Individual work: analysis of scientific sources, acquaintance with the basic principles and functions of project management, including resource provision and performance monitoring.	To develop the ability to plan project costs and monitor the project flow.
Analysis of successful projects which were realised in Ukraine.	Individual work: search and analysis of five successfully implemented projects, analysis of the results of their applications and implementation.	To motivate students to activities and reduce anxiety about the development of independent projects.
The distinctive design of the project and its presentation.	Individual work of students on project development according to the algorithm with a subsequent presentation to the teacher and the academic group.	To apply the obtained knowledge & skills for the creation and presentation of independent projects.
Finding of grant programs.	Analysis by students of current grant programs that accept applications in certain areas	To give reasons for the realisation of developed projects and further project activity.

Table 3. Average learning preferences of students in groups formed on the base of success in project completion (students of the 2016 enrolment year).

Characteristic	Group	Act	Ref	Sen	Int	Vis	Vrb	Seq	Glo
Share of students in the group, %	Group 1- Project completed	54.5	45.5	63.6	36.4	90.9	9.09	90.9	9.09
Share of students in the group, %	Group 2 - Project uncompleted	83.3	16.7	50.0	50.0	83.3	16.7	66.7	33.3
The average score of the group, points	Group 1 - Project completed	5.64	5.36	7.45	3.55	7.91	3.09	7.00	4.00
The average score of the group, points	Group 2 - Project uncompleted	8.00	3.00	5.33	5.67	7.83	3.17	6.17	4.83

4. Discussion

Figure 3 illustrates a generalised scheme of PBL and PjBL methods implementation in the educational process. The implementation purpose was to develop the ability of future engineers to carry out professional project activities. The existing discipline syllabi have been changed to start the process of integrating PBL and PjBL methods into the educational process at KNUTD. It was done as course parts that the institution chooses at its discretion to meet the requirements of the regional labour market. All changes took place within the framework of credits approved by state education standards. It was considered appropriate to implement PBL and PjBL when students already have enough knowledge to solve professional problems. As a result, the seventh and eighth semesters of bachelor training were used, respectively.

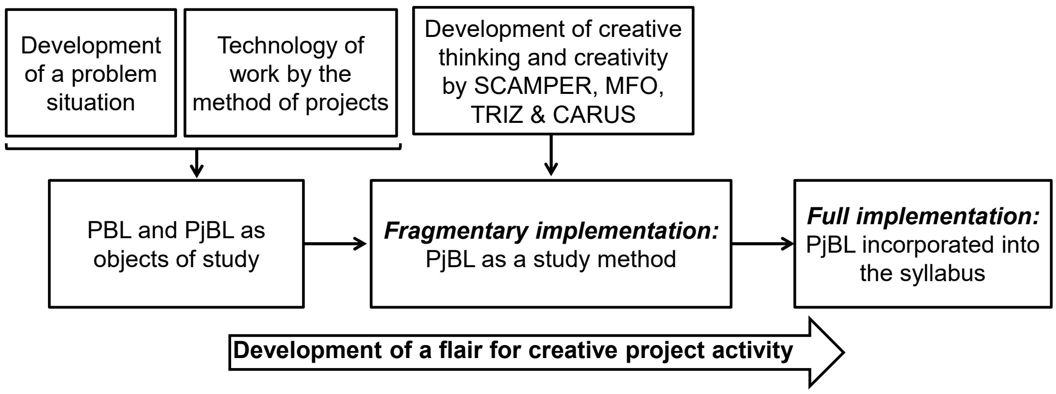

Figure 3. Scheme of PBL and PjBL method implementation in the training process for future technologists and designers.

In general, the proposed implementation scheme can be considered successful. Survey data showed that most students demonstrated a positive attitude towards projecting. According to students, they are more interested in learning using PjBL than in traditional learning. They agree that teaching strategy is an essential factor influencing their interest in the learning process. About 51% of students agreed that project-based learning increases their critical thinking. About 49% firmly agreed that they became more creative when designing their projects. The derived conclusions are supported by the statements in [1], [3], and [33] that PjBL is aimed at involving students in the study of real-life events and the development of personal creativity. Teachers noted that when creating a project, students often exchanged ideas, discussed ideas within a group and learned to find solutions. PjBL increased students' ability to work in a team.

