Implementation of Project-Based Learning in the Professional Subject of Scripting

Peter Tokoš[1], Zlatica Huľová[2,*], Roman Hrmo[1], and Lucia Krištofiaková[1]

[1]Department of Didactics of Vocational Subjects, DTI University, Dubnica nad Váhom, Slovak Republic
[2]Faculty of Education, Catholic University of Ružomberok, Hrabovská cesta 1, Ružomberok, Slovak Republic
Email: peter.tokos@petertokos.com (P.T.); zlatica.hulova@ku.sk (Z.H.); hrmo@dti.sk (R.H.); kristofiakova@dti.sk (L.K.)
*Corresponding author

Manuscript received February 12, 2025; revised April 7, 2025; accepted June 20, 2025; published November 19, 2025

***Abstract*—In this paper, the authors present the implementation of Project-Based Learning (PBL) in the vocational subject of Scripting Languages at a vocational high school of Information Technology. The research aimed to validate the effectiveness of the three-stage project-based model within the Science, Technology, Engineering, Arts, Mathematics (STEAM) approach. The research sample consisted of 15 students, three of whom had Special Educational Needs (SEND). A combination of quantitative and qualitative methods was used to monitor changes in pupils' performance, independence, and active engagement in the learning process. The results showed a slight improvement in average scores for pupils with SEND, increased independence, and more active participation in learning. Task differentiation strengthened team cohesion and promoted teamwork. The integration of PBL within the STEAM approach contributed to a deeper understanding of the technical curriculum and promoted complex thinking. Based on the findings and the comparison of results, we conclude that the systematic introduction of PBL within the STEAM approach in vocational education is a suitable tool for effective and creative programming instruction.**

***Keywords*—project-based learning, scripting languages, web applications, teamwork, creative thinking, Science, Technology, Engineering, Arts, Mathematics (STEAM), inclusive education**

I. Introduction

Teaching programming in secondary vocational schools requires didactic approaches that promote the practical application of knowledge, students' independence, and their ability to work together to solve problems. Traditional forms of work, based on static explanations and repetition of basic tasks, often do not lead to a deeper understanding or the development of the skills needed in the field of information technology. Many pupils perceive programming as abstract and difficult, especially if there is a lack of linking the learning to a concrete outcome that is meaningful to them.

At the same time, the need to take into account the diverse needs of pupils is increasingly encountered in the school environment. Classrooms contain pupils with different levels of prior knowledge, different learning styles, as well as pupils with special educational needs. In such an environment, it is important to offer tasks that are tailored to individual abilities, but at the same time promote cooperation and lead to a common goal.

This study aims to validate the effectiveness of a three-stage model of instruction in the professional subject of Scripting Languages that links independent and teamwork, uses differentiation by difficulty, and combines technical, creative, and organizational skills. The focus is on students' ability to solve tasks that have concrete outcomes and real-world applications, while allowing them to participate in a team in a way that takes into account their abilities, interests, and individual needs. The aim is to explore the impact of this strategy on pupils' performance, independence, and activity in an inclusive classroom.

II. Literature Review

Given the rapid technological developments and the changing needs of the labour market, it is essential that the teaching of programming in schools' changes and innovates didactic approaches. Traditional methods often do not take into account the need to link theory with practical application, which reduces students' motivation and ability to apply the knowledge acquired. Ou [1] points out that the level of programming education in secondary schools is behind expectations, and the current curriculum design requires modernisation and didactic revitalisation with an emphasis on practicality and meaningfulness of learning.

According to Shin [2], traditional teaching approaches to programming, which involve complex syntax and less intuitive user interfaces, often do not appeal to learners. Many of them perceive programming as a challenging field meant only for professionals. To reduce these barriers and make programming accessible to a wider range of learners, teaching methods based on visual and tangible tools that facilitate the understanding of basic concepts and the development of practical skills need to be used.

Project-Based Learning (PBL) is an approach to learning that allows students to develop skills through practical problem solving [3].

It is also used in the field of Information Technology, where the emphasis is on the ability to apply knowledge in real-life situations and technological tasks. Especially in the subject of Scripting Languages, students must learn not only the syntax and structure of languages such as JavaScript or PHP, but also how to use them to create functional and interactive web solutions. It is scripting languages, with their dynamic nature, visual feedback, and immediate output, that provide the ideal environment for introducing PBL, which motivates pupils to experiment creatively and solve real-world problems. In this way, pupils' anxiety and stress about possible failure in the classroom are also reduced.

Zhang [4] points out that the use of PBL helps to reduce learner anxiety by encouraging active learning, collaboration, and experimentation. It also enables teachers to create a stimulating environment that fosters students' self-confidence, independence, and deeper intellectual engagement in learning.

However, teaching scripting languages in traditional

doi: 10.18178/ijiet.2025.15.11.2447

settings faces several challenges. Learners often do not understand the practical meaning of particular language constructs, do not see the connection between theory, and application, and lack motivation to learn without concrete outcomes.

However, the implementation of PBL faces several challenges, namely engaging learners, defining the role of the teacher, and developing effective assessment mechanisms [5].

PBL guides students to build their solutions from the ground up, with each step in the learning process having a specific purpose, and goal. By solving problems that simulate real-life situations, pupils gain experience relevant to employment in the IT sector.

PBL is also suitable for teaching programming as it develops problem-solving, algorithm design, and teamwork skills. However, successfully mastering the basics requires combining PBL with hands-on programming exercises that help practice syntax and working with tools. The key to effectiveness is well-designed case problems with a sufficient degree of open-endedness and the support of a tutor who guides students in finding solutions [6].

Where PBL is often implemented as an open-ended, loosely structured process, this model offers three clearly defined and sequenced project stages, differentiated by difficulty, form of work, and target skills. Emphasis is also placed on inclusiveness, interdisciplinarity, and the use of teamwork management tools. In this way, an effective, reflective, and technically relevant environment is created that fosters the comprehensive development of the learner as a creator, collaborator, and future professional.

