

INTERACTIVE-GAMIFIED MECHANISMS FOR DEVELOPING CREATIVE COMPETENCE OF TECHNOLOGY TEACHERS IN INDEPENDENT LEARNING**Muhammadiyev Elyor Tolqinovich,
Turayev Khumoyiddin Abdigafforovich**Assistant, Termez State University
of Engineering and Agrotechnology, Termez, Uzbekistan
PhD, Termez State University, Termez, Uzbekistan
e-mail: e.muhammadiyev.1992@gmail.com

Abstract: this article examines interactive-gamified mechanisms for developing the creative competence of pre-service technology teachers in the process of independent learning. The study is based on systemic, activity-oriented, and MDA-based methodological approaches, through which the cognitive, motivational, practical, and reflective components of creative competence are clarified. The proposed pedagogical model transforms independent learning tasks into creative quests by using Order, Classification, Crossword, and Multiple Choice Question modules. The article argues that gamification increases students' motivation, strengthens project-based thinking, and supports the formation of a creative portfolio. The findings may be used in improving independent learning assignments in technology education and related pedagogical programs.

Keywords: creative competence, gamification, independent learning, MDA model, technology education, creative portfolio.

Introduction

The modernization of higher education requires the training of specialists who are able not only to reproduce ready-made knowledge but also to search for new solutions, design practical products, and act independently in non-standard pedagogical situations. This requirement is especially important in the preparation of future technology teachers. Technology education is directly connected with design, construction, modelling, invention, and the practical transformation of ideas into material or digital products. Therefore, creative competence should be regarded not as an additional personal quality, but as one of the central indicators of professional readiness.

Creative competence includes the ability to generate original ideas, analyze a problem from different perspectives, choose appropriate technological solutions, and critically evaluate the result of one's own activity. In classical psychological research, J. Guilford explained creativity through divergent thinking and the ability to produce several solutions to one problem [1]. This idea is important for technology education because students are often required to find not one fixed answer, but different ways of designing, producing, improving, or presenting a product.

The development of creative thinking is also connected with the diagnostic and educational approach proposed by E.P. Torrance. Torrance emphasized fluency, flexibility, originality, and elaboration as important characteristics of creative thinking [2]. These qualities are relevant to the professional training of technology teachers. When students design a technological product, they must propose several variants, select a reasonable solution, justify the structure of the product, and improve it through reflection. For this reason, independent learning tasks in technology education should encourage students to think flexibly rather than repeat ready-made theoretical information.

In many higher education institutions, independent learning is still organized mainly through reproductive assignments. Students prepare abstracts, answer theoretical questions, or copy information from available sources. Such tasks may help them become familiar with a topic, but they do not always lead to creative activity. As a result, independent learning may remain formal,

monotonous, and weakly connected with professional practice. This situation shows the need to renew the structure, content, and motivational mechanisms of independent learning.

One of the effective ways to address this problem is the use of gamification. Gamification means the application of game elements in non-game educational contexts. S.Deterding and his co-authors define gamification as the use of game design elements to increase engagement and meaningful participation in activities that are not games by nature [3]. In education, this approach can help transform ordinary independent assignments into motivating and active learning tasks. However, gamification should not be understood only as the addition of points, badges, or competition. Its real value depends on whether game elements serve the educational purpose and support the development of specific competencies.

Research by J.Hamari, J.Koivisto, and H.Sarsa shows that gamification can improve motivation and participation, although its effectiveness depends on the design of the learning environment and the characteristics of learners [4]. This conclusion is important because mechanical use of game elements may create only short-term interest. In technology education, gamification should be connected with project-based tasks, practical problem solving, design thinking, and reflective evaluation. Only in this case can it support the development of creative competence rather than become a superficial motivational tool.

K.M.Kapp also notes that gamification in learning should be based on meaningful goals, feedback, challenge, and learner activity [5]. These principles are particularly suitable for independent learning. When students receive a clear mission, understand the criteria of success, collect points for meaningful actions, and receive feedback on their progress, they become more actively involved in the learning process. In this way, gamification changes the student's role from a passive performer of assignments into an active participant in educational design.

The methodological organization of gamified learning can be explained through the MDA model. The MDA framework, proposed by R.Hunicke, M.LeBlanc, and R.Zubek, includes three interrelated components: Mechanics, Dynamics, and Aesthetics [6]. In an educational context, mechanics may include points, levels, badges, quests, and tasks; dynamics may include interaction, competition, cooperation, progress, and decision-making; aesthetics may include emotional satisfaction, curiosity, engagement, and the feeling of achievement. This model is useful because it allows the teacher to design gamification not randomly, but as a structured pedagogical system.

