

## Chapter 7. PREPARING TEACHERS FOR TEAMWORK IN A DIGITAL EDUCATIONAL ENVIRONMENT

| Artem Yurchenko, Olena Semenikhina

**Abstract.** *This chapter provides a theoretical rationale and a practical examination of the development of teachers' teamwork skills in a digital educational environment. The relevance of the topic stems from the fact that the digital transformation of education is changing not only the tools of teachers' professional activity, but also the very logic of their interaction with colleagues, administrators, professional communities, and learners. Under these conditions, teamwork is no longer merely an additional organizational ability; it becomes an important component of contemporary educational leadership. The aim of the study is to clarify the essence of teacher teamwork in a digital educational environment, identify its structure, assessment criteria, and indicators, develop a methodology to foster teachers' teamwork skills in this environment, and analyze the results of its pilot implementation. The study employed theoretical analysis of scholarly sources, modeling, generalization, structural-functional analysis, and elements of a pilot formative experiment using self-assessment, structured observation, analysis of digital artifacts, and comparison of results from two assessment points. The author's understanding of teachers' teamwork skills in a digital environment is refined as an integrated set of professional actions that ensure effective interaction through communication, coordination, role distribution, collaborative product creation, facilitation of group processes, and reflective adjustment of activity. Three interrelated components of teacher teamwork in a digital educational environment are identified: communicative-facilitative, cooperative-productive, and organizational-projective. An assessment framework is substantiated, including criteria, indicators, levels of development, and diagnostic tools. A methodology for developing these skills was designed and implemented through a series of three weekly online training sessions using Zoom, messengers, shared documents, and Miro-like digital boards. The pilot experiment involved 26 future master's students in secondary education at A. S. Makarenko Sumy State Pedagogical University. The results showed positive dynamics across all components, with the most noticeable growth in the organizational-projective dimension of teacher teamwork. It was concluded that the development of teachers' teamwork skills in a digital educational*

*environment requires targeted methodological support, professionally relevant collaborative tasks, a functionally structured digital environment, reflective guidance, and institutional recognition of teamwork as a significant component of pedagogical activity.*

**Keywords:** *digital educational environment; teamwork; teacher; digital competence; educational leadership; facilitation; collaborative content creation; digital boards; teacher professional development; pilot experiment; teacher education.*

## Introduction

Social uncertainty, the accelerated digital transformation of education, and changes in the nature of professional interaction within educational institutions have significantly increased the importance of teacher teamwork. Whereas digital technologies were previously viewed mainly as tools for supporting individual teaching activity, it is now increasingly clear that they are reshaping the very logic of professional collaboration, including modes of communication, collective planning, role distribution, the creation of shared educational resources, coordination of actions, and reflective analysis of outcomes. Researchers consistently emphasize that teacher education systems long remained insufficiently prepared to support the full development of digital practice skills, especially when the issue extends beyond teaching with technology to more complex forms of digitally mediated professional interaction (Hodges et al., 2026). In this sense, the development of teacher teamwork in a digital educational environment should be understood not as a narrow methodological issue, but as part of the broader question of teachers' professional readiness to work under conditions of instability, flexible instructional formats, and the growing role of distributed educational leadership. In addition, recent studies of digital educational environments show that their effectiveness depends not only on the availability of individual platforms or services, but also on the alignment of organizational decisions, digital infrastructure, software, and models of professional interaction among participants in the educational process. For this reason, the digital environment is increasingly interpreted as an integrated pedagogical and managerial system that affects the quality of future professionals' training (Hrechanyk et al., 2024; Majdi et al., 2024).

The relevance of the problem is further reinforced by the fact that teachers' digital competence is increasingly understood as a multidimensional construct that includes not only information and technology-related actions, but also communication, collaboration, digital content creation, organization of the educational process, professional development, and support for learners' development (Tzafilkou et al., 2023; Alom & Ramalingappa, 2025). At the same time, teacher readiness to use digital tools in a STEAM-oriented educational environment is directly associated with digital literacy, methodological preparation, innovativeness, adaptability, and communication skills, as well as with the need to foster creativity, critical thinking, and teamwork skills in learners (Soroko & Shymon, 2025). Thus, teamwork in a digital educational environment is no longer a peripheral element of teachers' professional activity and is increasingly becoming one of its core contemporary characteristics. At the same time, the scholarly literature stresses that digital competencies should not be considered in isolation from the goals of accessibility and pedagogical adaptation, but rather in connection with the inclusive organization of the educational environment, continuity of participation, and the quality of interaction among all its participants. This approach broadens the understanding of teachers' digital competence and provides grounds for linking it not only to technical proficiency, but also to the ability to sustain productive and open collaboration in a diverse educational environment (Holovnia et al., 2024).