PBL encompasses a wide range of activities that are often defined differently in the literature. A project is a complex school task aimed at the practical application of knowledge, resulting in an original solution or unique product, and requires an active approach from the student [7]. The use of PBL contributes significantly to the development of students' critical thinking skills and increases their engagement in the learning process compared to the traditional lecture-based form of teaching. This model also promotes dynamic and interactive collaboration not only between the teacher and the students, but also among the students themselves, thus enhancing active participation and the ability to think independently during instruction [8].

The process of project development by the teacher includes defining the project goal, planning and organising the work, dividing tasks, working in a team, and preparing the final deliverables such as applications, websites, documentation, or presentations.

In everyday practice, we encounter pupils with special educational needs from all categories in secondary schools. In addition, foreigners who do not speak Slovak and come from different cultures or nationalities are now a common part of classrooms [9].

In such cases, it is essential to take individual needs into account when designing projects and to develop individual tasks and recommendations that psychologists have created specifically for each pupil with SEND. These disorders are mainly grade II dyslexia, grade III dysorthography, grade II dysgraphia, and grade II dyscalculia.

D'Elia [9] points out that inclusive education enables students with specific needs to understand the curriculum more effectively through activities such as role-playing, making objects or visual representations. These methods help them to participate actively in the classroom, to feel like a full part of the learning process, and to translate their capabilities and environment into concrete actions, thus positively shaping their relationship to learning.

One of the main advantages of project-based learning in IT is the opportunity to acquire skills such as working with programming languages, application development, and database management. In this way, students develop critical and logical thinking, creativity, and the ability to design and implement solutions. At the same time, project-based learning enables the simulation of processes from the real IT industry, thus preparing pupils for their future professional challenges. As stated in, [10] feedback is also part of this approach, encouraging discussion of solutions and improving the quality of outputs.

PBL promotes students' active engagement, independence, and satisfaction with learning programming. It enables them to solve problems by analysing and creating their solutions, thereby deepening their understanding. It also highlights the need for further research in areas such as working in teams with different input knowledge or fine-tuning the methodology [11]. The use of PBL strongly promotes students' responsibility for their learning. Making decisions about the course of work, dividing tasks, and taking responsibility for the outcome leads to higher motivation, engagement, self-direction, and persistence [12]. Traditional forms of teaching often do not provide space for these competences, which is why PBL education is the key to their development. According to Lu Zhang [13], PBL is a learner-centred approach that aims to develop 21st-century skills, especially higher-order cognitive skills. These are based on solving complex problems that are based on real-life situations and require an open-ended, flexible approach. It leads pupils to actively seek solutions, thus naturally fostering analytical thinking, creativity, and the ability to think independently.

Today's students face a complex array of global, and societal challenges [14].

Project-based learning in IT subjects is therefore an effective tool for preparing students for their future careers in the dynamic world of information technology [15].

In PBL, the teacher plays a key role as a facilitator, guiding students through the learning process rather than directly presenting them with ready-made solutions. This approach encourages their autonomy, independent discovery, and active engagement. While pupils perceive a higher level of collaboration and engagement, teachers appreciate the opportunity to respond to individual needs in a more targeted way [16].

Part of facilitation, as one of the main roles of the teacher, is to communicate with students positively.

In pedagogical communication, there is interaction and interaction between the student and the teacher through positive verbal and non-verbal expressions that contribute to the creation of a positive classroom climate [17].

Project-based learning in IT also finds a strong underpinning in the STEAM curriculum, which emphasises the link between technical disciplines and artistic thinking.

The STEAM approach emphasises the integration of knowledge from multiple disciplines, and the development of complex thinking plays a key role in shaping the skills needed for students' long-term personal and professional growth [18].

STEAM has now become an accepted approach in education and is increasingly used in schools around the world [19].

The PBL strategy, within the STEAM approach, represents a model of learning that goes beyond traditional vocational education frameworks. Unlike its common use as a stand-alone method, the strategy proposed and implemented by the authors facilitates the development of technical skills, creativity, and teamwork.

An important element of the proposed strategy is also a thoughtful differentiation of the difficulty of the project tasks concerning the needs of pupils with SEND.

Task differentiation arises not only as a result of pre-prepared plans, but also as a teacher's response to the changing needs of pupils during the lesson. Effective teaching, therefore, requires responsiveness to diversity in an inclusive classroom. At the same time, differentiation must be underpinned by systematic planning, which is an integral part of teacher preparation and professional development [20]. Pupils with SEND often benefit greatly from the support of teachers with whom they are in daily contact. Teachers, therefore, play a key role in meeting their individual needs, not only professionally but also in terms of emotional support. They need to be prepared for this role, to know specific didactic approaches and procedures, to be able to respond flexibly, and to create an environment that enables pupils to learn according to their abilities, aptitudes, and personal pace [21].

A. Limits and Risks of PBL

It is appropriate to develop students' competencies through PBL, but its implementation also poses several challenges. One of them is the significant time commitment from project preparation, through implementation, to evaluation. It is difficult to devote sufficient space to all topics in the context of a limited school timetable. The more active pupils often take over the work for the more passive ones. There are higher demands on the teacher, who has to fulfil the role of facilitator, which requires experience and methodological skill. Evaluation of projects can be subjective, especially in ascertaining the individual contribution of the pupil.

If the focus is only on output, there is a risk of superficial learning. Work can be stressful for pupils with SEND if there is no clear instruction and no differentiated tasks. Lack of technical equipment can limit the delivery of more challenging projects, affecting their quality and equity. Despite these limitations, PBL remains a powerful tool when implemented thoughtfully and with a focus on supporting learners.

