

IMPROVING THE METHODOLOGY FOR DEVELOPING STUDENTS' INVENTIVE AND CREATIVE THINKING THROUGH PROJECT-BASED LEARNING IN TECHNOLOGY LESSONS

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Abstract: This article examines ways of improving the methodology for developing students' inventive and creative thinking through project-based learning in technology lessons. The study focuses on the pedagogical value of project activities in developing students' ability to identify practical problems, generate alternative ideas, design technological solutions, create prototypes, evaluate results, and improve products. A structured methodological model consisting of motivational, analytical, design, practical, evaluative, and reflective stages is proposed. Particular attention is paid to the organization of invention-oriented projects, interdisciplinary integration, differentiated tasks, collaborative learning, and criteria-based assessment. The article also identifies the pedagogical conditions necessary for the effective development of inventive and creative thinking in technology education. It is concluded that project-based learning can significantly increase students' independence, technical imagination, initiative, problem-solving skills, and ability to transform ideas into practical technological solutions when it is implemented systematically and supported by appropriate assessment tools.

Keywords: project-based learning, technology education, inventive thinking, creative thinking, technical creativity, project activity, design thinking, prototyping, problem-solving, innovation.

Introduction

The growing importance of technological innovation in modern society has increased the need for educational approaches that prepare students not only to use existing technologies but also to create, improve, and adapt them. Contemporary education is therefore increasingly focused on the development of creativity, problem-solving, critical thinking, collaboration, and innovation-oriented skills.

Technology education has a special role in this process because it provides students with opportunities to work with real materials, tools, technical systems, design tasks, and practical products. Unlike purely theoretical subjects, technology lessons allow learners to transform an idea into a tangible result.

However, the effectiveness of technology education depends significantly on how the learning process is organized. If students mainly repeat teacher demonstrations or reproduce ready-made products, the potential of the subject for developing inventive thinking remains underused.

Project-based learning provides a different model. It places students in situations where they are expected to identify or understand a problem, plan their activity, search for information, generate possible solutions, make design decisions, produce a prototype, and evaluate the result.

For this reason, improving the methodology of project-based learning is an important condition for developing students' inventive and creative thinking.

The relationship between inventive and creative thinking

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Creative thinking refers to the ability to produce original, flexible, and meaningful ideas. It includes the ability to look at a problem from different perspectives, establish unexpected connections, and propose several possible solutions.

Inventive thinking is closely related to creativity but has a stronger practical and technological orientation. It involves applying creative ideas to solve concrete problems and develop functional solutions.

In technology education, inventive thinking can be observed when a student:

- identifies a weakness in an existing product;
- suggests several possible improvements;
- designs a new construction;
- selects suitable materials;
- creates a prototype;
- tests its performance;
- makes modifications based on the results.

Thus, creative thinking provides the generation of possibilities, while inventive thinking transforms these possibilities into practical technological outcomes.

The educational potential of project-based learning

Project-based learning is based on meaningful activity organized around a problem, question, challenge, or product.

In technology lessons, project work can be particularly effective because it naturally combines theoretical knowledge and practical application.

A well-organized technological project usually includes several elements:

- a real or simulated problem;
- clear design requirements;
- independent or collaborative planning;
- research and information gathering;
- idea generation;
- selection of materials and technologies;
- construction or modeling;
- testing;
- evaluation;
- presentation.

These elements correspond closely to the structure of inventive activity.

Project-based learning also increases student responsibility. Learners must make choices and justify them instead of following a complete algorithm provided by the teacher.

Methodological model for developing inventive and creative thinking

The proposed methodology includes six interconnected stages.

Stage 1. Motivation and problem orientation

The first stage aims to create interest and introduce a meaningful problem.

The project should be connected with situations familiar to students.

For example:

“How can we create a compact device for organizing school supplies in a limited workspace?”

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“How can we reuse household waste to produce a useful product?”

“How can we design a simple construction that reduces water consumption?”