Recent scholarly publications convincingly show that effective professional development for educators in the digital sphere cannot be achieved through one-time instructional sessions or merely technical familiarization with digital services. The most effective programs combine hands-on learning, collaborative formats, mentoring, and institutional support (Amemasor et al., 2025). Similar conclusions are presented in research on preparing instructors to use active learning methods and digital integration, which emphasizes the importance of workshops, joint activities, and a step-by-step approach to entering a digitally enriched educational environment (Abildinova et al., 2024). These findings are directly relevant to our topic because they show that teamwork skills in a digital environment do not emerge simply from the presence of technology. Rather,

they develop through deliberately organized experience in shared professional activity. A similar conclusion is supported by studies on digital educational practices in the humanities, which show that learning effectiveness is associated with the use of small virtual groups, shared discussions, mind maps, simulations, and other interactive formats that stimulate interaction and joint decision-making. This once again underscores that a digital environment becomes productive only when its tools are embedded in a pedagogically grounded logic of collaborative activity (Balova-Tzvetkova & Panayotova, 2023).

The problem also has a distinct Ukrainian dimension. Ukrainian studies emphasize the need to develop teachers' information and digital culture, particularly through computer visualization tools that not only support content presentation but also expand the possibilities for pedagogical interaction and the organization of digital educational space (Yurchenko et al., 2024b; Yurchenko et al., 2025b). A comparative analysis of Ukrainian and European practices in organizing digital educational environments likewise shows that productive models of digitalization are associated not so much with the mere availability of separate services as with an integrated logic of organizing the educational process, coordinating participants' activity, and aligning digital tools with pedagogical tasks (Bohoslavskyi et al., 2025). This means that the development of teacher teamwork in a digital environment should be viewed both as a matter of professional culture and as a matter of the very architecture of the educational environment. In this connection, it is also important to consider studies that describe the digital educational environment as a space for shaping professionally significant qualities in future specialists, particularly their ability to communicate, collaborate, and engage in shared activities. Thus, the architecture of the digital environment affects not only the organization of the educational process but also the very character of participants' professional development (Hrechanyk et al., 2024; Shuppe et al., 2024).

Particular attention should be paid to the connection between digital teamwork and the development of soft skills. A study on the impact of team competitions on the development of young people's soft skills found that team interaction has a

positive effect on communication, collaboration, responsibility, and the ability to act under conditions of shared task (Yurchenko et al., 2024a; Yurchenko et al., 2025a). Although the focus of that study differs from ours, its findings are important because they confirm the developmental potential of deliberately organized team activity. Combined with evidence on the role of communicative tasks in the development of learners' emotional intelligence (Semenog et al., 2024), this suggests that teachers' digital teamwork has not only instrumental but also personal and professional significance: it is associated with the development of a culture of interaction, sensitivity to other participants, and the ability to negotiate and coordinate joint activity. This argument can be further strengthened by studies that view the digital educational environment as a factor in the development of future professionals' communicative competence. Notably, it is the combination of a virtual learning environment, digital communication, and specially designed tasks that supports the transition from formal participation to more mature forms of professional interaction and cooperation (Shuppe et al., 2024).

Contemporary research also shows growing interest in digital tools that directly support collective activity. In particular, interactive boards are viewed as digital means that help structure interaction, visualize ideas, support joint work on content, and organize the contemporary educational process in a more open and coordination-rich manner (Rudenko et al., 2024). A similar logic is reflected in studies on the use of dashboards to develop learners' analytical thinking, where digital data visualization is understood not merely as a monitoring tool, but as an environment for sense-making and coordination of activity (Rudenko et al., 2025). This is of fundamental importance for our study because it allows us to see digital boards, shared documents, and visual interfaces not simply as technical add-ons, but as tools for developing teamwork, facilitation, and project-based work organization. The practical potential of such digital tools is also confirmed by studies that treat Teams, Zoom, Google Classroom, Webex, digital boards, and visualization tools as mechanisms for supporting coordination, integration, and participants' involvement in shared activity. Particularly illustrative are findings from supporting Ukrainian children and youth abroad, where digital tools effectively served as instruments

of educational integration and organizational connection among participants in the interaction (Nychkalo et al., 2024).