K.Werbach and D.Hunter further developed the practical application of game thinking and showed that gamification becomes effective when the designer clearly defines the purpose, expected behavior, feedback mechanisms, and progression system [7]. In independent learning, this means that every gamified element must be connected with a learning outcome. For example, a badge should not be awarded only for completing a task. It should indicate a specific competence, such as "original design solution", "accurate technological sequence", or "successful reflective analysis". Thus, gamification can also serve as a tool for competence-based assessment.

The systemic approach provides a broader theoretical foundation for the proposed model. According to L. von Bertalanffy's general system theory, any pedagogical process should be viewed as a whole consisting of interconnected components [8]. From this standpoint, independent learning in technology education should include a clear goal, meaningful content, appropriate methods, motivating mechanisms, assessment tools, and expected outcomes. If one of these components is weak, the entire process loses effectiveness. Therefore, the development of creative competence requires not separate tasks, but a complete pedagogical system.

The activity-oriented approach also plays an important role in this research. A.N.Leontyev emphasized that knowledge is formed through activity and that the learner's consciousness develops in the process of purposeful action [9]. This idea is directly applicable to technology education. A future technology teacher cannot develop creative competence only by reading

theoretical material. He or she must design, classify, model, compare, construct, make decisions, and evaluate results. For this reason, independent learning should be built around practical and project-based activity.

The aim of this article is to develop and theoretically justify interactive-gamified mechanisms for developing the creative competence of pre-service technology teachers in independent learning.

Materials and Methods

This study was organized as a theoretical and methodological research. The methodological basis of the study consisted of systemic, activity-oriented, competence-based, and gamified learning approaches. The study did not aim to conduct a large-scale empirical experiment. Its main task was to clarify the structure of creative competence and to develop a pedagogical model that can be applied in independent learning for future technology teachers.

The research was carried out in several stages. At the first stage, scientific sources related to creativity, creative competence, gamification, the MDA model, systemic approach, and activity theory were analyzed. At the second stage, the structure of creative competence in the training of future technology teachers was clarified. At the third stage, an interactive-gamified pedagogical model for independent learning was developed. At the fourth stage, practical mechanisms were designed through Order, Classification, Crossword, and Multiple Choice Question modules.

In this study, creative competence was interpreted as an integrated professional quality consisting of four interrelated components. The cognitive component refers to knowledge, analytical thinking, and understanding of technological processes. The motivational component reflects the student's internal interest, persistence, and readiness to search for original solutions. The practical component includes the skills of designing, modelling, producing, and presenting creative products. The reflective component involves the ability to analyze one's own learning activity, identify mistakes, and improve the final result.

The MDA framework was used as the main structure for designing gamified learning mechanisms. The "Mechanics" component included points, levels, badges, leaderboards, quests, and modular assignments. The "Dynamics" component included learner activity, interaction, progress, competition, cooperation, and feedback. The "Aesthetics" component included interest, emotional involvement, satisfaction, and the feeling of creative achievement.

The proposed model was designed for independent learning in technology education. It can be applied to topics related to folk crafts, materials science, design, technological modelling, product development, digital modelling, and household technologies. The model is flexible and may be used in both traditional classroom learning and digital independent learning platforms.

Results

As a result of the theoretical and methodological analysis, an interactive-gamified pedagogical model for developing the creative competence of pre-service technology teachers was developed. The model consists of four structural blocks: target, content, technological, and result blocks.

The target block defines the main aim of the model. Its central purpose is to develop creative competence in independent learning. At this stage, the teacher determines the expected indicators of learning: originality of ideas, logical organization of technological operations, quality of the product, level of independence, and depth of reflection. This block gives direction to the whole pedagogical process and helps connect independent learning tasks with professional competence formation.

The content block transforms ordinary independent learning assignments into creative quests. Instead of asking students only to prepare written answers, the teacher gives them problem-based and project-oriented tasks. For example, a topic related to folk crafts may be organized as a design

mission in which students analyze traditional materials, create a modern product idea, prepare a technological sequence, and justify the aesthetic and functional value of the product. Such tasks are more suitable for technology education because they connect theory with practical creation.

The technological block includes the main gamification tools used in the model. These tools may include points, levels, leaderboards, badges, progress maps, and modular tasks. However, the central part of this block is formed by four interactive modules: Order, Classification, Crossword, and Multiple Choice Questions.

The Order module helps students arrange technological operations in a correct sequence. This module develops algorithmic thinking and teaches students to understand the logic of production or design processes. In technology education, an incorrect sequence of operations can lead to poor product quality. Therefore, the ability to organize actions in the right order is one of the important signs of creative and practical competence.