Also, according to Kokotsaki [22], PBL is presented as an effective method of learning, but teachers face increased workload and constraints from traditional school schedules that are often incompatible with time-consuming projects.

Inadequate material and technological equipment, as well as an unfavourable school culture, can make the implementation of PBL significantly more difficult. Limited understanding on the part of teachers, who often perceive PBL as a loss of control over the classroom, is also a problem. These factors can cause resistance to innovation and the persistence or maintenance of traditional forms of teaching at the expense of active learning.

III. Materials and Methods

The authors' intention in the research is to investigate whether the proposed teaching design leads to increased activity, motivation, and improved learning outcomes for pupils. Thus, the main aim of the research is to verify the effectiveness of the PBL strategy within the STEAM approach regarding the differentiation of tasks according to the level of skills and needs of pupils, including those with SEND in the vocational subject of Scripted Languages.

A. Research Questions

From the defined objective, two main research questions emerged, which were sought to be answered through the chosen qualitative and quantitative research methods.

VO1: What is the impact of implementing a PBL strategy within a STEAM approach with differentiated tasks on student performance (improved learning outcomes) in inclusive instruction?

VO2: Will collaboration, pupil interest in learning (increased engagement of pupils with SEND), and greater autonomy of all stakeholders be improved following the implementation of a PBL strategy within a STEAM approach with differentiated tasks in inclusive teaching?

B. Research Sample

The research was carried out in the third-year class of the Secondary Vocational School of Information Technology and involved 15 pupils, 3 of whom are SEND pupils with diagnoses of dyslexia grade II, dysorthography grade III, and a combination of dysgraphia grade II and dyscalculia grade II.

C. Methods of Measurement and Evaluation

Through the chosen qualitative and quantitative methods of investigation (see Table 1), answers to the stated research questions and to check the verification of the main research objective were sought.

The pupils' baseline scores are shown in Table 2.

Table 1. Methods of measurement and evaluation in research

evaluation method	data type	the focus of the evaluation
Comparison grades before and after intervention	quantitative	change in pupil performance, tracking the progress of pupils with SEND, and reducing the gap between groups
interviews semi-structured interviews with pupils	qualitative	subjective perception of the project, motivation, independence, and satisfaction with the tasks
observation observation of behaviour during teaching	quantitative-qualitative	activity, teamwork, willingness to tackle tasks of varying difficulty, including pupils with SEND

Table 2. Assessment of pupils

Group of pupils	Number of pupils (n)	Rating (AM)
pupils without SEND	$n = 12$	AM 2.3
pupils with SEND	$n = 3$	AM 2.9
total	$n = 15$	AM 2.4

D. Intervention: Implementing a PBL Strategy within a STEAM Approach with Differentiated Roles

The intervention consisted of the implementation of a three-step PBL strategy within a STEAM approach with differentiated tasks according to the individual needs of students with SEND.

E. Expectations

After the implementation of the intervention, it is expected that:
1) learning outcomes will improve,
2) engagement of pupils with SEND will increase, and,
3) All pupils will demonstrate greater independence in learning.

IV. Design and Implementation of a PBL Strategy in a Steam Approach with Differentiated Tasks in the Subject of Scripting Languages

While the standard PBL model in similar subjects often ends up with individual or team output without linking results between students, this teaching strategy leads students to collectively integrate outputs, simulating a real team-based software development environment. At the same time, the strategy is designed to promote differentiation by skill level with respect to students with SEND, ranging from simpler individual tasks to complex team integrations. The use of tools such as Trello or Asana develops pupils' project management skills, which go beyond traditional scripting language learning outcomes and move the learning towards the development of 'future skills', which are in demand in today's labour market. The three-stage strategy we have designed allows pupils to engage according to their abilities and preferences.

In the first stage, they work individually and have the opportunity to learn basic technical skills in a protective, low-pressure environment. In the second stage, they choose the functionality they will implement, while the scope and complexity of the assignment are flexible. Pupils with SEND can work on less complex solutions, while more advanced pupils can work on more algorithmically and logically challenging elements. In the third stage, teamwork, pupils have different roles (programming, testing, documentation, design), thus respecting their abilities. This form of differentiation also reduces stress, increases the involvement of all pupils, and creates a fair but challenging environment where everyone can develop to the best of their ability. In doing so, segregation is not created, but diversity is encouraged in a shared team, which also strengthens social competence and collaboration in an inclusive team. A particular benefit of this strategy is the purposeful integration of elements of the STEAM approach into all three phases of project-based learning. While traditional project-based learning often focuses solely on technical problem solving, in this model, students are encouraged to link engineering and programming skills with artistic and design thinking. The aesthetics of the user interface (A - Arts) are already applied in solving the first stage of the project, in the second stage mathematical and logical challenges such as calculations, algorithms, date validation (M - Mathematics) are tackled, and in the third stage pupils are encouraged to work as a team, planning and optimising solutions (E - Engineering and T - Technology).

This holistic approach helps students understand that a successful IT solution is not just about functionality, but also about usability, visual appeal, and the ability to work collaboratively in a multidisciplinary team. STEAM thus extends typical PBL to include the dimensions of creativity, aesthetics, and systems thinking that are now crucial for complex tasks in digital environments.

A. Design of a PBL Strategy within the STEAM Approach

The PBL strategy within the STEAM approach is designed for third-year students in the 2573 M Digital Media Programming major, with a focus on web application development, and is focused on creating a web application using the JavaScript scripting language. 15 pupils participated in the solution, three of whom have SEND. The whole project is conceived as a sequence of three project tasks, which are logically connected and form the stages of a complex assignment for pupils according to the principles of the PBL strategy:

Stage I: creation of a basic web calendar

Technologies used: HTML5, CSS3, Bootstrap, JavaScript (JS), jQuery.