The issue of teamwork in digital environments is also actively discussed in international scholarship. Studies on virtual team building show that cohesion, trust, communication skills, and motivation for joint work can be developed even in remote and blended formats, although this requires intentional pedagogical design and does not emerge spontaneously (Kuznetsova et al., 2023). Research on Team-Based Learning likewise confirms that systematically organized small-group teamwork contributes not only to academic achievement but also to the development of critical thinking, responsibility, and the ability to operate within a shared problem-solving framework (Brannan et al., 2019). In this sense, the digital educational environment does not eliminate team-based pedagogy. Rather, it calls for its reinterpretation, one in which the technological dimension is integrated with the activity-based, communicative, and organizational dimensions.

An important argument in support of this approach is provided by research on digital pedagogical competence as a factor that mediates the expansion of learners' opportunities. Lin et al. (2022) demonstrated that digital pedagogical competence, rather than general ICT proficiency alone, is the leading factor linking teachers' technical and data literacy skills with the development of collaboration, communication, and responsible use of technology in the classroom. This allows us to draw an important conclusion: teacher teamwork in a digital environment is not only a way of organizing teachers' professional activity, but also an important precondition for creating an educational space in which learners themselves acquire corresponding models of interaction. In addition, findings from several studies suggest that the digital educational environment also affects deeper dimensions of future teachers' professional development, including types of self-realization, motivation, creativity, and attitudes toward professional activity. This provides grounds for viewing digital interaction in the educational environment as having not only a functional but also a personal and professional dimension, which is important for developing readiness for teamwork (Popovych et al., 2024).

No less important is the issue of analytical and reflective support for teamwork. The TeamSlides study showed that multimodal dashboards can strengthen instructor-guided reflection on team activity, make certain aspects of interaction more visible, and support the interpretation of collaborative work, although they also introduce new interpretive challenges (Echeverría et al., 2024b). This point is especially important for our study because we likewise assume that digital artifacts, revision histories, comments, and the structures of shared boards can serve not only as means of completing a task, but also as material for assessment and reflection. Thus, the digital educational environment creates new opportunities to identify and purposefully develop teacher teamwork. In international scholarship, the organizational dimension of this issue is also becoming increasingly clear. In particular, research has shown that teachers' teamwork effectiveness depends on a culture of knowledge sharing, a sense of fairness, a supportive professional environment, and institutional mechanisms for collaboration. At the same time, studies on teaching teamwork in virtual educational environments indicate that the digital form of interaction alone does not guarantee well-coordinated team activity and therefore requires dedicated pedagogical design, guidance, and extended feedback (Xu et al., 2026; Espejo et al., 2023).

Taken together, international and Ukrainian studies allow several principal conclusions to be drawn. First, the digital transformation of education shifts the focus from individual command of tools to collective forms of professional activity. Second, the development of teachers' digital teamwork requires specially organized professional learning built on practical, collaborative, and reflective formats. Third, such development depends not only on digital services as such, but also on the pedagogical design of tasks, a culture of interaction, the role of leadership, mentoring, and a structured environment. Fourth, scholarly discourse has already established sufficient grounds for treating teachers' digital teamwork as an independent subject of analysis; however, its structure, assessment criteria, and development methods still require further clarification.

In view of this, the aim of this chapter is to provide a theoretical rationale for the essence and structure of teachers' teamwork skills in a digital educational environment, identify approaches to their assessment, develop a methodology for their advancement, and analyze the results of its pilot implementation. To achieve this aim, the chapter consistently examines the theoretical foundations of the digital transformation of pedagogical activity, refines the author's understanding of digital teamwork skills, characterizes their structural components, substantiates the criteria, indicators, and levels of development, describes a series of training sessions as a formative intervention, and analyzes the results of the pilot experiment. Ultimately, this makes it possible to move from general reflections on digitalization and collaboration to a more precise scholarly description of how teacher teamwork can develop in a digital educational environment and which pedagogical conditions ensure its effectiveness.