The Classification module develops analytical thinking. Through this module, students classify materials, tools, processing methods, design solutions, or product types according to certain criteria. This process helps them compare, group, and justify their decisions. It also supports the formation of systematic thinking in technological activity.

The Crossword module strengthens terminology and conceptual knowledge. Students repeat key terms in an interactive form and consolidate their understanding of design, technology, materials, and production processes. This module is especially useful when theoretical concepts need to be connected with practical tasks.

The Multiple Choice Question module supports knowledge control and decision-making. Students compare possible solutions and choose the most appropriate answer according to technological, aesthetic, or functional criteria. This module also helps evaluate whether students understand not only facts, but also the logic behind a design or technological decision.

The result block focuses on the evaluation of learning outcomes. In this model, results are assessed not only through the number of points collected by the student, but also through the quality of the creative product and the depth of reflection. Therefore, three types of indicators are used: quantitative, qualitative, and reflective. Quantitative indicators include points, completed levels, and module results. Qualitative indicators include originality, functionality, technological correctness, and the quality of the final product. Reflective indicators include self-assessment, explanation of the chosen solution, and analysis of mistakes. On this basis, each student forms an individual creative portfolio.

The practical implementation of the model may be organized in four stages. The first stage is project orientation. At this stage, the teacher presents the independent learning task as a mission rather than a simple assignment. Students are informed about the goal, expected product, criteria, points, and levels. This stage is important because it creates a clear learning direction and activates students' interest.

The second stage is technological modelling. Students begin to analyze the task, choose materials, identify technological operations, and plan the sequence of actions. The Order module is especially useful at this stage because it teaches students to think algorithmically and systematically.

The third stage is the integration of interactive-gamified components. Students use the Classification module to group materials, tools, processing methods, or design features. They complete Crossword tasks to reinforce key terms and concepts. They answer Multiple Choice Questions to compare possible design solutions and evaluate functional or aesthetic decisions. At this stage, gamification increases engagement, but each task remains connected with professional learning outcomes.

The fourth stage is reflection and result verification. Students present their products, explain the logic of their decisions, compare the achieved result with the initial plan, and identify what could be improved. Reflection is necessary because creative competence cannot be fully developed without self-analysis. A student may create a product, but if he or she cannot explain why this solution was chosen and how it may be improved, the learning process remains incomplete.

For example, in the topic “Folk Crafts and Innovation”, students may receive a modular quest. First, they arrange the technological stages of producing a decorative or functional object through the Order module. Second, they classify raw materials such as wood, metal, textile, or polymer according to their properties and possible use. Third, they solve a crossword based on design, ornamentation, and technological terminology. Fourth, they create a simple 3D model or design sketch and justify its function through Multiple Choice Questions and reflective explanation. This structure allows students to move from knowledge acquisition to practical creative activity.

Discussion

The proposed model shows that interactive-gamified mechanisms can renew the organization of independent learning in technology education. The main advantage of the model is that it connects motivation with meaningful activity. Students do not simply collect points; they perform technological operations, classify materials, solve conceptual tasks, design products, and reflect on their results. In this process, gamification serves as a didactic mechanism that supports attention, interest, discipline, and progress.

The model corresponds to Guilford’s concept of divergent thinking because it encourages students to search for different solutions and not limit themselves to one fixed answer [1]. It also corresponds to Torrance’s understanding of creativity, especially in relation to fluency, flexibility, originality, and elaboration [2]. In technology education, these qualities are expressed through product design, material selection, technological planning, and improvement of the final result.

The MDA model also supports the structure of the proposed approach. Mechanics such as points, levels, badges, and modules create the external structure of learning. Dynamics such as interaction, progress, decision-making, and competition keep students active during independent learning [6]. Aesthetics such as satisfaction, curiosity, and the feeling of achievement increase emotional involvement [7]. Therefore, the MDA framework is useful not only for designing games, but also for organizing educational activity.

The proposed model also corresponds to recent studies on gamification in technical universities. R.Karshiev and U.Khaitov emphasized that gamification in digital education may increase students’ involvement in technical and project-based tasks when it is connected with meaningful learning activities [10]. This supports the idea that gamified mechanisms should not be isolated from the subject content. In the preparation of future technology teachers, the game element should serve the technological task, not replace it.

The development of creative competence is also related to the broader problem of visual and compositional thinking. D.B.Karshiboeva’s research on the role of composition in activating creative abilities shows that students’ creativity becomes more active when they consciously work with visual structure, proportion, balance, and expressive form [11]. In technology education, such skills are needed in product design, decorative applied work, modelling, and presentation of project results. Therefore, interactive-gamified independent learning should also include visual and compositional tasks.