Form of project implementation: it is recommended to implement the project in a combined full-time and distance form in a 50/50 ratio of 4 teaching hours.

Organisational form of work: independent work.

Aim of stage I of the project: to apply JS for dynamic manipulation of web content and to create a practical application in the field of everyday life.

Output: a functional web calendar in electronic form Students is advised to set a pre-agreed deadline for handing in the project, which will not be changed anymore.

Assignment: Create a simple web calendar using HTML, CSS, and JS. The calendar must contain features that allow:
- view the days of the month, including the name of the month and the current year,
- add buttons to move between months (forward and backward),
- dynamically update the calendar view according to the selected month,
- provide client-side calendar functionality without loading a new page.

In the implementation of the task, it is necessary to:
- modify the page to make it clear and aesthetic using basic CSS,
- implement button functionality in JS, with scrolling through the moons in any direction,
- take into account the number of days in each month, and correctly place days based on the day of the week the month begins.

Handing over the task:
- submit the project in the form of HTML, CSS and JS files by the agreed deadline,
- attach textual documentation that briefly describes:
  - the structure and functionality of the code,
  - the process of problem solving,
  - the problems encountered and how to solve them.

Assessment and grading: The assessment and grading of the assignment will be carried out in two steps involving both the student and the teacher. This process promotes an objective evaluation of the result and, at the same time, the development of reflection in the pupil. First, the pupil himself evaluates the task using a self-assessment. He/she assesses to what extent he/she has completed the assignment, what his/her approach to the work was, and what he/she would improve about the project. He/she gives a brief justification for his/her assessment and evaluates himself/herself, thus developing responsibility for his/her work and the ability to reflect on his/her strengths and weaknesses. The project is then evaluated by the teacher, who assesses whether the technical requirements have been met, the functionality of the calendar, the implementation of the technology, and the quality of the documentation. They will also take into account the pupil's reflection and self-assessment to ensure that the final grade is fair and supportive of the pupil's progress. The final assessment emphasises the development of technical skills and the creation of a positive attitude to learning. The final assessment also takes into account the special educational needs of the pupil.

Stage II: Extension of the web calendar functionality

Technologies used: HTML5, CSS3, Bootstrap, JavaScript (JS), jQuery.

Form of project implementation: it is recommended to implement the project in a combined full-time and distance form in a 50/50 ratio of 4 teaching hours.

Organizational form of work: teamwork (two pupils in a team).

Aim of stage I of the project: to extend the functionality of the created calendar from stage I by the selected additional function. This will teach students how to add new elements to an existing project, improve its functionality, and at the same time deepen their knowledge of JS programming.

Output: extended functional web calendar in electronic form, we recommend that students enter a pre-agreed deadline for the submission of the project, which will no longer be changed.

Assignment: Suggest that the pupils divide into groups of two. Agree on who will provide their Stage I problem as a basis for solving the Stage II problem. Each pupil chooses one of the following options to extend the functionality of the common calendar and implements it:

- modify the calendar generation logic so that the first day of the week is Monday,
- add the ability to display the week number for each row of the calendar,
- implement a function to calculate and display the number of days in the current year,
- add-on to switch the calendar display to weekdays only mode,
- create a function to return how many weekends there are in the current month,
- add a function to validate the entered date (e.g., check if there is a February 29 in the entered year),
- implement a function to calculate how many days are left until the end of the month,
- add option to highlight all days that are even (e.g., 2nd, 4th, 6th),
- implement a function to detect if the current year is a leap year,
- create a "Today" button that returns the calendar to the current month and marks today's day,
- add-on to generate a calendar for the entire year on a single page,
- create a function to list all Fridays of the thirteenth in the current year,
- implement to display the total number of days between two months,
- add the ability to move a month forward or backward three months at a time,
- add a function to add events to the calendar (normal tasks during the day, work meetings, meetings, trips, lunches, etc.),
- program the calendar to display names and public holidays,
- program the calendar to display Sundays and public holidays in colour.

Table 3. Differentiation of tasks for pupils with SEND in Phase II of the project

Pupil / SEND	Recommended tasks	Reason for selection
Pupil A (grade II dyslexia)	- "Today" button - highlight even days - date validation (e.g., February 29)	Visualisation and simple data operations without the need for text analysis.
Pupil B (dysorthography grade III)	- number of days until the end of the month - determine whether the year is a leap year - number of weekends in the month	Focus on calculations without the need for typing or spelling input.
Pupil C (dysgraphia II + dyscalculia II)	- displaying names and holidays - colour display of Sundays and holidays - adding events to the calendar	Work with pre-prepared data and visual elements; minimum calculations.
Other pupils	- The week starts with Monday - view week number - number of days between months - 3 months offset - calendar for the whole year - Fridays of the thirteenth - weekdays only mode	More complex tasks with working with dates, algorithms, and calculations - suitable for advanced learners.

Handing over the task:

- submit the project in the form of HTML, CSS, and JS files by the agreed deadline,
- attach textual documentation that briefly describes:
  - structure and functionality of the code,
  - the process of solving the problem,
  - the problems encountered and the methods of solving them.

Recommendation: It is recommended that pupils with SEND work in pairs with a classmate who has no special needs or accommodations (Table 3).

Assessment and grading: the assessment will be carried out in three steps, involving the pupil, his/her teammate, and the teacher. This process encourages the development of reflection, collaboration, and objective evaluation of the work.