## **1. Theoretical Foundations for the Development of Teachers' Teamwork Skills in a Digital Educational Environment**

### *1.1. The Digital Transformation of Education as a Factor in Changing the Teacher's Professional Role*

The digital transformation of education is not merely a process of introducing new technical tools into the operation of educational institutions. It involves a deeper restructuring of the ways the educational process is organized, of professional communication, of the creation and dissemination of instructional materials, of monitoring outcomes, of feedback, and of the coordination of actions among all participants in educational interaction. For this reason, digitalization should be viewed not as an external addition to traditional pedagogical practice, but as a factor that reshapes the teacher's professional role, functions, responsibilities, and forms of professional participation in the life of the educational community. This is consistent with studies that describe the digital transformation of higher education as a multidimensional process encompassing changes in curricula, teaching methods, assessment, infrastructure, and management.

Accordingly, the professional role of the educator is also changing across multiple dimensions at once, including communicative, organizational, and coordinative ones (Majdi et al., 2024).

Recent scholarly work consistently emphasizes that effective pedagogical activity in a digital environment cannot be reduced to mastery of individual digital tools. Far more important is the teacher's ability to integrate technology into instruction in ways that support educational goals, sustain interaction, and foster independence, critical thinking, creativity, and collaboration. For this reason, contemporary models of teachers' digital competence include not only technological, but also pedagogical, communicative, organizational, innovative, and reflective dimensions (Tzafilkou et al., 2023; Alom & Ramalingappa, 2025). This approach changes the very lens through which the teaching profession is understood: from a performer of separate didactic actions to an organizer of multi-layered pedagogical interaction in a digitally enriched environment. A similar logic is reflected in studies that treat the digital educational environment as a space for professional training, where the emphasis falls not on isolated digital actions but on the systemic design of an environment that supports learning, coordination, access to resources, and the professional growth of future specialists. This reinforces the idea that the contemporary educator in digital education acts not only as a user of technology, but also as a designer of conditions for collaborative activity (Hrechanyk et al., 2024).

The need for such a reconceptualization became especially evident during abrupt educational disruptions, when educational institutions were forced to shift rapidly to remote or blended formats. These situations showed that the mere availability of a platform or access to video communication does not in itself guarantee either the quality of learning or teachers' professional readiness. Researchers note that even after years of widespread use of digital technologies, teacher education systems in many cases remained insufficiently prepared to develop stable capacities for digital teaching, flexible instructional organization, and work in new modes of professional interaction (Hodges et al., 2026). Thus, digital transformation revealed not only technical gaps, but also methodological and organizational ones that directly affect the teacher's professional role. Notably, under such conditions, the

digital environment influences not only the activity-related aspects of teacher preparation but also deeper dimensions of future teachers' self-realization, including value orientations, creativity, cognitive needs, and motivational configurations. This means that the digital transformation of education changes not only the external organization of teachers' work, but also the internal mechanisms of their professional development (Popovych et al., 2024).

In the traditional view, the teacher is often seen primarily as a carrier of subject knowledge, an organizer of learners' activity, and the person responsible for assessing their outcomes. In a digital educational environment, these functions remain, but they become substantially more complex. New tasks are added: selecting and adapting digital resources; designing synchronous and asynchronous interactions; managing digital communication channels; creating shared educational materials; coordinating work in cloud-based environments; analyzing digital traces of activity; upholding ethical norms of interaction; and ensuring information security. Accordingly, the teacher's professional role becomes increasingly multifaceted.

This shift has another fundamental feature. In a digital environment, the teacher increasingly works not as an autonomous performer, but as a participant in various professional networks. Teachers coordinate actions with colleagues as they develop shared courses, instructional materials, interdisciplinary tasks, events, projects, internal monitoring processes, and methodological support. Thus, digital transformation strengthens the collective dimension of pedagogical work. This conclusion is also supported by studies on teachers' teamwork behavior, which show that the quality of collaboration within an educational organization is linked to perceptions of fairness, the intensity of knowledge sharing, and the overall climate of professional support. Therefore, the collective dimension of pedagogical work in a digital environment cannot be reduced merely to the technical possibility of shared editing or communication; it also requires an appropriate social and organizational foundation (Xu et al., 2026). In this respect, studies of virtual educational environments in which teamwork is treated as a distinct subject of instruction are especially revealing. They show that teamwork in a digital format

develops more successfully when participants are given structured roles, step-by-step tasks, continuous feedback, and specially designed conditions for mutual coordination (Espejo et al., 2023).