However, the overall result of the PjBL application is not entirely satisfactory, as 23% of students could not complete all project stages. When they worked on the project entirely under the teacher guidance, the success rate was much higher – 93%. Trying to explain this, we can assume the action of at least two factors. The first factor is the lack of knowledge needed to develop a full-fledged project. In particular, some students recognised a lack of training in economics. The possibility of implementing interdisciplinary projects instead of mono-projects can be considered as a way to improve the projecting in the future. Such interdisciplinary projects involve, if necessary, teachers of related fields (economists, applied mathematicians, computer scientists, mechanics, etc.) as supervisors or consultants. Such involvement can cause additional difficulties in planning the workload of teachers and the distribution of roles in project groups. The solution may be the introduction of a separate discipline. Then, for example, two different departments may be responsible for its implementation with the appropriate load distribution. Tighter fixation of project topic choice by students may be a disadvantage of the new approach. Therefore, this requires additional consideration.

Another factor is related to the characteristics of student learning styles (table 3). Based on the relative number of students, the predominance of the active style is observed in both groups. However, this advantage is much more pronounced for students of group 2. Comparing the average act indices suggests the reasons for this discrepancy. The average score of activity in group 2 is much higher than in group 1 (8 against 5.64 points). In other words, students with a strongly pronounced active style dominate in group 2.

In contrast, students of group 1 are characterised by a moderate advantage of the active over reflective style (table 3). Therefore, according to the obtained results, excessive activity and lack of reflective reflection hindered the successful completion of projects. In the sen-int dimension, students of group 1 exhibit a clear preference for sen style. A relative balance between sen-int styles is observed in group 2.

The results obtained at first glance contain contradictions. Group work and project activities are considered suitable for active students. Our results show that moderate activity contributes to successful project implementation. In contrast, excessive activity hinders its implementation.

It is also common knowledge that invention is natural for students with an intuitive style. Students with a sensitive style learn better about the facts linked to real life. Nevertheless, the results show that students with a predominant sensitive style demonstrate better results in projects that contradict with theoretic considerations. However, this contradiction disappears if we take into account that students independently chose the project topics. Students with a prevailing sensitive style chose projects that had a real connection to real life. Besides, they focused on mono-projects. In other words, they limited the need to work with unknown facts and focused on well-known things ([10], [11]).

The results obtained showed that more than half of the teachers noted the difficulty of using PBL and PjBL methods. The survey of teachers allowed to formulate several major methodological complications when working with the method of projects. They are as follows: uncertainty of some task definitions, inability to use in projecting all the knowledge required by the syllabus, difficulties in the assessment of group performance, and more complex than expected time management and monitoring. However, almost all teachers acknowledged that the project-based methods help to eliminate routine. The advantages of such an approach include higher enthusiasm in work, the interest of students, connection with the profession and real-life, cooperation in work, self-control, and discipline of the group.

Ideally, the involvement of the business sector is needed to formulate the project themes. It can be one of the most challenging stages and also requires methodological development. It is necessary to prove to the business sector that projecting is mainly devoted to a learning process. It is not a free labour force explicitly created for commercial purposes. However, such work can be useful for business, as it has the potential to find real solutions to problems that arise in the business sphere.

5. Conclusions

The learning preferences were investigated for groups of engineering students minoring in textile technology and design. On average, students show a tendency to active, visual, sensing and sequential learning styles. The learning preferences are relatively stable over the studied four enrolment years. Students specialising in the design are more visual than student-technologists. However, the profiles of the groups minoring in design look generally similar to the profiles of students specialising in technology.

The effectiveness of problem-based and project-based learning has been studied experimentally for teaching two professionally-oriented disciplines. Students initially experienced problems when the development of problem situations. However, they moved from simple elements of the studied methods to complex ones under teacher guidance. As a result, both PBL and PjBL methods have been successfully mastered by 93% of all students.

When students formulated and designed projects without teacher assistance, they experienced much more severe problems. The share of completed projects was only 73% against 93% at the previous stage. Besides, students tended to mono-projects. They lacked some knowledge, for example, in economics, which may have prevented them from doing interdisciplinary projects.

The study showed that successful projects under the studied conditions correlate with the existing student learning preferences. Student groups are successful in the implementation of projects if they have a more obvious advantage of reflective style and simultaneously maintain moderate activity. In the sen-int dimension, the presence of a pronounced sensitive style is also favourable for successful projecting. Successes in project implementation are mainly insensitive to changes in the dimensions of vis-vrb and seq-glo.

Thus, the initial hypothesis about the universality of the project-based methods for students with any learning preferences has not been fully confirmed. Nevertheless, the introduction of PBL and PjBL methods are useful for engineering students. They gain new competencies, obtain real experience in teamwork, increase their motivation to learn and develop creativity. Improving the methods of implementing PjBL is a promising topic for further research.

The problems of PBL and PjBL method application are discussed in terms of teacher training. Most of such problems can be solved by the organisation of specialised training of teachers.

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