In the first step, the pupil himself evaluates the task through self-assessment. He/she assesses to what extent he/she has completed the assignment, what his/her approach to the work was, and what he/she would improve about the project. He/she gives a brief justification for his/her assessment and proposes a grade, thus developing the ability to reflect on his/her strengths and weaknesses and to take responsibility for his/her work. In the second step, pupils evaluate each other within the group. Each team member assesses what his/her classmate brought to the project, what his/her approach, contribution, and willingness to cooperate. The evaluation will take the form of a short discussion or a written questionnaire. This step emphasises the importance of teamwork and the ability to objectively evaluate the work of others. In the last step, the project is evaluated by the teacher, who assesses the fulfilment of the technical requirements, the functionality and implementation of the new functionality, as well as the quality of the documentation. The teacher takes into account the student's self-assessment and feedback from classmates to make the evaluation comprehensive and fair. The final grade will be determined by a combination of all three assessments, with a greater emphasis on the teacher's professional judgement. This assessment system supports students' technical and personal development, while creating space to improve teamwork, reflect on their performance, and receive feedback. Assessment will be tailored to the special educational needs of pupils to support their progress and positive attitude to learning. Examples of pupil outcomes from Stage II are shown in Fig. 1 and Fig. 2.

Fig. 1. Output of a pupil without SEND—calendar for the whole year. Legend: the output is a complex calendar layout with twelve months displayed in a single view. This is a more challenging functionality designed for students without SEND, which is used to develop algorithmic thinking and practice working with dates.

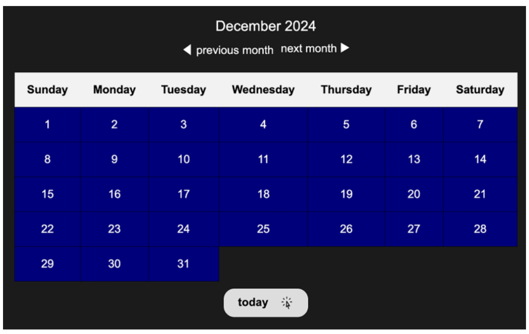

Fig. 2. Pupil with SEND output - today button. Legend: The output demonstrates a simplified calendar user interface containing only the functionality of the 'Today's Day' button. This task was designed for a student with dyslexia, with a focus on reducing the text-intensive nature of the task and providing immediate visual feedback.

Stage III: common integration of functionalities into a single web calendar

Technologies used: HTML5, CSS3, Bootstrap, JavaScript (JS), jQuery, project management tool (e.g., Trello, Asana, Taiga, etc.).

Form of project implementation: it is recommended to implement the project in a distance form for 8 teaching hours. *Organisational form of work:* teamwork, the whole class works as one group.

Phase III project goal: The goal of this phase is to combine all the features created in Phase II into a single calendar that will represent the common output of the class. Students will divide tasks among themselves, choose a team leader, and use the project management system to coordinate their work effectively. This stage develops not only technical skills but also the ability to work together in a large team to plan and manage a complex project.

Output: a single functional web calendar containing all the functionalities from the second phase integrated into one system. The calendar shall be aesthetically pleasing, clear, and fully functional. The project will be delivered by a strict deadline.

Task assignment consists of four parts:

1) *Team organisation*

- the whole class forms one team and chooses a leader to coordinate the work and communicate with the teacher,
- each student agrees on a role in the team according to his/her skills and preferences (e.g., code implementation, testing, design, documentation),

2) *Using a project management tool*

- the team will use a project management tool such as Trello, Asana, Taiga, or other systems where they divide tasks, set deadlines, and track each other's progress,

3) *Integration of functions*

- Each learner implements their functionality from the second stage into a common calendar, ensuring that all functions work correctly in combination with each other.
- the team will focus on overall code consistency, optimisation, and bug fixing,

4) *Presentation of the output*

At the end, the team prepares documentation and a presentation of the finished project. The documentation must include a description of each functionality, the progress of the collaboration and a reflection of the whole team.

Task handover:

- submit the project in the form of HTML, CSS, and JS files containing all functionalities from the second stage.
- attach common documentation that describes:
  - the structure and functionality of the resulting calendar,
  - the process for coordinating teamwork (including the project management tool used),
  - Reflection on teamwork - what worked well, what problems occurred, and how they were solved?

Evaluation and grading: The evaluation will consist of two parts: an evaluation of the whole team and an individual evaluation.

Team evaluation:

- the teacher will assess the functionality and aesthetics of the common calendar, the integration of the different functions, and the quality of the documentation,

- Take into account the overall teamwork process, the organisation of the project, and the ability to meet deadlines.

Individual assessment:

- each student writes a short reflection where they evaluate their contribution to the project and the work of the other team members,
- The team leader prepares a brief overview of who worked on which part of the project and provides feedback to the teacher on the teamwork.

The final rating will be a combination of team and individual performance. This approach encourages teamwork, organisation, and problem-solving skills within the group, while also motivating pupils to be responsible in their approach to their task.

V. Result and Discussion

In the investigation, which was conducted through the use of the quantitative and qualitative methods described above, we recorded findings that allow us to formulate answers to research questions VO1 and VO2.

VO1: What is the impact of implementing a PBL strategy within a STEAM approach with differentiated tasks on student performance (improved learning outcomes) in inclusive instruction?

VO2: Will collaboration, pupil interest in learning (increased engagement of pupils with SEND, and greater autonomy of all stakeholders be improved following the implementation of a PBL strategy within a STEAM approach with differentiated tasks in inclusive teaching?

The findings show that by implementing the PBL strategy within the STEAM approach in inclusive teaching, we were able to answer the questions of whether pupil performance and overall classroom average attainment would improve; that by implementing the three-stage PBL strategy within the STEAM approach, we can positively influence pupil interest in learning (increased engagement of pupils with SEND); and that there will be greater independence in learning for all pupils involved.

After implementing the intervention, which was based on the implementation of a three-step PBL strategy within a STEAM approach in inclusive teaching, we observed several changes in behaviour and a slight improvement in overall student performance (see Table 4).