For this reason, contemporary research increasingly treats teachers' digital competence as a multidimensional construct encompassing communication and collaboration, digital content creation, safety, problem-solving, professional development, and innovative activity (Alom & Ramalingappa, 2025; Tzafilkou et al., 2023). This understanding is central to the present study because it provides grounds for viewing teamwork not as a separate auxiliary skill, but as an organic part of teachers' professional readiness to work in a digital educational environment. A further argument in support of this view is that the development of communicative competence in digital settings is already regarded by researchers as an independent educational goal, one that requires specially organized forms of work, digital communication, and virtual educational environments. This once again confirms that teamwork is not a secondary byproduct of digitalization, but part of the very structure of contemporary teacher preparation (Shuppe et al., 2024).

Particular attention should also be paid to the relationship between teachers' digital competence and learners' development. There are grounds to argue that the effect of a teacher's technological preparedness on educational outcomes is not linear. What matters is not simply whether the teacher can use a given tool, but how that tool is used in pedagogical practice. Research shows that digital pedagogical competence, along with the ability to organize interaction, mediates the impact of ICT skills on expanding learners' opportunities, including in collaboration, communication, and the responsible use of technology (Lin et al., 2022). This means that digital transformation requires the teacher not merely to be a user of services, but also to be an educator capable of organizing meaningful interaction through them. From this perspective, the inclusive dimension of digital pedagogy becomes especially important. Recent studies show that digital competencies become truly productive only when they help remove barriers to participation, support adaptation, ensure continuity of educational interaction, and enable the involvement of diverse groups of learners. This framing significantly broadens

the understanding of the teacher's professional role in a digital environment (Holovnia et al., 2024).

In such a situation, the teacher's professional autonomy also changes substantially. On the one hand, digital tools expand opportunities for flexible instructional design, rapid resource updates, task personalization, and communication. On the other hand, they make professional activity more transparent, interconnected, and dependent on coordination with other participants in the educational environment. Teachers must work in a mode of constant alignment: with schedules and platforms, with the internal rules of the educational institution, with colleagues involved in shared educational decisions, with learners' needs, and with requirements related to safety, copyright, and digital ethics. As a result, the teacher's professional role shifts from a model of individual control to one of coordinated responsibility.

Another consequence of digital transformation is the change in professional communication. Whereas much collective interaction previously took place mainly through face-to-face meetings, methodological groups, and informal communication, it is increasingly moving to digital channels. This changes the pace, format, and structure of professional communication. Messages become shorter and more frequent, comments are recorded in shared documents, task statuses are tracked in project environments, and a large part of interaction takes on an asynchronous character. Under these conditions, teachers must command not only the language of pedagogical communication but also the culture of digital communication: the ability to formulate tasks clearly, provide constructive feedback, negotiate deadlines, maintain mutual respect, and reduce the risk of misunderstanding in text-based or hybrid interaction.

It is telling that teachers' readiness to use digital tools is now increasingly linked to their general ability to work in an innovative and collaborative mode. Researchers who analyze educators' readiness to work in a STEAM-oriented educational environment emphasize the importance of not only digital literacy but also methodological preparation, adaptability, innovativeness, and communication skills (Soroko & Shymon, 2025). This is directly relevant to our topic, as teamwork in a digital environment

always involves integrating technological, communicative, and organizational dimensions.

Thus, the digital transformation of education changes the teacher's professional role in several interrelated ways. First, it expands teachers' functions by adding new forms of digitally mediated activity to traditional didactic tasks. Second, it strengthens the importance of teamwork and coordination in professional practice. Third, it highlights the need for a new type of professional readiness that combines technical proficiency with pedagogical design, facilitation, communicative culture, and distributed leadership capacity. For this reason, the study of teachers' teamwork skills in a digital educational environment is a logical step in rethinking the contemporary teaching profession.

