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Pedagogical Possibilities of Project-Based Collaboration in Career Guidance For Schoolchildren Based on The STEAM Approach

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Abstract: This article presents a theoretical and analytical review of current research devoted to the pedagogical potential of project-based collaboration in career guidance for schoolchildren based on the STEAM approach. The relevance of this topic lies in the fact that traditional career guidance, focused primarily on informing students about professions, is proving insufficient in the context of the technologization of education, the expansion of interdisciplinary professional fields, and the growing importance of project-based, communication, and research skills. The source material includes research conducted between 2020 and 2025 on STEAM/PBL, integrated STEM, career awareness, STEM/STEAM interest, educational technologies, and project-based activities. Analysis shows that project-based collaboration in a STEAM environment serves not only an organizational function but also a career guidance function: it transforms students from observers to participants in professionally significant activities.

Keywords: STEAM Education, Project-Based Collaboration, Career Guidance, Students, Project-Based Learning, Interdisciplinary Learning, Career Awareness, Self-Efficacy, Educational Technologies, Career Self-Determination

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1. Introduction

In modern pedagogy, career guidance for students is no longer a secondary aspect of educational work and is becoming a key condition for the conscious development of their educational trajectory. This is due to the fact that the modern labor market demands of future specialists not only subject knowledge but also the ability to work in an interdisciplinary environment, design solutions, collaborate in a team, use digital tools, evaluate the consequences of decisions, and align their interests with real professional tasks. Traditional career guidance, based on discussions, testing, familiarization with a list of professions, and occasional meetings with specialists, retains a certain informational value. However, its limitation lies in the fact that students often remain external observers of the professional world. They receive information about the profession, but are not involved in the structure of professional action: they do not formulate the problem, distribute responsibilities within a team, design a product, test the solution, defend the result, or reflect on their own role. In this regard, interest in activity-based, project-based, and interdisciplinary career guidance formats is growing in pedagogical science [1][2].

The STEAM approach creates a particularly productive foundation for such reorientation. Its pedagogical significance lies not only in the unification of science, technology, engineering, art, and mathematics, but also in the creation of an educational environment where students solve practice-oriented problems, utilize knowledge from various fields, design a solution, and present the result. Contemporary research shows that STEAM/PBL and integrated STEM projects are most effective when built around a real-world problem, cross-curricular integration, project design, and active student collaboration [3].

Therefore, project-based collaboration in STEAM education can be viewed as a pedagogical mechanism for career guidance for schoolchildren. It allows students not only to learn about professions but also to try on individual professional roles: researcher, engineer, designer, technologist, analyst, programmer, coordinator, and presenter. It is this role-based and activity-based engagement that distinguishes STEAM career guidance from the traditional information model [4].

In this article, the STEAM approach is understood as an interdisciplinary educational strategy in which scientific knowledge, technological tools, engineering design, artistic design solutions, and mathematical reasoning are integrated to analyze and solve a practical problem. This understanding is consistent with contemporary research on STEAM-PBL, where the key role is played not by the external integration of subjects, but by the project task, STEM practices, student support, and the creation of an educational product [5][6].

Project-based collaboration should be distinguished from standard group work. Group work may be limited to distributing tasks among students, whereas project-based collaboration involves joint problem solving, goal alignment, role assignment, collective search for a solution, mutual accountability, public presentation of the result, and reflection on the contribution of each participant. In this sense, project-based collaboration is not only a form of organizing educational activities but also a way to model professionally significant interactions [6]. Career guidance for schoolchildren in the STEAM context is not limited to providing information about professions. It is a pedagogically organized process of developing students' understanding of professional fields, their own interests and abilities, their readiness to choose an educational trajectory, and their ability to connect their educational experience with future activities [7]. Important components of such guidance include career awareness, career self-efficacy, and career intention.

Career awareness refers to a student's understanding of the content of professional roles, requirements, tools, educational paths, and areas of application of STEAM-related professions. Career self-efficacy expresses a student's confidence in their ability to acquire the knowledge and actions necessary for further education or professional development in STEAM fields [8]. Career intention reflects a student's readiness to choose appropriate subjects, courses, clubs, specialized training, or a future profession. The theoretical mechanism of STEAM career guidance can be represented by the following chain:

STEAM environment → problematic situation → project collaboration → role assignment → interdisciplinary solution → reflection on experience → awareness of abilities and interests → career guidance.

