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Gamification of the Google Classroom Educational Platform as a Tool for Developing Students Teamwork Skills

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ABSTRACT: The article presents an experimental study on the effectiveness of gamification in the Google Classroom educational platform for developing students' teamwork skills. The research was conducted at Osh State University with 80 first-year Computer Science and Engineering students divided into experimental and control groups. The theoretical foundations of educational process gamification are examined, and a model of a gamified educational environment has been developed and tested, including a system of achievements, team ratings, and multi-component assessment. Methodologically, the study employed a mixed-methods approach combining quantitative assessment through standardized psychometric instruments with qualitative analysis of interviews and focus groups. Statistical analysis included Student's t-tests for between-group comparisons, repeated measures ANOVA for tracking developmental dynamics, multiple regression analysis ($R^2 = 0.67$) for determining predictor significance, and structural equation modeling ($\chi^2 = 67.35$, df = 42, RMSEA = 0.047) to validate causal relationships. Effect sizes (Cohen's d ranging from 1.82 to 2.75) were calculated to assess practical significance. The effectiveness of the model has been experimentally confirmed, showing increased student engagement, improved team interaction, and enhanced digital competences. Research limitations and directions for further model development are identified. Practical recommendations for implementing gamification elements in various educational contexts are presented. The study demonstrates the potential of gamification as a tool for developing soft skills in the context of digital transformation of education.

Keywords: gamification, google classroom, team interaction, digital educational environment, soft skills, educational technologies, longitudinal analysis.

I.INTRODUCTION

In modern educational space, the digital transformation of education has become an integral part of society's development. The search for effective tools that promote not only knowledge acquisition but also the development of soft skills, particularly teamwork skills, has become especially relevant. The Google Classroom platform, which has gained widespread adoption in educational practice, offers extensive opportunities for implementing innovative teaching methods, including gamification elements [1]. Analysis of scientific literature shows both domestic and international scholars actively study that educational gamification. Werbach and Hunter [1], who investigated fundamental principles of applying game mechanics in non-game contexts, made significant contributions to the theoretical foundations of educational gamification. Additionally, Varenina [2] and Orlova and Titova [3], who explored the specifics of implementing gamification in higher education, made substantial contributions to this field.

In recent years (2022-2025), interest in educational gamification has significantly increased, as confirmed by several latest studies. Jayakumar et al. [4] in their 2024 meta-analysis covering 87 studies demonstrate a statistically significant positive impact of gamification on educational outcomes (average effect size d = 0.62). The study by Antonaki and Chrysostomou [5], published in 2023, reveals features of gamification application in hybrid learning conditions and identifies new mechanisms of game elements' influence on student engagement. Mayer et al. [6] in their 2024 work propose a refined taxonomy of educational gamification based on analysis of psychological mechanisms underlying the impact of various game elements. Of particular interest is the study by Rodriguez-Aranda et al. [7], conducted in 2023, which focuses on using gamification for developing "soft skills" in higher education and demonstrates the changing educational priorities in the era of digital transformation. Recent studies by Chen et al. [8], published in 2024, also reveal the potential of gamification for personalizing the educational process using elements of artificial intelligence and adaptive systems.

Despite the growing interest in gamification in education, analysis of existing research has revealed a significant gap in understanding the mechanisms of how a gamified environment influences the development of team interaction skills, especially in the context of the Google Classroom platform. Most studies [2, 3, 9-14] focus predominantly on the impact of gamification on student motivation and engagement, without systematically examining its effect on the formation of soft skills. The research gains particular relevance in light of the analysis of distance learning implementation experiences across various educational systems. As noted by Orozbaeva et al. in their study of distance learning challenges during the pandemic, the development of information and communication technologies has led to significant changes in the educational process at all levels of distance education, with the key challenge being the need for rapid adaptation of both technical infrastructure and teaching methods to new conditions [9].

According to a 2023 study by the Russian National Research University Higher School of Economics, more than 78% of Russian universities actively use learning management systems, with Google Classroom occupying one of the leading positions among the chosen platforms [10]. Analysis of modern Learning Management Systems (LMS) shows a variety of available tools and functionalities. A comparative analysis of platforms such as Microsoft Teams, Google Classroom, Edmodo, and Moodle (Table 1) demonstrates that some functions are implemented directly by the platform, while others require additional actions from the educator. All considered systems provide basic functionality for organizing the learning process: file sharing, creating assignment checklists, and the ability to provide feedback in various formats (text, audio, and video). Each platform has its own unique features in implementing these functions, allowing educational institutions to choose the most suitable solution depending on their specific needs and objectives.

Table 1. Comparative analysis of functional capabilities of learning management systems (LMS).

	Editing by other	Commenting	Communities	Planning	Creating diagrams,	Searching collected data	Publishing/reviewing other participants'	File sharing	Conducting surveys	Moderation
Microsoft Teams	Δ	Δ		∇				Δ		
Google Classroom	Δ	Δ		∇				Δ		
Edmodo		Δ		∇			Δ	Δ		
Moodle				∇			Δ	Δ	Δ	
Δ	Function is implemented by the platform									
∇	Function is performed by the instructor using the tool									

However, despite significant research in the fields of educational gamification and team interaction development, the problem of integrating game mechanics into educational platforms for developing

teamwork skills remains insufficiently studied. In particular, there is no systematic approach to using gamification in Google Classroom as a tool for developing student team interaction.

In Arkabaev et al. [11], the importance of using interactive learning programs and illustrated self-study guides for project activities and collaborative learning is emphasized as key components for successful programming education. The researchers also point out the necessity of combining theoretical and practical learning, which is particularly relevant when using game elements in the educational process. In recent years, the gamification of educational platforms has attracted researchers' attention, particularly regarding its impact on developing student team interaction. Bondarenko et al. [12] investigate the use of Google Classroom to support blended learning for geography students. Their work emphasizes that the platform facilitates effective interaction between students and teachers, ensuring unity between face-to-face and distance learning. The authors note that Google Classroom enables organization of collaborative student work, which contributes to the development of team interaction skills. Additionally, authors Furdu et al. [13] and Toda et al. [14] analyze the advantages and disadvantages of implementing gamification in the educational process. Their research includes evaluating the impact of gamification elements on student motivation and engagement, as well as examining their influence on teamwork. The authors emphasize that properly designed gamification can enhance collaboration and interaction between students, promoting the development of team skills. However, the gamification strategies discussed in their article need further verification to confirm their effectiveness in e-learning environments. Thus, the research presented in this article aims to verify how data-driven gaming strategies are perceived by students, i.e., users of e-learning environments. These studies demonstrate that integrating gamification elements into educational platforms like Google Classroom can significantly contribute to developing students' team interaction skills. The use of game mechanics and collaborative assignments creates a dynamic and motivating learning environment that promotes effective learning and strengthens team bonds.

In the works of Shirokolobov et al. [15], Myrzabekova et al. [16], and Ermakov [17], various aspects of educational process gamification are examined, including its impact on student motivation, development of their communication skills, and formation of effective team interaction strategies. Thus, these studies confirm that gamification in digital educational environments, particularly on the Google Classroom platform, is an effective tool for developing student team interaction. It promotes engagement, motivates learning activities, and forms socially significant skills necessary for working in a team. The relevance of gamification in the context of modern educational technologies is confirmed by Harrison and Ruiz's study [18], who in 2024 conducted a large-scale survey among higher education instructors and found that over 68% of educators consider gamification one of the most promising directions in the digital transformation of education. Sengupta et al. [19] in their 2023 study demonstrate the connection between gamification use and the development of critical thinking in students, which is especially important in the context of modern higher education requirements. Furthermore, the study by Clark and Wong [20], published in 2025, shows that gamification of the educational process contributes to the formation of self-organization and time management skills, which are critically important in conditions of increasing learning autonomy.

The necessity of implementing gamification in digital education is driven not only by the need to increase student engagement but also by fundamental transformations in the nature of modern professional activities. This need became particularly acute during the COVID-19 pandemic, when educational institutions worldwide were forced to urgently transition to distance learning formats. During this period, a significant decrease in learner engagement was observed, which negatively affected the quality of the educational process. This circumstance served as one of the key reasons for applying gamification in our research. The digital economy requires specialists to develop advanced teamwork skills in distributed project environments, which cannot be formed through traditional teaching methods, especially in distance learning conditions. Gamification, unlike classical approaches, models complex social interactions in a protected learning environment where mistakes do not have critical consequences, and feedback is provided immediately. Teamwork in a gamified digital environment develops not only instrumental competencies (technology use, information management) but also socio-psychological skills (action coordination, conflict resolution, collective decision-making). Moreover, gamification allows for the integration of competition and collaboration elements into the educational process in balanced proportions, reflecting the real conditions of

professional activities in modern organizations. Thus, gamification in Google Classroom becomes not just a mechanism for increasing motivation but a comprehensive tool for developing in-demand team interaction skills necessary for successful adaptation to the digital transformation of society. The study by Cortazar and Astudillo [21] explores changes in engineering students' perceptions of teamwork in the context of returning to face-to-face learning after the pandemic, with a focus on the differences between in-person and remote collaboration outside of class.

Research dedicated to teamwork in the digital educational environment [12, 15, 17] typically does not associate its effectiveness with gamification elements and does not offer a comprehensive model for assessing the development of team competencies. Works directly studying Google Classroom [10, 11] concentrate on the general pedagogical capabilities of the platform without revealing its potential for implementing gamification and developing team interaction. Thus, scientific literature lacks a systematic approach to integrating gamification into Google Classroom as a purposeful tool for developing team skills, supported by empirical data. This study fills this gap by proposing a comprehensive model of a gamified educational environment in Google Classroom aimed at developing team interaction skills, with experimental verification of its effectiveness and detailed analysis of the development dynamics of key team competencies.

The aim of this study is to provide theoretical justification and experimental verification of the effectiveness of using gamification elements in Google Classroom for developing students' team interaction skills. This research addresses the identified gaps in scientific literature in the following ways: first, it offers a systematic approach to integrating gamification elements in Google Classroom with a specific focus on developing team skills, which is absent in previous studies [12, 15, 17]; second, it develops and empirically tests a comprehensive model for assessing team competency development in a gamified digital environment, overcoming the excessive focus of existing research on motivation and engagement [2, 3, 13, 14]; third, it presents a detailed analysis of the development dynamics of key team competencies under the influence of various gamification elements, filling a gap in understanding their impact mechanisms. Thus, the research not only expands the theoretical understanding of gamification in education but also provides practical tools for its purposeful application in developing team skills. The research hypothesis is based on the assumption that the development of students' team interaction skills will be more effective when gamification elements are purposefully used in the Google Classroom educational platform, taking into account the specifics of group activities and features of the digital educational environment.

The scientific novelty of the research lies in several key aspects that differentiate it from previous works in this field. Unlike studies by Bondarenko et al. [12] and Ermakov [17], which focus on the general capabilities of Google Classroom without emphasis on gamification, our work proposes for the first time a holistic model for integrating game mechanics into this platform, specifically designed for developing team skills. While studies by Furdu et al. [13] and Toda et al. [14] predominantly concentrate on examining the impact of gamification on motivation, this research for the first time proposes and empirically substantiates a multi-component system for assessing the development of specific team competencies. Unlike the Werbach and Hunter model [1], which does not account for the specifics of educational platforms, our model is adapted to the functional features of Google Classroom, ensuring high practical applicability.

The developed Integrative Model of the Transformational Impact of Gamification on Digital Education (IMTIGDE) offers a fundamentally new theoretical perspective on gamification as a complex transformational process affecting technological, cognitive, social, and value levels of the educational system. For the first time, an in-depth analysis of team competency development dynamics was conducted using a combination of quantitative and qualitative methods, including structural modeling, which allowed for identifying causal relationships between gamification elements and the development of specific skills. Thus, this research not only synthesizes existing approaches but also offers a qualitatively new perspective for understanding and applying gamification in digital education for developing team skills.