Table 4. Comparison of students' pre- and post-intervention assessment of learning outcomes (performance)

group of pupils	number of pupils (n)	AM before intervention	AM after intervention
pupils without SEND	$n = 12$	AM 2.3	AM 2.3 → 2.1
pupils with SEND	$n = 3$	AM 2.9	AM 2.9 → 2.3
total	$n = 15$	AM 2.42	AM 2.42 → 2.13

Pupils without SEND improved their performance slightly, with the average going from AM 2.3 to AM 2.1. Pupils with SEND, however, showed a positive shift in their scores from the original AM 2.9 to AM 2.3. The narrowing of the gap between the performance of the two groups suggests that the differentiated project tasks, visual support, and self-paced work had a positive impact on the ability of pupils with SEND to cope with the curriculum and to engage more actively in the classroom. The overall class average improved from AM 2.42 to AM 2.13 after the intervention, an improvement that supports the effectiveness of the implemented three-step strategy.

The use of other methods (interviews and observation) gave us answers to the second research question, VO2.

Table 5. A selection of pupils' responses from the interviews

Pupil	SEND	Statement from the interview
Pupil A	dyslexia	"What helped me the most was that I could do a role that I could see on the screen right away - no complicated lines."
Pupil B	without SEND	"I enjoyed working in a group because we could divide up the tasks according to who was good at what."
Pupil C	dysorthography	"When I had to enter an outlet where I didn't need to write a lot of text, I felt more confident."
Pupil D	without SEND	"It finally made some sense - we were doing something that could be used."
Pupil E	dysgraphia + dyscalculia	"The visual assignments and colour output helped me better understand what was going on in the code."

Table 6. Observations during teaching

Observed phenomenon	Example of behaviour	Intensity of occurrence
Active teamwork	Pupil A (with SEND) consults a pupil without SEND about the function of a button	In each team group
Self-management of work	Pupils independently use Trello tools to divide tasks	regularly
Visual support aids understanding	Pupils respond positively to browser output when changing code	very often
Problem with the pace of learning	Some pupils need significantly more time, but keep working	sporadically
Involvement of pupils with SEND	Regular completion of tasks without the need for teacher intervention	most tasks

Interviews with pupils (see Table 5) revealed that project-based learning gave them more scope for independence, creativity, and application of practical skills. Pupils with DD appreciated the clarity of the task, the visual support, and the opportunity to work at their own pace. These pupils felt more engaged and less frustrated than with traditional frontal forms of teaching, not least because they could work in a group with a non-SLD classmate and could collaborate, which increased their interest in learning.

Observations during class showed increased activity in most students, especially in teamwork (see Table 6). Pupils with SEND were actively engaged and more likely to complete the task without teacher assistance due to the appropriate choice of tasks. Differentiating tasks based on their abilities proved to be an effective tool for increasing interest in learning and for effectively promoting inclusive learning in the technical subject of Scripting Languages.

The results of the research showed that the implementation of a three-step PBL strategy within a STEAM approach with differentiated tasks in inclusive teaching positively influenced performance, increased the engagement of all students, including those with SEND, in teaching and their own learning, independence, and active involvement in problem solving within a collaborative team approach. Thus, in response to research questions VO1 and VO2, it can be concluded that the implementation of the three-step PBL strategy within the STEAM approach with differentiated tasks in inclusive teaching led to higher levels of activity, independence, and collaboration for all pupils, with teaching taking place in a more stimulating, creative, and engaging atmosphere. Pupils valued the choice of tasks, freedom in problem solving, and teamwork, which supports Hung's [12] findings on the relationship between PBL and the development of motivation, self-regulation, and responsibility for one's learning. The performance improvement was evident in the students with SEND, whose average grade improved from AM 2.9 to AM 2.3. It was confirmed that the well-tailored tasks, visual support, and the opportunity to work at their own pace allowed them to handle the challenging parts of the project without frustration. As stated by Rehman [8], task differentiation and teamwork promote active learning, which was also reflected in the overall classroom atmosphere and higher engagement of these students. The teacher's role in this process naturally transformed into a facilitator of learning, as Markula [16] elaborates. Elements of the STEAM approach contributed significantly to the development of complex thinking, fostering the linking of technical, creative, and aesthetic elements, making learning richer in interdisciplinary contexts. Thus, this approach demonstrated the potential to go beyond traditional PBL, traditional didactic practices in teaching, which is in line with Li [18]. Despite these positive findings, the research also confirmed several challenges. As Kokotsaki [22] and Alshaye [11] point out, the success of PBL depends not only on the didactic concept but also on the technical and organisational conditions of the school, as well as the teacher's preparedness. The time commitment, the need for systematic support, and the continuous assessment of students are among the key factors to be taken into account when implementing such innovations in practice. Despite these limitations, the results suggest that such a didactic approach has the potential to enrich vocational education and improve the participation of diverse groups of learners in an inclusive environment.

A. Challenges in Teaching Scripting Languages and the Benefits of a PBL Strategy within a STEAM Approach

Teaching scripting languages at the secondary vocational school level poses several pedagogical challenges. Students often struggle to understand abstract programming concepts without direct visual output. Moreover, differences in prior knowledge led to large differences in the pace of learning. Some pupils quickly master the syntactic elements but fail to apply them correctly, while others need more time and individual support. Pupils' motivation fluctuates, especially when they do not see the practical relevance of the commands they have learned.

Therefore, managing the diverse needs in the classroom, especially for students with SEND, is a significant challenge [23]. The PBL strategy within the STEAM approach has proven to be an effective response to these challenges. The creation of a concrete product through this strategy is an interactive web-based calendar, through which students verify the meaning of what they have learned in practice. They work at a pace that matches their pace and have the opportunity to choose a task according to their ability. PBL allows for better differentiation of instruction while motivating students through teamwork, feedback, and a tangible outcome they can be proud of. The use of real management tools also simulates the working environment of IT teams, preparing pupils for their future profession.