Based on the literature analysis, five interconnected channels of pedagogical influence of project collaboration on students' career development can be identified.

Channel of Influence	Contents	Career guidance value
Cognitive	Expanding knowledge of STEAM fields, professions, tools, and tasks	The student understands the knowledge that underlies professional activity

Activity-Based	Completing project tasks similar to professional practices	The student experiences elements of engineering, research, design, or technology
Social-Communicative	Team interaction, role assignment, and reasoning behind decisions	Soft skills necessary for modern professions are developed
Motivational-Value-Based	Growing interest in science, technology, engineering, art, and mathematics	The student begins to see the personal meaning of STEAM activities
Reflexive	Understanding one's own contributions, abilities, challenges, and intentions	A connection is established between the educational experience and the future educational trajectory

It is the combination of these channels that allows us to view a STEAM project not as a standalone learning assignment, but as a pedagogically organized professional trial.

2. Materials and Methods

This article presents an integrative review of current research on STEAM education, project-based learning, and career guidance for schoolchildren. The review's timeframe primarily covers publications from 2020–2025, as it was during this period that interest in the STEAM/PBL connection, career awareness, self-efficacy, and student career intentions increased [9].

The source base consisted of publications devoted to STEAM/STEM education, project-based learning, integrated STEM, career guidance, career awareness, STEM/STEAM interest, educational technologies, engineering thinking, educational project design, and career aspiration assessment. The review includes works of a scholarly nature, DOI, and a substantive connection to the topic of the article. Inclusion criteria were: relevance to the topic of STEAM/STEM education; analysis of project-based learning, collaboration, career guidance, motivation, or educational technologies; publication between 2020 and 2025; or the source's relevance to the theoretical context; and the applicability of the findings to school education and career guidance. Exclusion criteria included the lack of scientific apparatus, the inability to verify the source's content, and the lack of connection to STEAM/STEM or career guidance.

Methodologically, the review relies on content analysis, comparative analysis, thematic coding, conceptual systematization, and analytical synthesis. This approach allows for more than simply listing sources; it also identifies research areas, theoretical connections, pedagogical mechanisms, and unresolved issues.

Research Literature Analysis

Contemporary research views STEAM education as an educational environment in which students acquire knowledge through practical problem solving, design, modeling, and presentation of results. STEAM-PBL research emphasizes that interdisciplinarity should not be understood as a mechanical connection between subjects. Its pedagogical value arises when students encounter a task that requires the coordinated application of scientific explanation, engineering design, technological tools, artistic solutions, and mathematical justification [10].

In D.A. Semenova's work, STEAM technology is examined in the context of secondary school, educational laboratories, and student research activities. This source is important for the Russian-language context, as it demonstrates the potential for institutional inclusion of STEAM in school technology education. International research explores a similar approach through the analysis of STEAM-PBL designs and integrated STEM projects [11].

Of particular significance is that STEAM expands the traditional understanding of STEM by incorporating an artistic and design component. Azkin and Çevik's research

demonstrates that the STEAM approach is linked not only to subject-specific interest but also to students' attitudes toward art, understanding of STEAM, and professional interests [9]. This suggests that the art component serves a conceptual rather than a decorative function: it connects the technical solution with design, visualization, user experience, and cultural meaning.

Project-based collaboration is central to STEAM education, as it translates interdisciplinary content into collaborative activity. Research shows that project-based approaches are particularly productive when they include a real-world problem, distribution of responsibilities, product development, public advocacy, and process reflection [12]. Lu, Lo, and Xu's work, using the micro:bit paper-cutting lamp project as an example, demonstrates how programming, electrical circuits, optics, artistic design, and cooperative learning can be combined in a single STEAM project. This format is fundamentally important for career guidance: students see that modern professional activity is rarely limited to a single discipline. An engineering solution requires design, mathematical calculation, technological understanding, communication, and user consideration.

Konkuş and Topsakal examine STEAM activities in relation to students' attitudes toward STEAM, cooperative working skills, and career choices. This allows them to highlight an important theoretical proposition: collaboration in STEAM is not only a prerequisite for the successful completion of a project but also an independent factor in professional self-determination. Through the assignment of roles, students begin to understand which activities are more relevant to them: research, design, modeling, work organization, visualization, or presentation of results. Contemporary literature increasingly links STEM/STEAM education with students' career interests, career awareness, and career aspirations. A systematic review by Wang, Awan, Jenkins, and Sarkar examines integrated STEM in relation to instructional design, occupational interest, and career orientation [13]. This is of direct relevance to the topic of this article, as it demonstrates that the career guidance effect does not arise automatically but depends on how the educational situation is designed.