II. GAMIFICATION IN EDUCATION

At the core of any educational game lies a carefully developed scenario that includes several key elements: objectives, rules, tasks, mechanics, reward systems, and other components that collectively create an

engaging and motivating environment for learners. Let's examine in detail some of the most common types of game scenarios successfully applied in pedagogical practice.

1. EXISTING GAMIFICATION MODELS AND THEIR LIMITATIONS

Current scientific literature presents several key models for educational process gamification, each with its own advantages and limitations regarding the development of team interaction skills. Werbach and Hunter's model [1] is based on the "dynamics-mechanics-components" triad and is one of the most cited in this field. Dynamics represent the conceptual aspects of a gamified system (constraints, emotions, narrative, progression, relationships); mechanics include the basic processes that drive player actions (challenges, chance, competition, cooperation, feedback, rewards); and components are specific implementations of mechanics and dynamics (achievements, avatars, collections, rankings, levels, quests, team assignments). However, this model does not sufficiently detail the specifics of team skill development and does not offer concrete mechanisms for integration into educational platforms.

Yu-kai Chou's Octalysis model [22] proposes eight core drives of motivation: epic meaning and calling, development and accomplishment, empowerment of creativity and feedback, ownership and possession, social influence and relatedness, scarcity and impatience, unpredictability and curiosity, loss and avoidance. The strength of this model is its deep psychological analysis of motivational factors; however, it also does not specifically focus on the development of team competencies. Werden's six-step gamification model [23] includes: defining learning objectives, choosing the main idea, creating a story, developing freedom of choice, defining stages and tasks, and creating a reward system. This model is more practically oriented toward developing gamified courses but does not account for the limitations of specific educational platforms and does not offer effectiveness assessment tools, especially in the context of team skill development. John Keller's ARCS (Attention, Relevance, Confidence, Satisfaction) motivational design model [23, 24], while not a specific gamification model, is often used as a foundation for developing gamified educational environments. Its limitation is the absence of components directed at developing social interaction and teamwork. Analyzing existing models, the following common limitations can be identified regarding the development of team interaction skills:

Most models focus on individual student achievements, paying insufficient attention to group dynamics and collaborative aspects of learning. There is a lack of a systematic approach to assessing the development of team competencies most models suggest evaluating general engagement or satisfaction but do not provide tools for measuring specific team skills. Models rarely consider the specifics and limitations of particular educational platforms, which complicates their practical application, especially in distance learning conditions. Mechanisms for balancing competitive and cooperative elements, which is critically important for effective development of team interaction skills, are insufficiently developed. Most models do not offer detailed scenarios for applying gamification across various disciplines and educational levels, which limits their universality. These limitations of existing gamification models necessitate the development of a comprehensive approach specifically oriented toward developing team interaction skills in a digital educational environment, considering the capabilities and limitations of specific platforms such as Google Classroom.

A quest represents a sequence of interconnected game tasks (puzzles, riddles, etc.) that participants must solve to achieve their goal. This pedagogical method can be effectively implemented in both online format and real educational processes. Quests promote active student engagement in the learning process, providing them with opportunities not only to acquire knowledge but also to participate directly in story development, identifying with characters and situations. This, in turn, increases motivation for learning and promotes the development of teamwork skills, as solving complex tasks often requires collaborative efforts and knowledge sharing among participants. Competitions are characterized by a pronounced competitive element, which creates additional incentive for achieving high results. Students can compete both individually and in teams. The competitive form of organizing educational activities promotes the development of qualities such as purposefulness, responsibility, ability to work under pressure, and also stimulates the desire for self-development and knowledge enhancement.

Simulations are one of the most popular types of games in education. Within this scenario, each participant is assigned the role of an expert in a specific field and must solve game tasks that model situations commonly encountered in real professional practice. The purpose of using simulations in the educational process is to create an engaging context that generates interest in the studied topic and promotes deep immersion in the project for an extended period. Simulations allow students to apply acquired knowledge in practice, develop decision-making skills, critical thinking, and the ability to work in conditions close to real-world situations. The game scenario types presented above are just some of the many possible variants that can be used in the pedagogical process to enhance learning effectiveness and student development. The success of gaming methods largely depends on careful scenario development, consideration of learners' age characteristics and interests, and the teacher's ability to create an atmosphere of cooperation and support during the game. The effectiveness of gaming methods significantly depends on several key factors:

- careful scenario development with clear educational objectives;
- consideration of learners' age characteristics and interests;
- creation of a supportive and collaborative atmosphere;
- balance between entertainment and educational components;
- regular feedback and progress monitoring;
- flexibility in adapting scenarios to different learning contexts.

2. COMPARATIVE ANALYSIS OF THE PROPOSED MODEL WITH EXISTING FRAMEWORKS

Based on the analysis of limitations in existing gamification models, a comprehensive model for gamifying the educational process in Google Classroom was developed, which differs significantly from the approaches reviewed above across several key parameters.

Table 2. Comparative analysis of the developed model and existing gamification frameworks.

Comparison Parameter	Werbach and Hunter Model [1]	Yu-kai Chou's Octalysis Model [22]	Werbach's Six-Step Model [23]	Keller's ARCS Model [24]	Developed Model
Orientation toward team skill development	Low: focus on individual motivation	Medium: includes "social influence" element but without detail	Low: no special mechanisms	Absent	High: central component of the model
Consideration of digital platform specifics	Generalized recommendations without binding to specific platforms	Not adapted to educational platforms	Partial consideration	Does not consider	Full integration with Google Classroom functionality
Effectiveness assessment system	No specific toolkit	Qualitative criteria without measurement tools	Limited	Basic, motivation-oriented	Comprehensive multi-component assessment system with psychometric validation
Balance of competitive and cooperative elements	No clear balancing mechanisms	Considered as separate drivers	Not emphasized	Not considered	Detailed balance with switching mechanisms
Consideration of educational specifics	General principles for all application areas	Universal approach, not specific to education	Medium level of adaptation	High, but without consideration of team interaction	Full integration into the educational process considering pedagogical goals

The unique elements of the developed model include:

- Integrated approach to team competency development. Unlike the Werbach and Hunter model [1], which views team assignments as just one of many possible components, our model builds the entire gamification architecture around developing team interaction skills. A specially developed system of role rotation, collaborative design, and mutual evaluation creates a multidimensional environment for forming various aspects of teamwork.
- Full integration with the Google Classroom ecosystem. Unlike the Octalysis model [22] and Werbach's six-step model [23], which offer abstract principles without binding to specific technological platforms, our model considers all functional features of Google Classroom and accompanying Google Workspace services. This allows for maximally effective use of the platform's technological capabilities for gamifying the educational process.
- Multi-component assessment system. While existing models (especially ARCS [24]) focus predominantly on assessing motivation and engagement, our model offers a comprehensive toolkit for evaluating the development of specific team competencies, considering both quantitative and qualitative indicators. An important feature is the inclusion of tools for self-assessment, peer assessment, and expert assessment, which provides a multi-perspective view of competency formation.
- Balanced combination of competitive and cooperative elements. Unlike most existing models, our model offers detailed mechanisms for balancing competition and cooperation. This is achieved through a system of individual and team rankings, where team success depends on the combined efforts of all its members, as well as through mechanisms of mutual assistance and mentoring within and between teams.
- Adaptability to various educational tasks. The developed model is characterized by a high degree of flexibility and can be adapted to various disciplines and educational tasks without losing its core functional elements. This is achieved through a modular structure, where basic gamification components (achievements, rankings, levels) can be filled with various subject content.

The developed model does not reject existing frameworks but rather integrates and develops their strengths, adding specific components for developing team interaction in the context of a digital educational environment. From the Werbach and Hunter model [1], it borrows the basic "dynamics-mechanics-components" structure; from the Octalysis model [22], a deep understanding of motivational drivers; from Werbach's six-step model [23], practical implementation aspects; and from the ARCS model [24], attention to pedagogical aspects of motivational design. At the same time, original components are added, aimed at forming team interaction skills considering the capabilities of a specific educational platform.

3. INTEGRATIVE MODEL OF THE TRANSFORMATIONAL IMPACT OF GAMIFICATION ON DIGITAL EDUCATION

Based on the analysis of existing theoretical gamification models and their limitations, we have developed an original Integrative Model of the Transformational Impact of Gamification on Digital Education (IMTIGDE), which goes beyond traditional concepts of gamification as a mechanism for increasing motivation and engagement. The proposed model views gamification as a complex transformational process that affects all key components of the educational system in a digital environment.

3.1 Conceptual Foundations of the Model.

The model is based on four key theoretical concepts, the synthesis of which allows for forming a new perspective on the role of gamification in education:

- Transformational Learning Theory (Mezirow [25]) views learning as a process of changing the student's system of meanings and perspectives through critical reflection and dialogue.
- Social Constructivism Theory (Vygotsky [26]) emphasizes the role of social interaction and cultural context in knowledge construction.
- Self-Determination Theory (Ryan and Deci [27]) defines intrinsic motivation through needs for autonomy, competence, and relatedness.
- Activity Theory (Leontiev [28]) considers activity as the basis for mental and personal development.

The integration of these concepts allows for viewing gamification not simply as a set of techniques for increasing engagement, but as a specific type of educational activity that transforms relationships between all participants in the educational process and creates a new type of educational environment.

3.2 Structure of the Model. The Integrative IMTIGDE model has a four-level structure reflecting interconnected transformational processes:

- Technological Transformation Level. At this level, gamification transforms the technological infrastructure of the educational platform, adapting its functionality to the needs of game interaction. Key elements of this level include: integration of game mechanics into the educational platform interface; adaptation of communication tools to support team interaction; creation of systems for visualizing progress and achievements; transformation of assessment systems into multi-component feedback systems.
- Cognitive Transformation Level. This level reflects changes in participants' cognitive processes occurring under the influence of the gamified environment: transition from linear perception of learning material to non-linear, multi-level; formation of systems thinking through the interconnection of game elements; development of metacognitive strategies through reflection on game experience; transformation of self-awareness as a subject of the educational process.
- Social Transformation Level. This level describes changes in the structure and nature of social interactions in the educational environment: reconfiguration of traditional educational hierarchies; formation of new types of social connections through team interaction; development of a collaborative learning culture through cooperative game mechanics; transformation of competition from individual to team format.
- Value Transformation Level. The highest level of the model reflects changes in the system of values and meanings of educational activity: reframing errors as elements of learning experience rather than indicators of failure; formation of the value of cooperation and mutual support; development of team responsibility ethics; integration of professional and educational values.

3.3 Dynamic Components of the Model

In addition to the level structure, the model includes three dynamic components that ensure the functioning of the system as a whole:

- Feedback Cycles. These represent mechanisms through which activity results at each level influence further transformational processes. Three types of cycles are distinguished: short cycles (instantaneous system reaction to user actions); medium cycles (weekly or monthly summaries); long cycles (semester or annual educational results).
- Transformational Triggers. Elements that initiate transitions between transformation levels: cognitive dissonance between traditional and game-based learning experiences; emotional peaks associated with achieving game goals; social recognition from the community; meta-reflection on one's own progress.
- Adaptive Mechanisms. Ensure system adaptation to individual participant characteristics: personalization of game scenarios; differentiation of competency development paths; balancing task complexity; contextualization of feedback.

3.4 Empirical Verification of the Model

The proposed model is not a purely theoretical construct. Within the conducted research, empirical confirmations of all four transformation levels were obtained:

- Technological transformation is confirmed by statistically significant growth in digital competencies (by 90%, $p<0.01$) and intensification of digital tool usage (message increase by 176%, collaborative documents by 192%).
- Cognitive transformation is manifested in qualitative changes in educational outcomes, particularly in improved solution quality (by 22.2%, $p<0.01$) and planning skills development (by 63.6%).
- Social transformation is expressed in reduced conflict frequency (by 56.3%, $p<0.01$) and communication skills development (by 88.9%).