B. Limitations of Research

Although the research has provided valuable insights into the implementation of a three-step PBL strategy within a STEAM approach with differentiated tasks in inclusive instruction in the vocational subject of Scripting Languages, its results need to be interpreted in light of several limitations. The first limiting factor is the size and structure of the research sample. The research was conducted in one classroom with 15 pupils, 3 of whom had SEND. This number does not allow for a broader generalisation of the results, especially when assessing the effect of differentiation. Further, the assessment was based on grades, observation, and interviews, which, while providing a combination of both quantitative and qualitative data, risks introducing subjectivity in the interpretation of the results, particularly in the area of observing pupils' behaviour and their statements. Another limitation was the time allotment of the course - the project took place during several lessons, which affected the scope of the tasks and their gradual deepening. In real school conditions, it was difficult to ensure equal conditions for all pupils, for example, in the use of technology or individual support from the teacher. Another factor is the very role of the teacher as a researcher. Given the action research approach, the author was both teaching and collecting data, which may affect the objectivity of the observations, although efforts were made to minimise bias. Finally, the results reflect the specificities of the particular subject area and the profile of the school focusing on information technology. The transferability of the conclusions to other types of schools or subjects requires further validation.

C. Related Work

PBL has been extensively researched in a variety of educational levels and contexts, with its contribution to the development of 21st-century skills, computational thinking, and learner autonomy repeatedly confirmed. This section presents findings from previous research on PBL in IT and technology education, focusing on implementation models, impact on learning outcomes, and inclusion. These findings are then compared with a three-stage model of PBL integrated into a STEAM approach with differentiated tasks that has been designed for inclusive vocational education in secondary schools. In a meta-analysis of 31 studies published by Zhang *et al.* [6], the positive impact of PBL on computational thinking, problem solving, and collaboration was confirmed. In a study by Alshaye *et al.* [11] presented findings of improved programming skills through online PBL, were presented highlighting the importance of the digital environment for this form of learning. Chiang and Lee [3] focused on motivation and problem-solving ability in vocational school students. A study by Sudjimata *et al.* [7] highlighted the relevance of PBL for the development of job skills in vocational education. Rehman *et al.* [8] highlighted the benefits of PBL for the development of 21st-century competencies in mathematics education, with positive effects on student collaboration and engagement identified. Zhang and Ma [13] reported the results of meta-analyses that supported the effectiveness of PBL, albeit without proposing a specific implementation framework. Markula and Aksely [16] identified key characteristics of PBL in science education, such as autonomy and task relevance. Dean et al. [14] emphasized the importance of scaffolding and reflection as components of effective PBL.

In the field of inclusive education, the study by D'Elia *et al.* [9] highlighted the benefits of using cooperative and service learning for students with special needs. Mahmood *et al.* [21] described the importance of support from educators in creating an inclusive environment. Based on these findings, a three-phase model of PBL was developed and adapted to the specificities of vocational education in secondary schools. Within this model, STEAM principles were integrated, and targeted differentiation of instruction for students with special needs was implemented. The effectiveness of the model was confirmed when working with pupils with diagnoses such as autism spectrum disorders (ASD), specific learning disabilities (dyslexia, dysgraphia, and dyscalculia), and attention deficit hyperactivity disorder (ADHD), and speech disorders. The differentiation of tasks, the use of visual supports, and the opportunity to work at their own pace contributed to the effective involvement of these pupils in a complex project solution. In the above context, the proposed model was identified as practically applicable and scalable, demonstrating its positive impact on increasing pupils' engagement, collaboration, and independence.

In summary, the existing literature provides a solid framework that has been extended by this research to provide a concrete, effective model of learning that reflects the specificities of vocational IT education in an inclusive environment.

VI. Conclusion

Action research conducted in the subject area of Scripted Languages has demonstrated that a three-step PBL strategy within a STEAM approach with differentiated tasks in inclusive instruction has a positive impact on the performance, motivation, and engagement of students, including students with SEND. The implementation of the three-stage project model enabled pupils to develop not only technical and reasoning skills, but also teamwork, creativity, and independence. The improvement in the average performance of pupils with SEND suggests that differentiated tasks and teacher support can make a significant contribution to reducing performance inequalities in an inclusive environment. Research has also confirmed that linking technical content with elements of aesthetics, creativity, and interdisciplinary thinking enhances the effectiveness of IT instruction. The findings support the need for methodologically prepared and didactically thought-out project-based learning as a tool for modern vocational education. However, they also point to the need for systematic support for teachers in planning, facilitating, and evaluating PBL, as well as the need for further research to validate the effectiveness of this approach in a broader and longer-term context.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

The contributions of the individual authors are as follows: Peter Tokoš was responsible for conceptualization, design of the teaching strategy, implementation in the classroom, data collection and analysis, and drafting the original version of the manuscript. Zlatica Huľová contributed methodological guidance, review, and language editing of the text, and professional expertise in the field of inclusive education. Roman Hrmo contributed to validation, expert supervision, and review of didactic and pedagogical aspects. Lucia Krištofiaková participated in the project organisation, visualisation of pupil outcomes, and assisted in the analysis of qualitative data. All authors approved the final version of the manuscript.