The teacher can use photographs, objects, short demonstrations, practical situations, or discussion questions to stimulate interest.

At this stage, students should understand why the problem is important.

Stage 2. Analysis and research

Students analyze the problem and gather necessary information.

They may examine existing products, compare designs, investigate materials, calculate dimensions, or identify user needs.

The teacher can guide students with questions such as:

What is the main function of the product?

Who will use it?

What problems exist in current solutions?

What restrictions must be considered?

Which materials are available?

This stage prevents students from moving directly to production without sufficient analysis.

Stage 3. Idea generation and selection

Students produce several ideas rather than relying on the first solution that comes to mind.

Brainstorming, sketching, mind mapping, SCAMPER-type questions, morphological analysis, and combination techniques can be useful.

For example, students may be asked:

What can be replaced?

What can be combined?

Can the size be reduced?

Can one product perform several functions?

Can waste materials be used?

After generating alternatives, students compare them according to selected criteria.

These criteria may include:

functionality;

originality;

safety;

cost;

environmental impact;

availability of materials;

ease of production.

Stage 4. Design and prototyping

Students prepare sketches, drawings, technological maps, or digital models.

This stage transforms an abstract idea into a planned solution.

A good project plan should show:

product purpose;

main dimensions;

materials;

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construction details;
tools;
sequence of operations;
safety requirements.

Students then create an initial prototype.

Prototyping is essential because some design problems become visible only after the idea is physically implemented.

Stage 5. Testing and improvement

The prototype is evaluated against the original project criteria.

For example, students can test:

strength;
stability;
convenience;
safety;
functionality;
material efficiency;
appearance.

If the product does not meet some requirements, students should identify the cause and modify the design.

This stage is highly important for inventive thinking because improvement often requires a new creative solution.

Stage 6. Presentation and reflection

At the final stage, students present their project and explain:

the problem;
initial ideas;
selected solution;
materials;
construction process;
difficulties;
test results;
improvements.

Reflection should also include questions such as:

What worked well?
What did not work?
What would I change next time?
What new skill did I learn?
How original was my solution?

This helps students understand the process of invention as a cycle rather than a single action.

Types of project tasks

Different types of projects can be used to develop different components of inventive thinking.

Construction projects

Students design and build a functional object.

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Examples include:

- a foldable book stand;
- a lightweight bridge model;
- a multifunctional desk organizer;
- a storage system.

Improvement projects

Students examine an existing object and improve its function, convenience, or appearance.

For example, they may improve:

- a school bag organizer;
- a tool holder;
- a simple household object;
- a packaging system.

Environmental projects

Students create products using recycled or environmentally friendly materials.

Examples include:

- reusable containers;
- decorative objects from waste;
- eco-friendly packaging;
- simple water-saving devices.

Mechanism projects

Students develop simple mechanical solutions using levers, gears, pulleys, springs, or rotating elements.

Such projects strengthen technical thinking and understanding of physical principles.

Digital design projects

Where resources are available, students can create simple digital models before production.

This may include 2D drawing, 3D modeling, or elementary computer-aided design.

Pedagogical conditions for effectiveness

The success of project-based learning depends on several pedagogical conditions.

First, projects should be appropriate to students' age and experience. Tasks that are too easy do not stimulate creativity, while excessively difficult projects may reduce motivation.

Second, students should have real choice. If every learner is required to produce an identical object, the activity becomes reproductive rather than inventive.

Third, the teacher should allow sufficient time for idea development, testing, and improvement.

Fourth, mistakes should be treated as part of learning. In technological projects, an unsuccessful prototype can provide valuable evidence about what needs to change.

Fifth, assessment should reward both process and result.

Sixth, projects should be connected with practical contexts whenever possible.

Differentiated project tasks

Students differ in their technical experience, speed of learning, creativity, and practical abilities.

Therefore, project tasks can be differentiated.