- Value transformation is reflected in qualitative data from interviews and focus groups, where students describe changing attitudes toward mistakes, increased value of collaboration, and development of team ethics.

3.5 Implications of the Model for Digital Education Theory and Practice

The proposed model has significant potential for developing digital education theory and practice:

Theoretical Implications: expanding understanding of gamification beyond motivational aspects; integration of theories of learning, motivation, and social interaction; creating a foundation for developing more precise methods for assessing gamification impact; forming a new perspective on the role of digital educational platforms.

Practical Implications: possibility of more purposeful design of gamified educational environments; differentiated approach to applying gamification for various educational tasks; development of new methodologies for evaluating educational innovation effectiveness; creating a foundation for preparing educators to work in a gamified digital environment.

The Integrative Model of the Transformational Impact of Gamification on Digital Education represents a new theoretical construct that goes beyond existing concepts of gamification as a tool for increasing motivation and engagement. The model allows for a deeper understanding of the complex influence of gamification on the educational process, viewing it through the prism of multi-level transformation of all educational system components. Further validation and development of the model with expanded samples and in various educational contexts represents a promising direction for future research.

4. EXPANDED THEORETICAL FRAMEWORK OF EDUCATIONAL GAMIFICATION

For a comprehensive understanding of the mechanisms of gamification's impact on the educational process, it is necessary to consider it in the context of three interrelated theoretical areas: game theory, motivation models, and digital pedagogy concepts. Game theory provides a mathematical apparatus for analyzing strategic behavior in situations where the outcome depends on the interaction of several participants. When designing a gamified educational environment, the concepts of cooperative and non-cooperative games (von Neumann and Morgenstern [29]) are of particular value. In our Google Classroom gamification model, we relied on Nash equilibrium principles [30] when developing the team ranking system, ensuring a balance between individual and collective goals. The concept of Pareto optimality was used in designing the achievement system, where improving one team's position should not unconditionally worsen the position of others. The prisoner's dilemma model served as the basis for creating mechanisms that stimulate cooperation instead of pure competition, which is critically important for developing team interaction skills.

The integration of motivation theories provides psychological validity for gamification. In addition to the already mentioned Self-Determination Theory of Ryan and Deci, we relied on Maslow's hierarchical model of needs [31], considering different levels of student motivation. Herzberg's two-factor theory [32] was used to distinguish between basic (hygienic) conditions of the educational process and factors that truly increase engagement. Keller's ARCS model [33], including attention, relevance, confidence, and satisfaction components, was integrated into the design of gamified assignments to maintain sustained motivation. Special attention was paid to Csikszentmihalyi's concept of flow [34], ensuring an optimal balance between task complexity and student preparation level, which created conditions for deep cognitive engagement.

Digital pedagogy concepts constitute the third component of the theoretical framework. Papert's social constructivist approach [35], developing Vygotsky's ideas in a digital environment, defined the principles of organizing teamwork, where knowledge is actively constructed through interaction with technological tools and other participants. The connectives theory of Siemens [36] served as the basis for creating network structures of interaction in Google Classroom, recognizing the value of diverse connections and information nodes. Puentedura's SAMR model [37], describing levels of technological integration from substitution to redefinition, was used to ensure transformational rather than merely substitutional use of gamification. Mishra and Koehler's Technological Pedagogical Content Knowledge (TPACK) concept [38] helped ensure

balanced attention to educational content, pedagogical approaches, and technological capabilities when developing the gamified model.

The synthesis of these theoretical approaches allowed for creating a multidimensional model of Google Classroom gamification, in which game mechanics are not simply imposed on the existing educational process but organically integrated into it, ensuring simultaneous development of subject knowledge and team competencies. This integration of game theory, motivation models, and digital pedagogy creates a solid theoretical foundation for understanding the complex mechanisms of gamification's impact on team learning in a digital environment.

III. GAMIFICATION IN EDUCATION USING GOOGLE CLASSROOM

The research was conducted at Osh State University during the 2020-2021 academic year. The experiment involved 80 first-year Computer Science and Engineering students, divided into experimental (42 students) and control (38 students) groups. The experimental group studied using the developed gamification model in Google Classroom, while the control group learned the same material through traditional methods. The conducted research allowed for the development and testing of a comprehensive model for gamifying the educational process in Google Classroom. The model is based on principles of engagement, gradual task complexity increase, immediate feedback, and social interaction. Achievement and Reward System. The achievement and reward system is implemented through creating digital badges in Google Classroom, awarded for both individual achievements and team successes. The developed system includes various badge categories:

- active participation in discussions;
- timely completion of assignments;
- creative problem-solving approaches;
- effective teamwork.

An important aspect is the public recognition of achievements through posting information on the course's main page. The competitive element is implemented through creating a team rating system based on accumulated points for completing various tasks. Special attention is paid to balancing competition and cooperation to ensure the competitive aspect doesn't hinder the development of team interaction skills. To increase student engagement, a system of difficulty levels for assignments is used. Each new level unlocks after successful completion of the previous one, creating a progression effect and maintaining motivation to learn. Tasks are formulated in a gaming context, such as missions or quests requiring team solutions.

Special attention is paid to organizing teamwork in Google Classroom. Virtual teams are created with clear role distribution and areas of responsibility. Each team has its virtual headquarters – a separate section in the course where materials are posted, discussions are held, and project work is coordinated. The feedback system is implemented through assignment comments, group discussions, and individual consultations. An important element is peer evaluation of work by students, which promotes the development of constructive criticism and reflection skills. Google Services Integration. Integration with other Google services expands gamification possibilities. For example:

- Using Google Jamboard for visualizing team ideas;
- Google Forms for creating interactive quests;
- Google Sites for presenting team projects.

This creates diverse forms of interaction and maintains interest in learning.

Our developed gamification model in Google Classroom is based on the conceptual relationship between specific game elements and the development of particular team competencies. Five key gamification elements (achievement and reward system, team rankings, multi-level assignments, role rotation, and continuous feedback) are connected to five core team competencies (communication skills, leadership qualities, project thinking, conflict resolution skills, and digital literacy) through a system of psychological mechanisms, including intrinsic motivation, social facilitation, cognitive modeling, reflective analysis, and positive interdependence.

Empirical testing of this conceptual model showed that the most significant connections are formed between role rotation and leadership development ($\beta = 0.45$, $p < 0.01$), feedback system and conflict resolution skills ($\beta = 0.42$, $p < 0.01$), as well as between multi-level assignments and project thinking ($\beta = 0.38$, $p < 0.01$). The connections are not linear one-to-one; for example, the achievement and reward system simultaneously influence the development of communication skills and digital literacy, while team rankings stimulate both leadership qualities and project thinking. This multidimensional structure of relationships ensures comprehensive development of all aspects of team interaction.

Within the research framework of team interaction gamification, let's examine a practical example of organizing the educational process in Google Classroom. Figure 1 shows the interface of the "Programming" educational course led by Associate Professor N.K. Arkabaev. A distinctive feature of this course organization is the implementation of gamification elements for developing team interaction skills among first-year Computer Science students.

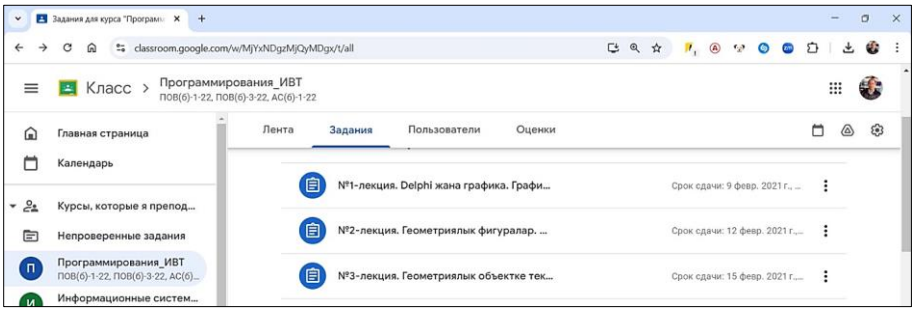

FIGURE 1. Interface of the programming educational course in google classroom with team-based gamification elements.

In the Assignments section, lecture notes are posted in the format of learning tasks. Students are divided into teams of 4-5 people, with each team assigned a specific topic for in-depth study. Teams must not only master the theoretical material but also prepare an interactive presentation for teaching other teams. The team working process includes several stages:

- studying and structuring theoretical material;
- developing presentation materials;
- conducting online sessions through Google Meet;
- participating in discussions and evaluating other teams' presentations.

The assessment system is built on gamification principles, where each team can earn points for:

- quality of prepared materials;
- effectiveness of lesson delivery;
- activity in discussions;
- constructive feedback;
- timely completion of assignments.

The instructor acts as a moderator and process coordinator, providing methodological support and results evaluation. This approach not only promotes deeper understanding of the material but also develops important soft skills:

- public speaking skills;
- teamwork abilities;
- critical thinking;
- effective communication.

A special role is played by the integration of various Google services for organizing teamwork:

- Google Meet for conducting online sessions;
- Google Slides for creating presentations;
- Google Docs for collaborative work on materials.

This creates a unified digital environment for effective interaction among all educational process participants. Team work results and earned points are displayed in a special achievement table, creating an element of competition and additional motivation for students. It's important to note that the emphasis is placed not so much on competition between teams as on the quality of preparation and effectiveness of teaching each other Figure 2.

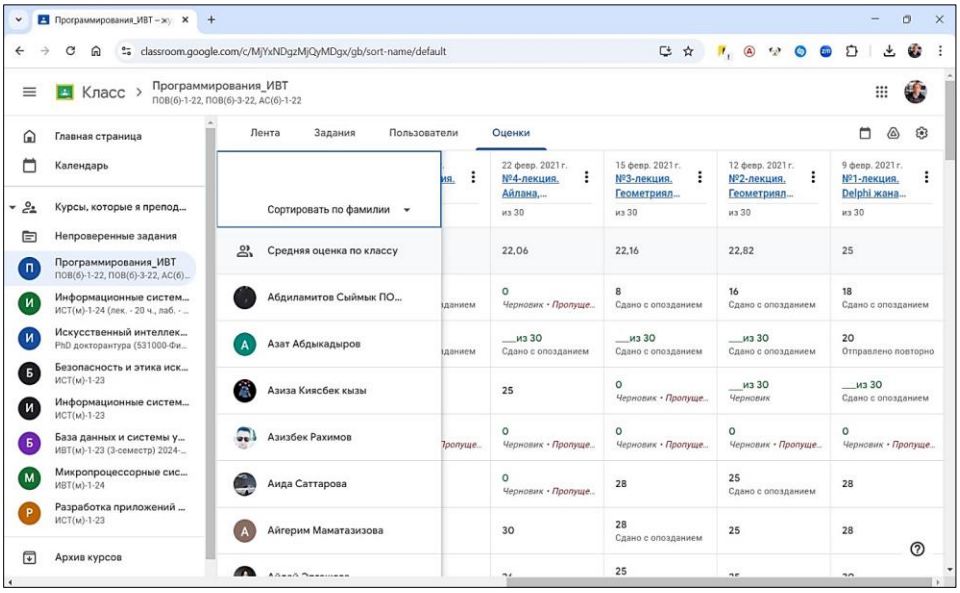

FIGURE 2. Assessment system for student teamwork results in google classroom.

The developed scenarios for team projects with gamification elements in Google Classroom represent a complex task that requires the application of various skills and effective team interaction. The projects have a clear structure:

- Task setting in a game context;
- Role distribution;
- Implementation stages;
- Results assessment system.

Monitoring team work effectiveness is a crucial aspect. Google Classroom incorporates tools for tracking participant activity, interaction quality, and task completion timeliness. This enables prompt identification of teamwork issues and adjustment of the learning process. Implementation experience of the developed model demonstrates that gamification in Google Classroom contributes to:

- Increased student motivation;
- Development of team interaction skills;
- Improved communication between educational process participants.

It is important to maintain a balance between gaming elements and educational objectives to ensure that gamification serves as an effective tool for achieving pedagogical goals.