A study by Arango-Caro et al. on 3D plant modeling demonstrates a link between the integration of science, design, and technology and high school students' interest in STEAM subjects and STEAM careers [14]. This source is particularly important because it connects school age, STEAM practice, and career interest. It confirms that project-based learning can serve as a career guidance tool if students perceive a connection between the educational product and the real-world professional sphere.

Career awareness and self-efficacy are considered in the literature as important psychological and pedagogical mechanisms for career choice. Han, Kelley, and Knowles link STEM learning with self-efficacy, outcome expectancy, 21st-century skills, and career awareness [15]. Chen, So, Zhu, and Chiu demonstrate that STEM learning opportunities are related to career aspirations through the self-concept and perceptions of STEM professionals [16]. Jiang, Zhang, and Zhang emphasize the role of career awareness, self-efficacy, and outcome expectations in shaping STEM career interests. Taken together, these studies explain why a STEAM project should conclude with a reflection on professional experience: without an awareness of one's own role and the connection between the task and professions, the educational effect does not become fully career-oriented.

A literature analysis allows us to systematize several groups of educational effects of STEAM projects. The first group is associated with subject-specific and interdisciplinary development: students master scientific concepts, technological tools, engineering solutions, mathematical calculations, and artistic and design methods for presenting results.

The second group of effects relates to the development of thinking. Design thinking, problem-based learning, and project-based activities contribute to the development of

creative self-efficacy, situational interest, and individual interest in STEM/STEAM fields. This is important for career guidance, as interest in a profession is rarely formed through information alone; it arises through successful action experience, overcoming difficulties, and awareness of one's own competence.

The third group of effects is associated with social and communication skills. STEAM projects require discussion, distribution of functions, argumentation, decision-making, and public defense of results. These activities are directly linked to professional soft skills, as modern professional activity is increasingly built in interdisciplinary teams [17].

The fourth group of effects relates to career guidance. Students begin to envision specific professional roles, understand the requirements of STEAM fields, assess their own inclinations, and formulate educational intentions. It is this result that allows us to consider STEAM project collaboration as a mechanism for career self-determination.

Several approaches to understanding STEAM career guidance for schoolchildren can be identified in the scientific literature.

Table 1. Pedagogical Approaches to Career Guidance in STEAM Education: Content, Mechanisms, Opportunities, and Limitations

Approach	Approach Content	Pedagogical Mechanism	Career guidance opportunities	Limitations	Sources
Informational	Introducing students to professions, requirements, and educational pathways	Transfer of Information	Expands general knowledge of professions	Does not create professional experience	[2][18] [19]
Interdisciplinary	Integrating science, technology, engineering, art, and mathematics	Connecting Different Areas of Knowledge into a Single Task	Demonstrates the complex nature of modern professions	May remain formal without a real problem	[6][12]
Project-based	Solving a practical problem through product design	Professional Testing Through Activity	Allows students to try on professional roles	Requires resources, time, and methodological preparation	[7][13] [14]
Social-constructivist	Co-creating knowledge and results in a team	Communication, Role Allocation, Shared Responsibility	Develops soft skills and an understanding of teamwork and professional work	Requires pedagogical support for group dynamics	[8][10] [13]
Career-oriented	Connecting learning experiences with professional interests and intentions	Career Awareness, Self-Efficacy, Reflection	Develops a conscious approach to career choice	Diagnostic tools are needed	[17][18] [19][23]

Technological	Using digital tools, 3D modeling, AIoT, and micro:bit	Materialization of an Idea into a Product	Displays the connection between the curriculum and modern professions	May be dependent on technical equipment	[4][5][7]
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A comparative analysis shows that the STEAM project approach differs from traditional career guidance not in the number of technologies used, but in the very logic of the pedagogical action.

3. Results and Discussion

Traditional career guidance conversations answer the question: "What professions exist?" A STEAM project answers a different question: "What role can I play in solving a real-world problem?" This transition from knowledge of a profession to the experience of professionally meaningful action constitutes the key advantage of STEAM career guidance.

Despite the active development of research on STEAM/PBL and STEM career interest, several unresolved questions remain in the scientific literature [18].