References

[1] Q. Ou, W. Liang, Z. He, X. Liu, R. Yang, and X. Wu, "Investigation and analysis of the current situation of programming education in primary and secondary schools," *Heliyon*, vol. 9, no. 4, 2023. doi: 10.1016/j.heliyon.2023.e15530

[2] N. Shin, J. Bowers, J. Krajcik, and D. Damelin, "Promoting computational thinking through project-based learning," *Disciplinary and Interdisciplinary Science Education Research*, vol. 3, 2021, Article 7. doi: 10.1186/s43031-021-00033-y

[3] C. L. Chiang and H. D. Lee, "The effect of project-based learning on learning motivation and problem-solving ability of vocational high school students," *International Journal of Information and Education Technology*, vol. 6, no. 9, pp. 709–712, 2016. doi: 10.7763/IJIET.2016.V6.779

[4] K. Xie, L. Lu, S. L. Cheng, and N. Sabastian, "Students' experiences of project-based learning in computing education: A mixed-methods study," *Education and Information Technologies*, vol. 27, no. 3, pp. 3859–3881, 2022. https://doi.org/10.1007/s10639-021-10757-z

[5] L. Babo, J. Mendonça, and C. Pinto, "Students' perceptions of PBL usefulness," *Open Education Studies*, vol. 6, 2024. doi: 10.1515/edu-2024-0051

[6] W. Zhang, Y. Guan, and Z. Hu, "The efficacy of project-based learning in enhancing computational thinking: A meta-analysis of 31 experiments and quasi-experiments," *Education and Information Technologies*, vol. 29, pp. 14513–14545, 2024. doi: 10.1007 /s10639-023-12392-2

[7] D. A. Sudjimat, A. Nyoto, and M. Romlie, "Implementation of project-based learning model and workforce character development for the 21st century in vocational high school," *International Journal of Instruction*, vol. 14, no. 1, pp. 181–198, 2021. doi: 10.29333/iji.2021.14111a

[8] N. Rehman, X. Huang, and A. Mahmood, "Project-based learning as a catalyst for 21st century skills and student engagement in the math classroom," *Heliyon*, vol. 10, no. 23, Art. e39988, 2024. doi: 10.1016/j.heliyon.2024.e39988

[9] P. D'Elia, A. Stalmach, S. D. Sano, and G. Casale, "Strategies for inclusive digital education: Problem/project−based learning, cooperative learning, and service learning for students with special educational needs," *Frontiers in Education*, vol. 9, 1447489, 2024. https://doi.org/10.3389/feduc.2024.1447489

[10] J. Jurinová and J. Miština, "Development of a desktop application for a complex heterogeneous evaluation system," in *Proc. International Conference on Emerging eLearning Technologies and Applications*, 2022, pp. 294–299. doi: 10.1109/ICETA57911. 2022.9974803

[11] I. A. Alshaye, Z. Tasir, and N. F. Jumaat, "The effectiveness of online problem-based learning tasks on Riyadh's secondary school students' problem-solving ability and programming skills," *Open Education Studies*, vol. 5, no. 1, 20220208, 2023. doi: 10.1515/edu-2022-0208

[12] W. Hung, D. Jonassen, and R. Liu, "Problem-Based Learning (PBL): Current perspectives on the implementation of PBL in engineering education," *SAGE Open Engineering*, vol. 8, pp. 1–9, 2020. doi: 10.1177/2158244020938702

[13] L. Zhang and Y. Ma, "A study of the impact of project-based learning on student learning effects: A meta-analysis study," *Frontiers in Psychology*, vol. 14, 2023. doi: 10.3389/fpsyg. 2023.1202728

[14] C. G. P. Dean, P. Grossman, L. Enumah, Z. Herrmann, and S. S. Kavanagh, "Core practices for project-based learning: Learning from experienced practitioners in the United States," *Teaching and Teacher Education*, vol. 133, 2023. doi: 10.1016/j.tate.2023.104275

[15] R. Hrmo, J. Miština, and L. Krištofiaková, "Improving the quality of technical and vocational education in Slovakia for European labour market needs," *International Journal of Engineering Pedagogy (iJEP)*, vol. 6, no. 2, pp. 14–22, 2016. doi: 10.3991/ijep.v6i2.5369

[16] A. Markula and M. Aksela, "The key characteristics of project-based learning: how teachers implement projects in K–12 science education," *Disciplinary and Interdisciplinary Science Education Research*, vol. 4, no. 1, 2022. doi: 10.1186/s 4303-021-00042-x

[17] J. Karasova and J. Nehyba, "Student-centered teacher responses to student behavior in primary classrooms: verbal and non-verbal immediacy and its impact on classroom climate," *Frontiers in Education*, vol. 8, 115653, 2023. doi: 10.3389/feduc. 2023.1156530

[18] J. Li, H. Luo, L. Zhao, M. Zhu, L. Ma, and X. Liao, "Promoting STEAM education in primary school through cooperative teaching: A design-based research study," Sustainability, vol. 14, no. 16, 2022. doi: 10.3390/su141610333

[19] J. A. Marín-Marín, A.-J. Moreno-Guerrero, P. Dúo-Terrón *et al.*, "STEAM in education: A bibliometric analysis of performance and co-words in Web of Science," *International Journal of STEM Education*, vol. 8, Article 41, 2021. https://doi.org/10.1186/s40594-021-00296-x

[20] E. Kupers *et al*., "Differentiation and students with special educational needs: Teachers' intentions and classroom interactions," *Effective Teaching Around the World*, 2023. doi: 10.1007/978-3-031-31678-4_36

[21] A. Mahmood, X. Huang, and N. Rehman, "The role of teachers and administrators in supporting the adaptation of students with special needs in mainstream high schools," *Quality Education for All*, vol. 2, pp. 35–54, 2024. doi: 10.1108/QEA-06-2024-0054

[22] D. Kokotsaki, V. Menzies, and A. Wiggins, "Project-based learning: A review of the literature," *Improving Schools*, vol. 19, no. 3, pp. 267–277, 2016. doi: 10.1177/1365480216659733

[23] A. I. García-Navarro, A. Llorca, M. Martínez-Viviente, and M. M. Sánchez-Zafra, "Overcoming challenges and promoting positive education in inclusive schools: A holistic framework," *Education Sciences*, vol. 14, no. 11, 1169, 2024. https://doi.org/10. 3390/educsci14111169