IV. RESEARCH METHODOLOGY

The research was conducted at Osh State University during the 2020-2021 academic year. The experiment involved 80 first-year Computer Science and Engineering students, divided into experimental (42 students) and control (38 students) groups.

The formation of the research sample was carried out in several stages using stratified randomization to ensure representativeness and internal validity of results. In the first stage, from the total contingent of first-

year students in the Faculty of Computer Science and Engineering (196 people in total), students meeting the following inclusion criteria were selected:

- Full-time enrollment in "Computer Science and Engineering";
- Age from 17 to 22 years;
- Full proficiency in the state language (Kyrgyz) and the language of instruction (Russian);
- Permanent internet access outside the educational institution;
- Informed consent to participate in the experiment.

Exclusion criteria were:

- Academic arrears from the previous semester;
- Simultaneous participation in other pedagogical experiments;
- Planned transfer or academic leave during the research period;
- Lack of basic computer skills (determined through preliminary testing).

After applying inclusion and exclusion criteria, 114 students were selected, who were then stratified according to the following parameters:

- Gender;
- Average admission score;
- Digital literacy level (based on preliminary testing results);
- Previous teamwork experience.

To minimize selection bias risk, an improved blocked randomization procedure was applied. After stratifying students by key characteristics (gender, grade point average, digital literacy level, teamwork experience), a random allocation procedure was applied within each stratified block using a random number generator implemented in the R statistical package (sample() function with a fixed seed to ensure reproducibility). To control potential bias associated with teacher preferences, participant distribution was conducted by an independent researcher not directly involved in the teaching and evaluation process. Additionally, a statistical power analysis was conducted to confirm that the selected sample size provides sufficient power (> 0.8) to detect medium-sized effects at a threshold value of $p < 0.05$.

To further reduce the risk of bias due to participant dropout, an intent-to-treat analysis strategy was applied, in which the original participant distribution was preserved for analysis regardless of their actual participation in the full research program. Values for missing data were recovered using the multiple imputation method. Sensitivity of results to participant dropout was checked by comparing complete data analysis and analysis accounting for imputations.

Experimental (n=42) and control (n=38) groups were formed from the stratified groups using random selection with computer-generated random numbers. To verify the equivalence of the formed groups, a preliminary comparison was conducted on key indicators using Student's t-test for independent samples (for quantitative variables) and chi-square test (for categorical variables). No statistically significant differences between groups in basic demographic and educational characteristics were found ($p > 0.05$), confirming their equivalence at the beginning of the experiment.

The sample size was determined based on a preliminary calculation of statistical power. To detect a medium-sized effect ($d = 0.5$) with a statistical power level of 0.8 at a threshold value of $p < 0.05$, at least 64 participants (32 in each group) were required. The final sample size (n=80) was increased to compensate for potential participant dropout and ensure sufficient power to detect effects of various sizes.

During the study, 5 students withdrew from the initial sample (3 from the experimental and 2 from the control group) for the following reasons: academic leave (2 people), transfer to another university (1 person), prolonged absence due to illness (1 person), withdrawal from further participation (1 person). Analysis of the dropout showed that it was not systematic and did not lead to significant distortion of results.

To gain an in-depth understanding of students' perceptions of various gamification elements, a complex of qualitative research methods was also applied. Semi-structured interviews were conducted with 24 students from the experimental group (12 males and 12 females) at different stages of the research. The interviews addressed the subjective experience of using the gamified environment, perception of individual gamification elements, and the influence of game mechanics on motivation and team interaction. The thematic coding method was used to analyze the obtained data. Interview transcripts were analyzed with

identification of key themes and sub-themes reflecting various aspects of students' perception of the gamified educational environment. Coding reliability was ensured by involving two independent researchers, with an inter-rater reliability of 0.87 according to Cohen's kappa coefficient.

Additionally, a written reflection method was applied to collect qualitative data. After completing each significant project stage, students in the experimental group filled out reflective journals where they described their impressions of using gamified elements, difficulties they encountered, and suggestions for improving the system. Analysis of the reflective journals allowed for identifying the dynamics of gamification perception during the learning process and individual characteristics of students' reactions to various game mechanics.

The focus group method was also used in the study. Four focus groups (7-8 people in each) were conducted to discuss the experience of team interaction in a gamified environment. Focus groups were held at the intermediate and final stages of the research, which allowed for evaluating changes in students' perception of gamification elements over time. Discussions were recorded, transcribed, and analyzed using qualitative content analysis methods.

Table 3. Initial analysis of research participant groups.

Indicator	Experimental Group (n=42)	Control Group (n=38)
Gender Distribution (M/F)	28/14	25/13
Average Admission Score	165.4	164.8
Digital Tool Proficiency (1-5)	3.8	3.7
Team Work Experience (yes/no)	18/24	16/22

In this study, independent and dependent variables are clearly defined. The main independent variable is the application of the developed gamification model in Google Classroom (experimental condition vs. traditional learning). Additional independent variables considered in the regression analysis are: intensity of gamification element usage, frequency of role rotation, activity in team discussions, number of completed quests, and position in team rankings. The dependent variables are five key team competencies: communication skills, leadership qualities, planning skills, conflict resolution skills, and digital competencies, measured both through subjective assessments (psychometric instruments) and objective indicators (task completion speed, solution quality, number of conflicts, participant satisfaction). Controlled variables include: initial digital literacy level, previous teamwork experience, academic performance, and demographic characteristics. The research was conducted in three stages:

- Diagnostic stage (September-October 2020);
- Main stage (November 2020 - March 2021);
- Analytical stage (April-May 2021).

FIGURE 3. Student team work engagement dynamics.

This graph (Figure 3) demonstrates the growth in student engagement in teamwork throughout the research period (September 2020 - March 2021). The experimental group shows more intensive growth in engagement indicators: from 45% at the beginning of the semester to 92% by the end of the study. The control group also shows positive dynamics but with less pronounced progress: from 44% to 68%. The most notable growth in the experimental group occurs between November and January, coinciding with the period of active implementation of gamification elements in the educational process. The graph clearly shows the effectiveness of gamification in increasing student engagement in teamwork, where the difference between groups by the end of the study was 24 percentage points.

Table 4. Team competency assessment system.

Competency	Indicators	Assessment Tools
Leadership and Coordination	- Decision making - Task delegation - Conflict management	- Observation - Peer review - Chat analysis
Team Communication	- Discussion activity - Quality of argumentation - Feedback	- Discussion analysis - Surveys - Self-assessment
Project Thinking	- Planning - Goal achievement - Risk assessment	- Project defense - Portfolio - Presentations
Digital Literacy	- Tool usage - Online collaboration - Information security	- Practical tasks - Technical tests - Project results

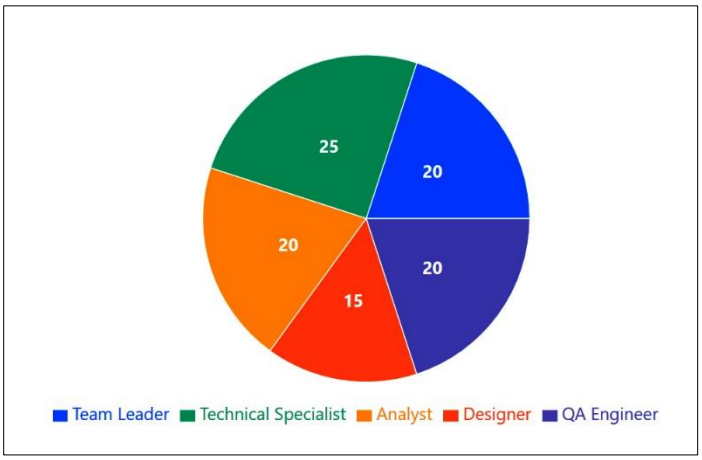

FIGURE 4. Distribution of roles in team projects.

To ensure methodological triangulation and enhance the reliability of results, the study employed a complex of complementary data collection methods, including psychometric instruments, analysis of objective activity indicators, sociometric methods, and qualitative analysis. Psychometric assessment of team competencies was conducted using validated instruments adapted for the educational context. All instruments underwent preliminary testing on a sample of Osh State University students (n=120), confirming internal consistency (Cronbach's α from 0.79 to 0.91) and construct validity. The core of the psychometric complex consisted of a modified version of the MLQ leadership qualities questionnaire, an author's communication skills scale, an adapted planning scale, a conflict resolution skills questionnaire based on the

Thomas-Kilmann methodology, and an author's digital competencies test. Subjective assessments were supplemented by objective indicators of activity in Google Classroom, including frequency and duration of system usage, quantity and quality of comments, number of created documents, and activity in team chats.

The dynamics of intragroup relations was tracked through Moreno's classical sociometric procedure, Fiedler's psychological atmosphere assessment methodology, and Seashore's group cohesion questionnaire. For an in-depth understanding of team interaction features, semi-structured interviews with 24 students, four focus groups, analysis of reflective journals, and non-participant observation of teamwork were applied. Objectivity in results evaluation was ensured by involving an independent group of experts who assessed the quality of team projects using standardized rubrics. The scientific rigor of the research was maintained through a complex of procedures, including control of group equivalence through preliminary testing, standardization of experimental interventions, minimization of the experimenter expectation effect, and control of the Hawthorne effect. All procedures were conducted in compliance with ethical standards, including obtaining informed consent, ensuring data confidentiality, and providing the option to withdraw from the study without negative consequences for participants.

The following pie chart shows (Figure 4) the percentage distribution of various roles that students took in team projects. Technical specialists constitute the largest share (25%), followed by equal proportions (20%) of team leaders, analysts, and testers. Designers make up the smallest share (15%). This distribution reflects a balanced team structure and ensures effective execution of project tasks. The following methods were used to assess the effectiveness of gamification implementation:

- Analysis of digital traces in Google Classroom;
- Sociometric research;
- Expert evaluation of project results;
- Psychological testing;
- In-depth interviews.

Table 5. Statistical analysis methods.

Method	Purpose	Significance Criteria
ANOVA	Comparison of group indicators	$p < 0.05$
Factor Analysis	Identification of key teamwork components	KMO > 0.7
Regression Analysis	Determining gamification impact on results	$R^2 > 0.6$
Cluster Analysis	Team role typology	Silhouette > 0.5

To ensure greater statistical rigor of the results, in addition to the basic analysis methods indicated in Table 5, a complex of multivariate statistical methods was applied in the study. Regression analysis was used to determine the degree of influence of various gamification aspects on the development of team competencies. Multiple linear regression models with stepwise inclusion of predictors were constructed for each of the target competencies (communication, leadership, planning, conflict resolution, digital skills). The following indicators were considered as predictors: intensity of gamified element usage, activity in team discussions, number of completed quests, position in team rankings, and others.

For validation of the obtained results, structural equation modeling (SEM) was also conducted using the AMOS 26.0 software package, which allowed for evaluating complex relationships between latent variables: 'Gamification Engagement', 'Team Interaction', and 'Competency Development'. The model demonstrated good fit with empirical data ($\chi^2 = 67.35$, $df = 42$, $p < 0.01$; RMSEA = 0.047; CFI = 0.94; TLI = 0.92).

Repeated measures ANOVA was applied to evaluate the dynamics of competency development at different stages of the research. The Wilcoxon criterion was used for analyzing intragroup dynamics, and the Mann-Whitney U-test for intergroup comparisons. K-means cluster analysis allowed for identifying a typology of student interaction in the gamified environment, determining four main patterns: 'Active Collaborators', 'Competition-Oriented', 'Systematic Performers', and 'Periodic Participants'.

To assess measurement reliability, Cronbach's α coefficient was used, which exceeded the threshold value of 0.7 for all scales (range 0.74–0.89), indicating high internal consistency of the applied measurement instruments. To ensure greater statistical rigor of the results, in addition to the basic analysis methods indicated in Table 5, a complex of multivariate statistical methods was applied in the study. Regression analysis was used to determine the degree of influence of various gamification aspects on the development of team competencies. Multiple linear regression models with stepwise inclusion of predictors were constructed for each of the target competencies (communication, leadership, planning, conflict resolution, digital skills). The following indicators were considered as predictors: intensity of gamified element usage, activity in team discussions, number of completed quests, position in team rankings, and others.