The first question concerns the diagnostics of the career guidance effect of STEAM projects. Some studies assess interest in STEM/STEAM, while others measure self-efficacy, career awareness, attitudes toward professions, or educational intentions. However, a unified system of metrics specifically designed to assess the impact of project-based collaboration on students' career development remains underdeveloped.

The second question concerns the sustainability of the effect. One-off STEAM activities can increase student interest, but career guidance requires repeated experiences, progressively more complex tasks, and regular reflection. Meta-analytical and review studies on STEM/PBL emphasize the importance of the structure, duration, and implementation conditions of project-based learning [19].

The third question concerns social and gender differences. Research shows that interest in STEM careers depends not only on educational experience but also on stereotypes, self-efficacy, outcome expectations, and social perceptions of professions [20]. Consequently, STEAM design should consider the distribution of roles within the team: if students are constantly offered stereotypical roles, the project may reinforce rather than expand their limited professional understanding.

The fourth question concerns the role of the art component. In some practices, art is included in STEAM as a decorative element of a product. However, research into the STEAM approach shows that art should be considered more broadly: as design, visualization, user experience, creative presentation of a solution, and humanistic understanding of a technological product [21]. This is especially important for career guidance, as modern professions increasingly find themselves at the intersection of technology, design, and communication.

The fifth question concerns the neuropsychological dimension of STEAM projects.

Theoretically, project-based activities activate the cognitive, sensorimotor, communicative, and emotional-motivational components of learning. However, the current body of literature on direct neuropsychological research on STEAM career guidance is insufficient. Therefore, this area should be considered promising and requires further empirical testing [22].

A systematic review of the literature allows us to propose a conceptual model of the pedagogical potential of project-based collaboration in STEAM career guidance for schoolchildren.

Table 2. Structural Model of STEAM-Based Career Guidance: Components, Pedagogical Mechanisms, and Learning Outcomes

Model Component	Contents	Pedagogical Mechanism	Expected Outcome
Input Conditions	STEAM content, project problem, age-appropriate characteristics, resources, pedagogical support	Creating an educational situation close to the professional task	Students' readiness for project-based activities
Procedural Mechanisms	Problem formulation, team design, role assignment, research, product creation, presentation	Involving the student in professionally significant activities	Professional trial experience
Cognitive Channel	Developing interdisciplinary knowledge and understanding STEAM professions	Expanding career awareness	More accurate understanding of professional fields
Activity Channel	Completing project tasks, modeling, construction, design	Experiencing elements of professional activity	Awareness of one's own abilities
Social-Communicative Channel	Teamwork, argumentation, presentation of results	Mastering soft skills	Understanding the team-based nature of modern professions
Motivational-Value Channel	Interest in solving a real-world problem and creating a product	Personal acceptance of STEAM activities	Increased interest in STEAM fields
Reflexive Channel	Analysis of one's role, challenges, successes, and intentions	Connecting educational experience with future trajectory	Development of professional intentions

In a generalized form, the model can be represented as follows:

STEAM environment → project problem → collaboration → professional trial → career reflection → professional self-determination [23].

This model demonstrates that the career guidance effect of a STEAM project does not arise automatically. It requires a special pedagogical organization: the selection of a meaningful problem, the assignment of roles, the involvement of students in real-life project planning, the demonstration of connections with professional fields, and mandatory reflection.

4. Conclusion

This review allows us to draw several conclusions. First, the STEAM approach has significant career guidance potential when implemented not as a set of interdisciplinary assignments, but as a project-based environment for professional trials. Its significance lies in the fact that students are given the opportunity to see the connection between educational content and real-life professional actions.

Second, project-based collaboration is a key mechanism for STEAM career guidance. It transforms students from passive recipients of information to participants in career-oriented activities. Through team planning, role assignment, product creation, and presentation of the results, students begin to understand their own interests, strengths, and potential educational paths.

Thirdly, the most significant channels of influence of project collaboration are cognitive, activity-based, social-communicative, motivational-value-based, and reflective. Each performs a specific function: it expands knowledge about professions, fosters action experience, develops soft skills, enhances interest, and helps connect educational experiences with future choices.

Fourthly, pedagogically organized career reflection is necessary to achieve career guidance. If, after the project, the student does not analyze their own role, abilities, challenges, and career aspirations, the STEAM project remains developmental but does not become fully career-oriented.

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