The role of digital tools is another important aspect. Studies devoted to AutoCAD and three-dimensional design show that modern technology education increasingly depends on students’ ability to understand modelling commands, visual styles, spatial construction, and digital representation [12]. For this reason, gamified independent learning can be connected with digital

modelling tasks. Students may receive points not only for theoretical answers, but also for creating a correct model, improving its structure, or presenting an original design solution.

Research on forming professional and creative competencies through AutoCAD-based instruction indicates that digital learning tools become effective when they are combined with a clear methodological system [13]. This idea supports the proposed model because the model does not use gamification as a separate entertainment element. It integrates gamification with independent learning, project-based activity, technological modelling, and reflective assessment. Such integration can help students develop both technical and creative skills.

Innovative methods in engineering and computer graphics teaching also demonstrate that active, digital, and problem-based approaches improve students' readiness for professional activity [14]. Although the present article focuses on future technology teachers, many methodological conclusions are similar. In both cases, learners must understand visual information, perform practical tasks, and solve problems independently. Therefore, the mechanisms of gamification may be adapted not only for technology education, but also for engineering graphics, computer graphics, design, and related disciplines.

The relevance of technical visualization is also confirmed by research on smart museum technologies and their role in promoting technical understanding of industrial history [15]. Such studies show that digital and interactive environments can make technical knowledge more understandable and engaging. This is close to the purpose of gamified independent learning: to make technological content not only informative but also active, visual, and personally meaningful for the learner.

The importance of teaching engineering and computer graphics in higher education has been emphasized in relation to the formation of spatial thinking, technical imagination, and professional communication skills [16]. These qualities are also significant for future technology teachers. A teacher who teaches technology must be able to explain processes visually, organize practical tasks, and guide students toward independent creative solutions. Therefore, the development of creative competence in teacher education has direct practical significance.

At the same time, technology education should not be separated from cultural and educational values. N.P. Jumaboyev's work on educating young people in an Eastern and modern spirit while taking historical values into account shows that educational content becomes richer when national traditions and modern approaches are combined [17]. This idea is useful for the proposed model, especially in tasks related to folk crafts, ornamentation, design culture, and technological creativity. Students can be encouraged to create modern products based on traditional artistic and technological heritage.

Modern pedagogical requirements also demand that visual arts and related practical lessons be organized in a way that increases effectiveness, activity, and learner engagement [18]. This approach is consistent with the purpose of interactive-gamified independent learning. If tasks are designed as meaningful creative missions, students become more active, responsible, and interested in the final result. In this way, independent learning becomes not a formal requirement, but a real environment for professional and creative development.

Another advantage of the model is its flexibility. The Order, Classification, Crossword, and Multiple Choice Question modules can be adapted to different topics in technology education. For example, they may be used in topics related to materials science, folk crafts, technical modelling, design, household technologies, robotics, or digital manufacturing. This makes the model suitable for both traditional classroom learning and digital independent learning platforms.

However, the model also requires careful methodological preparation. If the teacher designs tasks superficially, gamification may turn into a simple point-collecting activity. To avoid this,

each module should have a clear learning purpose. The Order module should develop technological sequence thinking; the Classification module should develop analytical grouping; the Crossword module should strengthen terminology; and the Multiple Choice Question module should support decision-making and assessment. Only then can gamification contribute to creative competence.

The main limitation of this study is that it presents a theoretical and methodological model rather than the results of a completed pedagogical experiment. Therefore, the next stage of research should be experimental testing of the proposed model in real educational conditions. Future studies should compare experimental and control groups, measure changes in creative competence, and analyze students' motivation, product quality, and reflective development.

Conclusion

The use of interactive-gamified mechanisms in independent learning is an effective methodological direction for developing the creative competence of future technology teachers. The proposed model transforms independent learning from a reproductive and formal activity into a creative, project-based, and reflective process.

The integration of the MDA framework, systemic approach, activity-oriented learning, and modular gamification tools creates favorable conditions for developing students' cognitive, motivational, practical, and reflective competencies. The Order, Classification, Crossword, and Multiple Choice Question modules help students organize technological operations, classify materials and tools, strengthen terminology, make decisions, and reflect on their own results.

The proposed approach can be used in technology education, engineering graphics, computer graphics, design, and other visually and practically oriented disciplines. Its effectiveness depends on the meaningful connection between game elements and professional learning outcomes.

Future research should focus on experimental testing of the model, comparative analysis of student outcomes, and the development of digital platforms that support gamified independent learning in technology education.

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