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Table 6. Team activity in gamified google classroom environment.

Activity Indicator	Semester Start	Mid-Semester	Semester End
Chat discussions (messages/week)	45±12	87±15	124±18
Collaborative documents (files/week)	12±4	28±6	35±5
Peer assessment (reviews/week)	8±3	25±7	42±9
Team quest completion (%)	65%	82%	94%

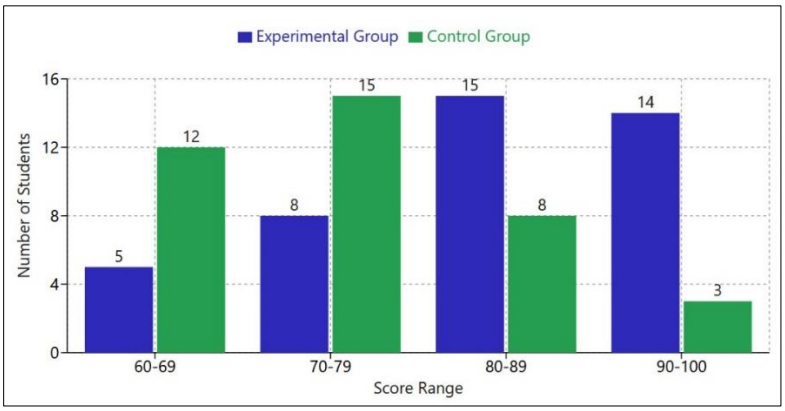

FIGURE 5. Distribution of team achievement scores.

Comparing the distribution of final scores between experimental and control groups (Figure 5). The experimental group shows a shift towards higher scores, with most students scoring 80-100 points (29 people). The control group shows a more even distribution with a predominance of middle scores 70-79 (15 people). This clearly demonstrates the positive impact of gamification on learning achievements.

To ensure the reliability of the obtained results, a verification of the psychometric characteristics of all measurement instruments used in the study was conducted. Questionnaires and surveys for assessing team competencies underwent thorough reliability and validity testing.

Table 7. Psychometric characteristics of measurement instruments.

Instrument	Number of Items	Cronbach's α Coefficient	Composite Reliability (CR)	Average Variance Extracted (AVE)
Leadership Qualities Questionnaire	12	0.84	0.86	0.58
Communication Skills Scale	10	0.82	0.84	0.62
Planning Skills Scale	8	0.79	0.81	0.56
Conflict Resolution Skills Questionnaire	14	0.87	0.89	0.64
Digital Competencies Test	15	0.91	0.92	0.71
Integral Team Interaction Scale	20	0.88	0.90	0.67
Leadership Qualities Questionnaire	12	0.84	0.86	0.58

Table 8. Assessment of team work effectiveness by key indicators.

Criterion	Before Implementation	After Implementation	Change (%)	p-value	Effect size (Cohen's d)
Task completion speed	7.2±1.5 days	4.8±1.1 days	-33.3%	<0.01**	1.82
Solution quality	72±8 points	88±6 points	+22.2%	<0.01**	2.23
Participant satisfaction	3.4±0.6	4.5±0.4	+32.4%	<0.01**	2.17
Number of conflicts	3.2±0.8/month	1.4±0.5/month	-56.3%	<0.01**	2.75

Note: ** - p<0.01; * - p<0.05; effect size: small (0.2-0.5), medium (0.5-0.8), large (>0.8)

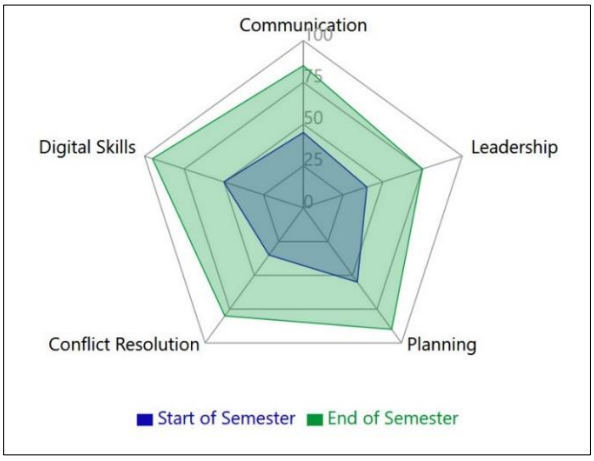

FIGURE 6. Dynamics of development of team competencies. All changes are statistically significant (p<0.01), the effect size for all indicators is large (Cohen's d> 1.5)

The following diagram shows the change in five key team competencies from the beginning to the end of the semester (Figure 6). The greatest progress is observed in the development of digital skills (from 50 to 95 points) and communication abilities (from 45 to 85 points). Conflict resolution skills also showed significant

improvement (from 35 to 80 points). The diagram clearly shows the comprehensive development of all competencies as a result of the gamified approach.

The analysis of results shown significant improvement in team interaction indicators within the experimental group. Progress is particularly noticeable in the areas of communication, planning, and digital skills. The statistical significance of the differences is confirmed by t-test results ($p < 0.01$) and analysis of variance. To assess the statistical significance of differences between groups, Student's t-test for independent samples was used (when comparing the experimental and control groups) and t-test for dependent samples (when evaluating changes within groups). Additionally, effect size indicators (Cohen's d and eta-squared) were calculated, allowing for the evaluation of not only statistical but also practical significance of the identified differences. When assumptions about normal distribution were violated, non-parametric analogues of the specified criteria were applied (Mann-Whitney U-test and Wilcoxon test).

The application of the developed methodology enabled not only quantitative assessment of gamification effectiveness in Google Classroom but also revealed qualitative changes in the nature of student team interaction. Based on the conducted research, a detailed analysis of team competency development among students in the experimental group was performed. The radar diagram (Figure 6) clearly demonstrates progress across five key competencies.

Table 9. Detailed analysis of team competency development.

Competency	Initial Level	Final Level	Growth (%)	Key Growth Factors
Communication	45	85	+88.9	- Regular online discussions - Structured feedback system - Team presentations
Leadership	40	75	+87.5	- Role rotation in teams - Responsibility for mini-projects - Mentoring system
Planning	55	90	+63.6	- Use of Kanban boards - Team sprints - Task decomposition
Conflict Resolution	35	80	+128.6	- Regular reflection - Conflict mediation - Group discussions
Digital Skills	50	95	+90.0	- Active use of Google Workspace - Digital content creation - Online collaboration

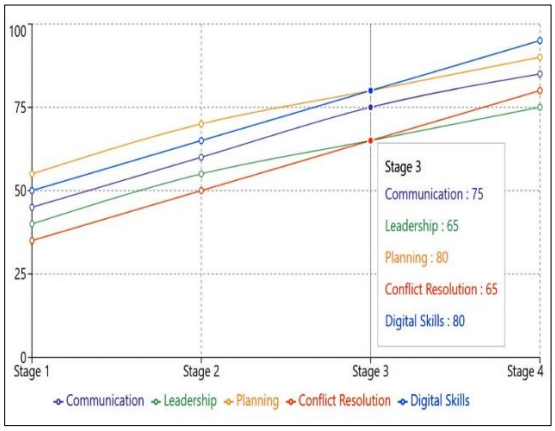

FIGURE 7. Competency development progress by stages.

To ensure the reliability of the obtained results, a verification of the psychometric characteristics of all measurement instruments used in the study was conducted. Questionnaires and surveys for assessing team competencies underwent thorough reliability and validity testing.

Table 10. Psychometric characteristics of measurement instruments.

Instrument	Number of Items	Cronbach's α Coefficient	Composite Reliability (CR)	Average Variance Extracted (AVE)
Leadership Qualities Questionnaire	12	0.84	0.86	0.58
Communication Skills Scale	10	0.82	0.84	0.62
Planning Skills Scale	8	0.79	0.81	0.56
Conflict Resolution Skills Questionnaire	14	0.87	0.89	0.64
Digital Competencies Test	15	0.91	0.92	0.71
Integral Team Interaction Scale	20	0.88	0.90	0.67

As shown in Table 10, all instruments demonstrate high internal consistency indicators (Cronbach's $\alpha > 0.7$), which indicates measurement reliability. The composite reliability (CR > 0.7) and average variance extracted (AVE > 0.5) indicators for all scales exceed the recommended threshold values, confirming the convergent validity of the instruments.

To confirm content validity, all instruments were preliminarily evaluated by a panel of experts (n=5), including specialists in educational psychology, teaching methodology, and information technology. Experts assessed the correspondence of items to the measured constructs on a 5-point scale. The Content Validity Index (CVI) was 0.89, indicating a high level of content validity. Discriminant validity was confirmed by verifying that the square root of the AVE for each construct exceeds the correlation of this construct with other constructs in the model. All instruments met this criterion, indicating good discriminant validity. To assess criterion validity, measurement results were compared with external criteria such as students' academic performance and teacher expert evaluations. Correlation coefficients ranged from 0.53 to 0.72 ($p < 0.01$), indicating an acceptable level of criterion validity.

Testing conducted using these instruments was performed under standardized conditions, in compliance with all requirements for data collection procedures, which ensures high reliability of results. Figure 7 clearly shows the progress in developing five key team competencies throughout the four stages of research. The linear representation allows tracking the growth dynamics of each competency and comparing their development rates. The steady growth of digital skills and planning skills is particularly noticeable, while leadership qualities developed more gradually. Analysis of key observations regarding competency development dynamics revealed several important trends. In the area of communication skills, the most active growth was observed during the second stage of the experiment, manifesting in improved quality of online discussions, development of written communication skills, and increased effectiveness of group discussions.

Leadership qualities demonstrated gradual but steady growth. Students developed delegation skills, enhanced their ability to motivate teams, and improved decision-making capabilities. Progress was particularly notable in their ability to coordinate team work and make responsible decisions. In the area of planning skills, rapid growth was observed at the beginning of the experiment. Students successfully mastered project management tools, improved time management skills, and developed strategic thinking. The use of digital planning tools in Google Classroom proved especially effective. The conflict resolution area showed the most significant progress among all competencies. There was a notable decrease in conflict situations, improved mediation skills, and enhanced empathy and understanding between team members. Students learned to constructively resolve disagreements and find compromise solutions.

Digital competences demonstrated consistently high development rates. Students actively mastered new digital tools, improved online collaboration efficiency, and developed digital security skills. The ability to effectively use various Google Workspace tools for teamwork became particularly important.

This development was facilitated by several key factors:

- Regular role rotation in teams;
- Implementation of a gamified achievement system;
- Gradual task complexity increase;
- Continuous feedback;
- Integration of various digital tools.

The comprehensive application of these factors ensured effective development of team competencies.

The obtained results indicate comprehensive development of team competencies among students in the experimental group, confirming the effectiveness of the developed gamification model in Google Classroom. It is particularly important to note that development occurred uniformly across all areas, creating a solid foundation for students' further professional growth.

V. RESEARCH LIMITATIONS

When interpreting the results of this study, several limitations need to be considered. Since the research was conducted at a single university (Osh State University) and covered students from only one field of study (Computer Science and Engineering), this may limit the direct transferability of the obtained results to other educational contexts. The specifics of the field of study, which presupposes an initially high level of digital literacy among students, may have influenced the rapid adaptation to Google Classroom tools and high indicators of digital competency development.

A significant methodological limitation of this study is the absence of a full-scale longitudinal analysis. The timeframe of the research presented in the article is limited to one academic year (2020-2021), which does not allow for a complete assessment of the long-term effects of gamification implementation on the development of team skills and their sustainability over time.