At the basic level, students may receive:

- a clear problem;

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a limited range of materials;
several design conditions;
partial teacher guidance.

At the intermediate level, students may independently select materials and develop more than one design option.

At the advanced level, students may formulate part of the problem themselves, conduct comparison studies, prepare a more complex prototype, and justify its technical advantages.

Differentiation allows all students to participate successfully while maintaining an appropriate level of challenge.

Collaborative learning in technological projects

Project-based learning can be organized individually or in groups.

Group work is especially useful for complex projects because it allows students to distribute responsibilities.

Possible roles include:

project coordinator;

designer;

constructor;

materials specialist;

researcher;

tester;

presenter.

Collaborative work also develops communication and decision-making skills.

However, the teacher should ensure that each student contributes meaningfully to the project. Otherwise, some learners may become passive participants.

Interdisciplinary integration

Technology projects become more meaningful when they include knowledge from other subjects.

Mathematics can be integrated through measurement, proportion, scale, geometry, and cost calculation.

Physics contributes knowledge about force, energy, motion, electricity, and stability.

Informatics can be used for digital design and data presentation.

Biology and environmental science support projects related to sustainable materials and resource conservation.

Art and design contribute to form, color, aesthetics, and visual communication.

Such integration reflects the real nature of invention, which often requires knowledge from different disciplines.

Assessment criteria

Assessment should consider both the final product and the student's creative and inventive activity.

A possible assessment structure is presented below.

Criterion	Description
Problem understanding	Ability to identify the main project challenge
Idea generation	Ability to propose several possible solutions

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Originality	Degree of novelty in the proposed design
Technical feasibility	Possibility of implementing the idea in practice
Design quality	Accuracy and logic of sketches and plans
Practical implementation	Quality of prototype construction
Functionality	Ability of the product to perform its intended function
Resource efficiency	Rational use of materials and tools
Improvement	Ability to modify the design after testing
Independence	Level of independent decision-making
Reflection	Ability to evaluate strengths and weaknesses
Presentation	Ability to explain and justify the project

A rubric with several performance levels can make the evaluation process more transparent for students.

Practical recommendations

Technology teachers can improve the effectiveness of project-based learning by introducing short projects before larger ones.

Projects should begin with meaningful problems rather than product names alone.

For example, instead of saying:

“Make a wooden box,”

the teacher may say:

“Design a compact storage product for small school tools using minimal material.”

This gives learners greater freedom to think.

Teachers should encourage students to produce several sketches before selecting a final design.

It is also useful to create a project portfolio containing photographs, drawings, design notes, prototypes, and reflection sheets.

School exhibitions can be organized at the end of a project cycle.

Projects can also be evaluated by classmates through peer review.

Local materials and inexpensive resources should be prioritized to make project activities accessible.

Expected educational outcomes

Systematic project-based learning can contribute to the development of several important outcomes.

Students become more capable of identifying practical problems.

They learn to generate and compare different ideas.

Their technical vocabulary and design skills improve.

They become more confident in working with materials and tools.

They gain experience in prototyping and testing.

They develop responsibility for the quality of their own work.

They learn to improve an unsuccessful design rather than abandon it.

Most importantly, they begin to view technology not only as a set of ready-made products but as a field in which they can create their own solutions.

Conclusion

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Project-based learning provides a strong methodological basis for developing students' inventive and creative thinking in technology lessons.

Its educational value lies in organizing learning around meaningful problems that require students to plan, generate ideas, design, create, test, evaluate, and improve technological solutions.

The proposed methodological structure based on motivation, analysis, idea generation, design, prototyping, testing, improvement, and reflection allows inventive activity to be organized systematically.

The effectiveness of this approach increases when projects are differentiated, interdisciplinary, practical, and supported by clear assessment criteria.

Therefore, improving the methodology of project-based learning in technology education can contribute to the formation of students who are capable of independent technical thinking, creative problem-solving, responsible decision-making, and practical innovation.

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