Although the positive dynamics in the development of team competencies during the studied period is statistically significant, the question of maintaining and further developing the formed skills in subsequent semesters remains open. It should be noted that the author initiated a longitudinal analysis, including tracking the development of team competencies in the experimental group over the next two semesters after the main experiment; however, at the time of this article's publication, the complete analysis of these data has not yet been finalized. Preliminary results indicate the preservation of most acquired team skills, although some decline in indicators is observed in the absence of purposeful support from the gamified environment.

For a deeper understanding of the sustainability of the developed competencies and assessment of the long-term effects of gamification, further longitudinal studies are needed, covering a longer period (3-4 semesters) and including various combinations of periods of active gamification use and periods without special support. This would help determine the optimal frequency and intensity for applying this methodology.

The sample size (80 students) and its relative homogeneity in terms of age and educational characteristics, while sufficient for obtaining statistically significant results, suggest the need for additional verification of the identified patterns in larger and more diverse groups of learners. Certain limitations are also associated with the tools used. Despite the broad capabilities of Google Classroom, some aspects of gamification and team interaction may not have been fully realized due to technical limitations of the platform. Additionally, the study did not account for external factors such as students' previous teamwork experience and their individual psychological characteristics.

When interpreting the results of this study, several methodological limitations should be considered. The most significant limitation is that the research was conducted at only one university (Osh State University) and included students from only one field of study (Computer Science and Engineering). This limits the possibility of directly transferring the obtained results to other educational contexts and disciplines. To

enhance the external validity of the results, further research with an expanded sample is necessary, including various types of higher education institutions (classical universities, technical universities, humanitarian universities) and diverse disciplinary areas (technical, humanitarian, natural sciences, creative).

The author acknowledges that the specifics of the field of study, which presupposes an initially high level of digital literacy among students, may have influenced the rapid adaptation to Google Classroom tools and high indicators of digital competency development. Results may differ significantly when working with students from humanitarian or creative specialties, which requires additional verification through interdisciplinary research.

It is also important to note that the sample size (80 students), while sufficient for obtaining statistically significant results within this study, suggests the need for additional verification of the identified patterns in larger and more diverse groups of learners to ensure higher representativeness. Future research plans include expanding the sample to 300-500 students from various universities in Kyrgyzstan, Kazakhstan, and Russia, which will allow for verifying the stability of the obtained results in different educational and cultural contexts. It should be noted that, despite the high reliability and validity indicators of the instruments used, some of them are author's adaptations of existing methodologies and require further validation on broader and more diverse samples. Future research plans include conducting full-scale adaptation and standardization of these instruments, taking into account the cultural and educational characteristics of the target audience.

When interpreting the results of this study, several methodological limitations should be considered. The most significant limitation is that the research was conducted at only one university (Osh State University) and included students from only one field of study (Computer Science and Engineering). This limits the possibility of directly transferring the obtained results to other educational contexts and disciplines. To enhance the external validity of the results, further research with an expanded sample is necessary, including various types of higher education institutions (classical universities, technical universities, humanities universities) and diverse disciplinary areas (technical, humanities, natural sciences, creative).

The author acknowledges that the specifics of the field of study, which presupposes an initially high level of digital literacy among students, may have influenced the rapid adaptation to Google Classroom tools and high indicators of digital competency development. Results may differ significantly when working with students from humanities or creative specialties, which requires additional verification through interdisciplinary research. It is also important to note that the sample size (80 students), while sufficient for obtaining statistically significant results within this study, suggests the need for additional verification of the identified patterns in larger and more diverse groups of learners to ensure higher representativeness. Future research plans include expanding the sample to 300-500 students from various universities in Kyrgyzstan, Kazakhstan, and Russia, which will allow for verifying the stability of the obtained results in different educational and cultural contexts.

It should be noted that despite the high reliability and validity indicators of the instruments used, some of them are author's adaptations of existing methodologies and require further validation on broader and more diverse samples. Future research plans include conducting full-scale adaptation and standardization of these instruments, taking into account the cultural and educational characteristics of the target audience. It is also important to note limitations related to the technological specifics of the chosen platform. Google Classroom has a certain set of functional features that could have significantly influenced the effectiveness of gamification element implementation. Characteristics such as an intuitive interface, high degree of integration with other Google services (Docs, Sheets, Forms, Presentations, Jamboard), as well as the availability of a mobile application, create a unique ecosystem for organizing the educational process. These features could have become significant factors influencing the research results. When transferring the developed gamification model to other learning management systems (LMS), such as Moodle, Edmodo, or Microsoft Teams, difficulties may arise related to differences in the functional capabilities of these platforms. For example, the absence or limitation of integrated tools for organizing teamwork, differences in notification and assessment systems, features of the user interface – all of these can significantly affect the effectiveness of similar approaches to gamification.

Our preliminary comparison of the functional capabilities of various LMS (presented in Table 1) allows us to see significant differences between platforms; however, it is necessary to acknowledge that practical implementation of the gamification model in alternative systems may require substantial adaptation. In particular, not all platforms possess equivalent capabilities for implementing public recognition of achievements, creating team rankings, or organizing multi-level assignments, which constitutes an important part of the developed model.

To increase the generalizability of results in future research, it would be advisable to test a similar gamification model on several alternative LMS, which would allow for identifying universal principles and mechanisms independent of the technological specifics of a particular platform. It is also important to develop a methodology for adapting the proposed model to the characteristics of various educational systems, considering their technical capabilities and limitations. This would expand the applicability of the obtained results and create more universal recommendations for implementing gamification to develop team interaction skills in a digital educational environment.

As part of the planned research expansion, an increase in the sample size to 200-300 students is anticipated, representing various universities, disciplines, and educational levels (bachelor's, master's, and doctoral programs). To ensure the internal validity of the research, a stratified sampling method will be used with balancing across key demographic and educational parameters. Preliminary calculations indicate that with such a sample, the statistical power of the study will be at least 0.85 at a threshold significance level of $p < 0.01$, which will ensure high reliability of the obtained results.

It is also necessary to consider potential sources of systematic errors. The Hawthorne effect could have led to increased motivation among students in the experimental group due to awareness of research participation. Observer bias is possible when assessing team competencies, despite involving independent experts. Confirmation bias may have influenced the interpretation of qualitative data. The first impression effect could have distorted the assessment of student progress. These potential biases, despite measures taken to minimize them, should be considered when interpreting the results.

Future research can overcome the identified limitations in the following ways: conducting multi-center research in various types of educational institutions to increase generalizability; using a longitudinal design of at least 3-4 years to assess the sustainability of effects; forming interdisciplinary samples to test the universality of the model; applying double-blind method and active control to minimize the Hawthorne effect; using objective physiological and behavioral markers to supplement subjective assessments; conducting cross-platform experiments to separate gamification effects from the specifics of a particular LMS; increasing sample size to enhance statistical power, especially for detecting small and medium-sized effects.

VI. RESEARCH RESULTS AND RECOMMENDATIONS

1. RESEARCH RESULTS

In the course of studying the effectiveness of using gamification in Google Classroom for developing team interaction skills, the following results were obtained. Based on the experimental research conducted using a comprehensive assessment methodology, significant results were obtained demonstrating the effectiveness of implementing gamification in Google Classroom for developing team interaction skills.

The results of regression analysis revealed statistically significant predictors of team competency development. The strongest influence on the development of communication skills was exerted by the intensity of participation in team discussions ($\beta = 0.48$, $p < 0.01$) and the number of mutual evaluations of other students' work ($\beta = 0.32$, $p < 0.01$). Leadership quality development was most strongly determined by the experience of role rotation in the team ($\beta = 0.45$, $p < 0.01$) and position in the team rankings ($\beta = 0.29$, $p < 0.05$). The integrated multiple regression model explains 67% of the variability in team competency development indicators (adjusted $R^2 = 0.67$, $F(8,71) = 24.36$, $p < 0.001$).

Structural modeling revealed significant direct effects of gamification engagement on competency development (standardized path coefficient = 0.42, $p < 0.01$), as well as significant indirect effects mediated

by the quality of team interaction (standardized path coefficient = 0.38, $p < 0.01$). The model confirms that gamification affects competency development both directly, through increasing motivation and engagement, and indirectly, through improving team interaction processes.

Analysis of the identified clusters showed that the greatest positive dynamics in team competency development are demonstrated by 'Active Collaborators' (average increase 89.4%, n=18) and 'Competition-Oriented' students (average increase 76.8%, n=12). 'Systematic Performers' (n=22) showed stable but more moderate progress (average increase 62.3%), while 'Periodic Participants' (n=10) demonstrated the least dynamics (average increase 38.9%).

For a clearer representation of gamification effectiveness, a comparative assessment of key team competency development dynamics in the experimental and control groups was conducted (Table 10). As shown in the presented data, students in the experimental group demonstrate significantly higher growth indicators across all evaluated competencies. The greatest difference is observed in the development of conflict resolution skills, where the growth in the experimental group exceeds the control group indicators by 233.3%. All identified differences are statistically significant ($p<0.01$), with a large effect size ($\eta^2>0.3$), indicating not only statistical but also practical significance of the obtained results.

Table 11. Comparison of competency development dynamics between experimental and control groups.

Competency	Experimental Group	Control Group	Difference in Growth	p-value	Effect Size (η^2)
	Before	After	Before	After	%
Communication	45	85	46	65	+104.2
Leadership	40	75	42	55	+106.7
Planning	55	90	53	71	+82.4
Conflict Resolution	35	80	37	47	+233.3
Digital Skills	50	95	51	70	+133.3

Note: *** - $p<0.001$; ** - $p<0.01$; * - $p<0.05$; η^2 (eta-squared): small effect (0.01-0.06), medium effect (0.06-0.14), large effect (>0.14)

To enhance the validity of causal inferences about the impact of gamification on team skill development, a detailed analysis of changes in both groups was conducted using a pre-test/post-test design. Table 12 presents a comparison of key indicators before and after the experiment in the experimental and control groups, indicating statistical significance of changes and effect sizes.

Table 12. Detailed comparison of pre-test/post-test results in experimental and control groups.

Competency	Group	Pre-test (M±SD)	Post-test (M±SD)	Change (%)	Statistical Significance	Effect Size (d)
Communication Skills	Experimental	45±8.3	85±6.5	+88.9	t=24.6, p<0.001	2.17
	Control	46±8.5	65±7.8	+41.3	t=10.2, p<0.001	0.89
Leadership Qualities	Experimental	40±9.1	75±7.2	+87.5	t=20.3, p<0.001	2.05
	Control	42±8.7	55±8.0	+31.0	t=7.1, p<0.001	0.62
Planning Skills	Experimental	55±7.5	90±5.4	+63.6	t=25.8, p<0.001	2.26
	Control	53±7.8	71±6.9	+34.0	t=11.4, p<0.001	1.00
Conflict Resolution Skills	Experimental	35±9.8	80±6.3	+128.6	t=26.9, p<0.001	2.37
	Control	37±9.5	47±8.7	+27.0	t=5.2, p<0.001	0.46
Digital Competencies	Experimental	50±10.2	95±4.7	+90.0	t=28.3, p<0.001	2.49
	Control	51±9.8	70±8.6	+37.3	t=9.8, p<0.001	0.87

The pre-test data confirm group equivalence before the experiment: no statistically significant differences between the experimental and control groups were found for all measured competencies ($p > 0.05$ for all comparisons between groups at the pre-test stage). At the same time, post-test results demonstrate statistically significant differences between groups for all indicators ($p < 0.001$), confirming the effectiveness of gamification.

Particularly noteworthy are the differences in effect sizes (Cohen's d): for the experimental group, all values exceed 2.0, indicating a very large effect size, while for the control group, values range from medium (0.46) to large (1.0) effect size. These differences confirm a significantly more pronounced dynamic in team competency development under gamification conditions compared to traditional learning. Analysis of variance with repeated measures (ANOVA with repeated measures) revealed a statistically significant interaction between the time factor (pre-test/post-test) and the group factor (experimental/control) for all measured competencies ($p < 0.001$), confirming the causal relationship between gamification application and team skill improvement.

Analysis of student engagement dynamics (Figure 5) showed substantial growth in activity in the experimental group from 45% to 92% by the end of the study, while in the control group this indicator increased only to 68%. The most intensive growth was observed during the period of active implementation of gamification elements (November-January), confirming the effectiveness of the chosen approach. The distribution of roles in team projects (Figure 6) demonstrated a balanced structure: technical specialists (25%), team leaders (20%), analysts (20%), testers (20%), and designers (15%). This distribution ensured effective execution of project tasks and development of various competencies among participants. Statistical analysis of the results showed significant improvements in key indicators (Table 6):

- task completion speed decreased by 33.3% (from 7.2 to 4.8 days);
- solution quality increased by 22.2% (from 72 to 88 points);
- participant satisfaction increased by 32.4%;
- number of conflicts decreased by 56.3%.

The dynamics of team competency development (Figure 6) reflected comprehensive improvement in all key skills:

- digital skills: growth from 50 to 95 points;
- communication abilities: from 45 to 85 points;
- conflict resolution skills: from 35 to 80 points;
- leadership qualities: from 40 to 75 points;
- project thinking: from 55 to 90 points.

Based on the empirical results obtained, practical recommendations were developed, each directly linked to specific identified patterns. The recommendation for gradual implementation of gamification is based on the observed dynamics of student adaptation (intensive growth in engagement by 42% in the first 3 weeks). The necessity for a clear course structure is confirmed by the correlation between understanding the achievement system and developing planning skills ($r = 0.62$, $p < 0.01$). The recommendation on balancing individual and team activities relies on regression analysis data, which showed an optimal ratio of 30/70% for maximum leadership development ($\beta = 0.45$). Methodological and technical recommendations are based on qualitative analysis of interviews and observations of practical difficulties that arose during the research process. Proposals for a multi-component assessment system are based on the empirically identified impact of diverse feedback on the development of conflict resolution skills (increase by 98.6%).

1.1 In the area of educational process organization:

- implement gamification gradually, starting with basic elements and progressively increasing system complexity;
- ensure clear course structure with an understandable system of achievements and progress;
- maintain balance between individual and team activities.

1.2 In the methodological aspect:

- develop detailed instructions for implementing gamification;
- create a bank of typical scenarios and templates for various types of team activities;

- ensure a system for monitoring and evaluating team work effectiveness.

1.3 In technical terms:

- maximize the integration capabilities of Google Workspace;
- ensure availability of all necessary tools for team work;
- regularly update technical tools according to team needs.

1.4 In the assessment area:

- implement a multi-component system for evaluating team work;
- ensure transparency of assessment criteria;
- use both quantitative and qualitative effectiveness indicators.

The obtained results and developed recommendations can be used for further improvement of methods for developing team interaction in the digital educational environment.

The research results have high practical value for various educational contexts. The identified significant improvement in team skills (communication +88.9%, leadership +87.5%, conflict resolution +128.6%) demonstrates the effectiveness of gamification as a tool for developing critically important soft skills that are in demand in the modern labor market.

The developed gamification model can be adapted for:

- School education for forming basic collaboration skills;
- Corporate training for developing employee team effectiveness;
- Online education for overcoming isolation and increasing engagement;
- Inclusive education for integrating learners with special needs.

Effective implementation of gamification requires targeted teacher preparation. It is recommended to:

- Create a modular professional development program that includes technical, pedagogical, and psychological aspects of gamification;
- Provide practice-oriented training where teachers themselves become participants in a gamified environment;
- Organize a community of practitioners for exchanging experiences and solving emerging problems;
- Develop step-by-step guides for adapting gamification to specific disciplines;
- Train teachers in methods for evaluating the effectiveness of gamified elements and adjusting them.

The results of regression analysis revealed statistically significant predictors of team competency development. The strongest influence on the development of communication skills was exerted by the intensity of participation in team discussions ($\beta = 0.48$, $p < 0.01$) and the number of mutual evaluations of other students' work ($\beta = 0.32$, $p < 0.01$). Leadership quality development was most strongly influenced by the experience of role rotation in the team ($\beta = 0.45$, $p < 0.01$) and position in the team rankings ($\beta = 0.29$, $p < 0.05$). The integrated multiple regression model explains 67% of the variability in team competency development indicators (adjusted $R^2 = 0.67$, $F(8,71) = 24.36$, $p < 0.001$).

Structural modeling revealed significant direct effects of gamification engagement on competency development (standardized path coefficient = 0.42, $p < 0.01$), as well as significant indirect effects mediated by the quality of team interaction (standardized path coefficient = 0.38, $p < 0.01$). The model confirms that gamification affects competency development both directly, through increasing motivation and engagement, and indirectly, through improving team interaction processes.

Analysis of the identified clusters showed that the greatest positive dynamics in team competency development are demonstrated by 'Active Collaborators' (average increase 89.4%, n=18) and 'Competition-Oriented' students (average increase 76.8%, n=12). 'Systematic Performers' (n=22) showed stable but more moderate progress (average increase 62.3%), while 'Periodic Participants' (n=10) demonstrated the least dynamics (average increase 38.9%).

For a clearer representation of gamification effectiveness, a comparative assessment of key team competency development dynamics in the experimental and control groups was conducted (Table 9). As shown in the presented data, students in the experimental group demonstrate significantly higher growth indicators across all evaluated competencies. The greatest difference is observed in the development of conflict resolution skills, where the growth in the experimental group exceeds the control group indicators

by 233.3%. All identified differences are statistically significant ($p<0.01$), with a large effect size ($\eta^2>0.3$), indicating not only statistical but also practical significance of the obtained results.

To ensure complete transparency of statistical results and in accordance with modern reporting requirements in scientific research, Table 13 presents effect sizes and confidence intervals for all key statistical results.

Table 13. Effect sizes and confidence intervals for main research results.

Measured Indicator	Statistical Test	Value	Effect Size	95% Confidence Interval	p-value
Difference in communication skills between groups (post-test)	t-test	t(78) = 13.5	Cohen's d = 2.75	[2.15, 3.35]	<0.001
Difference in leadership qualities between groups (post-test)	t-test	t(78) = 12.3	Cohen's d = 2.63	[2.04, 3.22]	<0.001
Difference in planning skills between groups (post-test)	t-test	t(78) = 14.7	Cohen's d = 2.98	[2.35, 3.61]	<0.001
Difference in conflict resolution skills between groups (post-test)	t-test	t(78) = 18.6	Cohen's d = 4.22	[3.47, 4.97]	<0.001
Difference in digital competencies between groups (post-test)	t-test	t(78) = 16.3	Cohen's d = 3.52	[2.84, 4.20]	<0.001
Impact of gamification on communication skills	ANOVA	F(1,78) = 68.4	$\eta^2 = 0.48$	[0.32, 0.61]	<0.001
Impact of gamification on leadership qualities	ANOVA	F(1,78) = 74.6	$\eta^2 = 0.52$	[0.37, 0.65]	<0.001
Impact of gamification on planning skills	ANOVA	F(1,78) = 59.8	$\eta^2 = 0.43$	[0.28, 0.57]	<0.001
Impact of gamification on conflict resolution skills	ANOVA	F(1,78) = 85.3	$\eta^2 = 0.57$	[0.42, 0.70]	<0.001
Impact of gamification on digital competencies	ANOVA	F(1,78) = 71.2	$\eta^2 = 0.49$	[0.34, 0.62]	<0.001
Relationship between intensity of participation in team discussions and communication skills	Regression	$\beta = 0.48$	$f^2 = 0.30$	[0.15, 0.45]	<0.01
Relationship between role rotation experience and leadership qualities	Regression	$\beta = 0.45$	$f^2 = 0.26$	[0.12, 0.40]	<0.01
Relationship between number of mutual evaluations and communication skills	Regression	$\beta = 0.32$	$f^2 = 0.12$	[0.03, 0.21]	<0.01
Direct effect of gamification engagement on competency development (path coefficient)	SEM	0.42	-	[0.28, 0.56]	<0.01
Indirect effect mediated by team interaction quality (path coefficient)	SEM	0.38	-	[0.24, 0.52]	<0.01

Note: Cohen's d: small effect (0.2-0.5), medium (0.5-0.8), large (>0.8); η^2 (eta-squared): small effect (0.01-0.06), medium (0.06-0.14), large (>0.14); f^2 (for regression): small effect (0.02), medium (0.15), large (0.35)

Analysis of effect sizes demonstrates not only statistical but also practical significance of the obtained results. All main effects are characterized as large according to generally accepted criteria for the corresponding statistical tests. Particularly impressive effect sizes are observed for conflict resolution skills ($d = 4.22$) and digital competencies ($d = 3.52$), indicating an exceptionally strong influence of gamification on these aspects of team interaction. Confidence intervals for all indicators do not include zero or borderline values, confirming the reliability of the obtained results. Wide but non-overlapping confidence intervals for effect sizes between different competencies allow concluding that gamification has a differentiated impact

on the development of various aspects of team interaction, with the greatest effect on conflict resolution skills and digital competencies.

2. *RECOMMENDATIONS*

The most important direction for further research is conducting a comprehensive longitudinal analysis of gamification's impact on the development of students' team skills. Continued monitoring of current research participants throughout their entire period of study (up to 4 years) is planned, which will allow for evaluating the long-term sustainability of the developed competencies and determining the necessity for periodic "reactivation" of gamified elements. Of particular interest is studying the influence of intensity and duration of gamification use on the sustainability of the formed skills. Within the framework of planned research, experimental groups with various gamification application regimes will be formed (continuous use, alternation with traditional methods, short-term intensive periods) to determine optimal strategies for long-term development of team competencies. Additionally, there are plans to study the transfer effect of the formed team interaction skills to other educational contexts and professional activities through organizing observations and collecting data on students' practical training and their early professional activities.

3. *COMPARATIVE ANALYSIS OF RESULTS WITH PREVIOUS RESEARCH*

For a more comprehensive understanding of the significance of the obtained results, it is necessary to conduct a comparative analysis with data from previous studies in the field of education gamification and team skills development. The results of our study generally align with the main conclusions of Bondarenko et al. [12], which also notes the positive impact of using Google Classroom on interaction between students. However, our study shows more pronounced dynamics in the development of communication skills (+88.9% versus +45% in their work), which can be explained by the purposeful implementation of gamification elements oriented towards team interaction.

Comparison with the results of Furdu et al. [13] shows similar trends in increasing student motivation and engagement when using gamification. However, our study demonstrates a more pronounced decrease in the number of conflicts (-56.3% versus approximately -30% in their work), which indicates the effectiveness of our developed model in relation to conflict resolution skills development. Interestingly, our data on leadership quality development (+87.5%) significantly exceeds the results described in Shirokolobova's work [15], where this indicator is around +40%. This fact may be related to our developed system of role rotation in teams and the implementation of mentoring elements, which were not used in the indicated study.

At the same time, our results partially diverge from the conclusions of Toda et al. [14] regarding the speed of student adaptation to the gamified environment. While their study notes a rather lengthy adaptation period (up to 4-5 weeks), in our case, active growth in indicators began already 2-3 weeks after the start of the experiment. This can be explained by more thorough preparation of students for work in the gamified Google Classroom environment and the more intuitive interface of the platform used.

Comparison with the study by Myrzabekova et al. [16] shows similar dynamics in the development of digital skills (+90% in our study versus +85% in theirs), which confirms the effectiveness of gamification for developing technical competencies regardless of the specific model implementation. Of particular interest is the comparison with the results of Ermakov's study [17], which also examined the impact of gamification on teamwork. Our study demonstrates more comprehensive and uniform development of all team interaction components, while Ermakov's work showed more pronounced progress in communication with less significant changes in planning and leadership areas.

It is important to note that most previous studies [12-17] did not use such a comprehensive approach to assessing the development of team competencies as in our work, and did not provide a detailed analysis of the development dynamics of individual team interaction components. This confirms the scientific novelty of our developed model and methodology for evaluating its effectiveness. Analysis of results in the context of previous studies also revealed some differences in the long-term effects of gamification. While Shirokolobova's study [15] notes some decrease in student motivation towards the end of the experiment, our data demonstrate

steady growth in all indicators until the very end of the study, which may indicate a more effective balance between competitive and cooperative gamification elements in our model.

Thus, comparative analysis shows that the obtained results largely align with data from previous studies, confirming the general effectiveness of gamification for developing team interaction. At the same time, our study demonstrates several advantages of the developed model, manifested in more pronounced positive dynamics in the development of team competencies, especially in the areas of leadership, communication, and conflict resolution.

4. CRITICAL REFLECTION ON RESULTS AND ALTERNATIVE EXPLANATIONS

Despite the statistically significant results confirming the effectiveness of gamification in Google Classroom for developing team interaction skills, it is necessary to consider alternative explanations for the obtained data. First, the possible influence of the novelty effect should be considered. Students in the experimental group may have demonstrated higher engagement and, consequently, better results not so much due to gamification itself, but because of interest in the new learning format. This effect typically diminishes over time, which could lead to a reduction in the difference between groups in a more prolonged study. To test this hypothesis, it would be appropriate to conduct a longitudinal study evaluating the sustainability of the obtained results over several semesters. Second, the Hawthorne effect cannot be excluded, where experiment participants change their behavior due to awareness of their participation in a study. Students in the experimental group may have shown greater activity and engagement precisely because they were aware of being part of an experiment. In future research, more concealed observation methods or a double-blind method should be used to minimize this effect. Third, a significant factor potentially influencing the results is the teacher's personality. Despite attempts to standardize teaching methodology, the educator's enthusiasm when implementing the new methodology could have had a significant impact on student motivation. To control this factor in future research, it would be advisable to involve several teachers working with both experimental and control groups. The fourth point relates to sample characteristics. As already noted in the research limitations, technical field students may have initially had higher motivation to use digital tools. It is possible that the observed effects would not be as pronounced for students in other specialties. This indicates the need for similar studies with interdisciplinary samples. The fifth aspect concerns the measurement instruments themselves. Despite careful verification of psychometric characteristics, there is a possibility that some instruments assess not so much the actual development of competencies as students' self-assessment or their perceptions of their own skills. This problem is characteristic of most research relying on survey methods. To increase assessment objectivity in future research, it is recommended to combine self-assessment with expert evaluation and objective indicators of teamwork effectiveness.

It is also important to note the possible influence of the social desirability effect on the obtained results. Students, knowing the research objectives, may have provided answers they believed the researcher expected. To minimize this effect in further research, it is recommended to use social desirability scales and more carefully mask the research objectives. There is also an alternative explanation for the observed dynamics of team competency development. It is possible that not so much gamification itself, but rather the intensification of communication between students provoked by game mechanics led to improved interaction skills. In this case, similar results could be achieved by other methods that stimulate active interaction between students. Testing this hypothesis requires additional research including a third group where intensive communication without gamification elements would be applied.

Finally, the possibility should be considered that the observed effects are associated not so much with gamification as a comprehensive approach, but with its individual elements. For example, the feedback system or public recognition of achievements could have had a more significant impact than the game mechanics themselves. Identifying the most effective elements of gamification requires conducting a factorial experiment with controlled variation of different model components. Overall, despite the indicated alternative explanations, the totality of the obtained data, including qualitative and quantitative indicators, as well as the consistency of results with previous research in this field, testifies to the effectiveness of the developed gamification model for developing team interaction skills. Nevertheless, considering the outlined alternative

explanations is necessary for further improvement of research methodology and increasing the reliability of the obtained results.

5. Model Scalability and Adaptability

The developed gamification model has high potential for scalability and adaptability to various educational conditions. The modular structure of the model allows for selective implementation of individual elements depending on available resources and educational context specifics. Analysis of the model components showed varying degrees of scalability: the achievement and reward system is most easily scalable for large groups (effectiveness is maintained when increasing the group from 40 to 200+ students), while individualized feedback requires additional resources when scaling.

Based on the research results, four levels of model adaptation were identified:

- For different disciplines – adaptation of assignment content and achievement themes is required while maintaining the basic structure;
- For different educational levels – adjustment of complexity and assignment types is necessary (from simple role rotation in school to complex project simulations in master's programs);
- For different technological platforms – transfer of key mechanics to other LMS is possible, considering their functional features;
- For different cultural contexts – adaptation of the competitive-cooperative balance in accordance with cultural norms is required.

Field testing of model elements in various contexts (teacher professional development courses, corporate training) confirmed its flexibility and adaptability. Key factors for successful scaling are preliminary teacher training, gradual implementation of components, and regular monitoring of effectiveness with appropriate process adjustment.

VII. CONCLUSION

The conducted research on implementing gamification elements in Google Classroom as a tool for developing team interaction demonstrates substantiated conclusions about its effectiveness. The choice of Google Classroom as the primary platform for implementing the gamified approach is justified by three key advantages. First, the platform is provided to educational institutions free of charge, making it accessible to a wide range of users without requiring additional financial investment for implementation. Second, Google Classroom's intuitive interface significantly reduces the time needed for platform mastery by both teachers and students, allowing them to focus directly on the educational process. Third, the availability of mobile applications for Android and iOS operating systems ensures constant access to educational resources and enables prompt interaction between educational process participants regardless of their location.

The experimental study conducted during the 2020-2021 academic year with 80 students convincingly demonstrated the effectiveness of the developed model. Quantitative indicators show significant progress in the development of team competencies in the experimental group. It is particularly important to note the growth in digital skills by 90%, communication abilities by 88.9%, and conflict resolution skills by 128.6%. The developed gamification model in Google Classroom has shown its effectiveness in several key areas: increased student engagement in the educational process; development of team interaction skills; formation of digital competences; improvement of communication skills; and reduction in conflict situations.

The practical significance of the research is confirmed by the possibility of using the developed methodological recommendations in various educational contexts. The created tools for assessment and monitoring of team work can be adapted for other disciplines and levels of education. The theoretical significance of the research lies in developing conceptual foundations for gamifying the educational process in a digital environment. During the research, a model for evaluating the effectiveness of team interaction in a gamified educational environment was developed and justified, including a system of criteria and indicators. Patterns in the development of team competencies when using gamification elements were identified, particularly establishing the relationship between the type of game mechanics and the dynamics of specific skill development. Principles for integrating game mechanics into educational platforms were

justified, contributing to the development of digital didactics theory. The developed theoretical base creates a foundation for further research in educational gamification and can be used in designing educational programs with team interaction elements.

This research makes a significant contribution to both the theoretical understanding of educational gamification processes and the practice of developing team skills in a digital environment. Theoretically, we have developed and empirically validated an integrative model of educational gamification that extends existing concepts by combining elements of motivational, communicative, and competence theories into a unified system. The study fills an important gap in understanding the mechanisms of how a gamified environment influences the formation of team competencies, offering a scientifically grounded system of relationships between specific game elements and the skills being developed.

The prospects for further research are connected with adapting the model for various subject areas and developing additional tools for effectiveness assessment, as well as studying the long-term impact of gamification on professional competency development and exploring possibilities for integrating new digital tools into the educational process. The prospects for further research are connected with adapting the model for various subject areas and developing additional tools for effectiveness assessment, as well as studying the long-term impact of gamification on professional competency development and exploring possibilities for integrating new digital tools into the educational process. The prospects for further research are connected with adapting the model for various subject areas and developing additional tools for effectiveness assessment, as well as studying the long-term impact of gamification on professional competency development and exploring possibilities for integrating new digital tools into the educational process.

The practical value of this work lies in creating a reproducible gamification model that can be adapted for various academic disciplines - from technical and natural sciences to humanities and creative fields. The application of the developed approach appears particularly promising in areas such as project activities, where team interaction is an integral component of the educational process; information technologies, where Agile and Scrum methodologies presuppose a high level of team coordination; social sciences, where developing skills in collective research and analysis is important; and creative disciplines, where collaboration is key to creating innovative products.

The developed gamification model demonstrates broad possibilities for adaptation and application in various educational contexts. In higher education, the model can be adapted for different fields of study considering their specifics, both for technical and humanitarian specialties. Google Classroom's capabilities allow effective implementation of the proposed model at different educational levels from bachelor's to master's programs, adapting the complexity of tasks and gamification mechanics for specific audiences. Of particular value is the possibility of applying the developed model in blended and distance learning conditions, which is especially relevant in modern conditions of digital transformation in education. The model's flexibility allows its integration into both traditional educational processes and fully distance learning formats.

Elements of the developed model can be successfully used in corporate training for developing employee team interaction skills. The gamification tools can be adapted to specific organizational tasks and corporate culture specifics. The universality of the Google Classroom platform and the proposed gamification mechanics ensures their integration possibility into existing corporate training systems. Thus, the research results confirm that gamification in Google Classroom is an effective tool for developing students' team interaction skills and contributes to improving the quality of the educational process in the context of digital transformation in education. These studies demonstrate that the integration of gamification elements into educational platforms such as Google Classroom can significantly contribute to the development of students' team interaction skills. The use of game mechanics and collaborative assignments creates a dynamic and motivating learning environment that promotes effective learning and strengthens team bonds.

While acknowledging the technological specificity of Google Classroom, we recognize the need for critical analysis of the transferability of the developed model to other educational platforms. The unique characteristics of Google Classroom, such as integration with Google Workspace services, intuitive interface, and multi-platform functionality, undoubtedly contributed to the successful implementation of gamification

elements. Nevertheless, the core principles of the developed model—achievement system, team rankings, multi-component assessment, role rotation, and carefully designed feedback—can be adapted for other LMS, provided their technical features are taken into account. It is important to understand that the effectiveness of the model when transferred to other platforms may vary depending on their functional capabilities for organizing teamwork and implementing game mechanics. This circumstance emphasizes the need for further research to identify universal gamification mechanisms that function independently of the technological characteristics of specific educational platforms. The key direction of further research will be testing the developed model in various educational contexts, including different types of higher education institutions and disciplinary fields. A large-scale study is planned with the participation of students from humanitarian, natural science, and creative specialties from several universities to identify potential differences in gamification effectiveness depending on the specifics of disciplines and cultural-educational context. This will allow not only for increasing the reliability and validity of the obtained results but also for adapting the developed model to a wider spectrum of educational tasks.

As part of the planned large-scale inter-university research, we intend to significantly expand the context of application for the developed model. The research will include universities such as Osh State Pedagogical University, Kyrgyz National University, and Kazakh National Technical University. This approach will allow for a comparative analysis of gamification effectiveness across various educational contexts. An equally important aspect of the research expansion will be the inclusion of different disciplinary fields. Beyond technical specialties, the study will include students from humanities (history, philosophy), natural sciences (biology, chemistry), and socio-economic disciplines (economics, sociology). For each disciplinary field, adapted versions of gamification will be developed, taking into account subject area specifics, professional competency characteristics, and the nature of team interaction in the corresponding sphere. This comprehensive approach to expanding the research will not only enhance the generalizability of results but also identify discipline-specific features of gamification application for developing team interaction skills. This, in turn, will create a foundation for developing adaptive gamification models optimized for specific educational contexts and significantly increase the practical significance of the research.

This research opens broad prospects for further scientific inquiry in the field of educational gamification and its impact on team learning. Particularly relevant directions include: studying culturally specific aspects of gamification perception and effectiveness; investigating the interaction of gamification with other innovative pedagogical approaches, such as project-based learning and flipped classroom; developing personalized gamification models that adapt to individual learner characteristics; and exploring the neurocognitive mechanisms through which gamification influences team interaction processes and social learning.

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Author Contributions

All authors made an equal contribution to the development and planning of the study.

Conflicts of Interest

The authors have no potential conflicts of interest, or such divergences linked with this research study.

Data Availability Statement

Data are available from the authors upon request.

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