### *1.2. Teamwork as a Professional Characteristic of the Contemporary Teacher*

In educational scholarship, teamwork is increasingly viewed not as an additional organizational ability, but as an essential feature of the contemporary teacher's professional activity. This perspective is also supported by studies on collaborative learning and teamwork strategies in modern educational environments. These studies show that educators generally recognize the value of collaboration for learning; however, the practical implementation of teamwork is often constrained by a lack of prior preparation, unclear assessment procedures, and insufficient resources. This means that recognizing teamwork as a professionally significant characteristic does not in itself guarantee its systematic development in pedagogical practice (Amayou et al., 2025). This is because the educational process in educational institutions is becoming more complex in content, more open to interdisciplinary connections, more responsive to learners' individual needs, and, at the same time, more dependent on coordinated actions of different participants. Teachers can no longer effectively perform all functions solely within the bounds of individual professional autonomy. Even with a high level of subject-matter and methodological preparation, the effectiveness of their work depends to a considerable extent on the ability to work with others: to plan, negotiate, share responsibility, support

joint decisions, contribute to the creation of a collective product, and adjust shared activity when conditions change.

Teamwork in education has its own specific features. Unlike the formal distribution of duties, it implies not merely the coexistence of individual performers, but real interdependence of actions, a shared vision of the goal, alignment of professional positions, and responsibility for the overall outcome. In school practice, this may be expressed in collaborative lesson design, coordination of educational and extracurricular activities, development of integrated courses, interaction within methodological associations, participation in interdisciplinary projects, organization of inclusive support, work with digital instructional materials, and collective resolution of professional problems. Thus, teacher teamwork is not episodic in nature, but systemic.

At the theoretical level, it is useful to distinguish several related but not identical concepts. *Group interaction* is the broadest term and may refer to any shared presence or exchange of actions among several participants. *Cooperation* usually involves dividing tasks among participants working toward a common goal while retaining relative independence in completing their respective parts. *Collaboration* is inherently deeper because it involves the joint development of a solution, active alignment of positions, the creation of a shared product, and mutual adjustment of actions. *Teamwork* combines elements of both cooperation and collaboration, while also including continuity of interaction, role distribution, responsibility for the overall outcome, elements of self-organization, and the maintenance of a small professional community. For pedagogical activity, this distinction is fundamental, since not every form of joint work among teachers is truly team-based.

To clarify the meaning of teacher teamwork in a digital educational environment, it is useful to synthesize the most common approaches in the scholarly discourse to describing teachers' shared professional activity (Table 1.1). Such a comparison makes it possible to distinguish more clearly among group interaction, cooperation, collaboration, teamwork proper, and facilitation-organized team interaction. This distinction is

necessary for further substantiating the author's approach to understanding teachers' digital teamwork.

Table 1.1

**Comparison of Approaches to Understanding Teacher Teamwork in a Digital Educational Environment**

| <i>Approach / Concept</i> | <i>Core Meaning</i>                                                                                                               | <i>Nature of Interaction</i>                        | <i>Teacher's Professional Role</i>                          | <i>Function of the Digital Environment</i>                                                         | <i>Methodological Limitations</i>                                                           |
|---------------------------|-----------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------|-------------------------------------------------------------|----------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------|
| Group interaction         | Shared participation of several individuals in a particular type of activity or communication                                     | Situational, not always structured                  | Participant in a group process                              | Enables the exchange of messages, materials, and responses                                         | Does not necessarily involve a shared goal, role distribution, or collective responsibility |
| Cooperation               | Division of a shared task into separate parts among participants                                                                  | Mainly parallel performance of interrelated actions | Performer of a specific function or segment of work         | Makes it possible to coordinate contributions, transfer results, and synchronize stages of work    | May preserve an external appearance of joint activity without deep alignment of positions   |
| Collaboration             | Joint development of solutions, ideas, content, or products through continuous alignment                                          | Intensive, interdependent, dialogic                 | Co-author of a shared outcome                               | Creates space for joint editing, commenting, reflection, and negotiation of changes                | Requires a sufficient level of communicative culture, trust, and time                       |
| Teamwork                  | Coordinated activity of a group with a shared goal, roles, distribution of responsibility, and orientation toward a common result | Organized, role-structured, relatively stable       | Team member, co-performer, coordinator of particular stages | Supports communication, planning, monitoring of implementation, and collaborative product creation | Requires developed organizational, communicative, and reflective skills                     |

|                                         |                                                                                                                                                                  |                                                                       |                                                                                              |                                                                                                                       |                                                                                                                               |
|-----------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------|----------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------|
| Facilitation-organized team interaction | Team activity in which participant engagement, alignment of decisions, productive communication, and movement toward a shared result are intentionally supported | Organized yet open, reflective, guided through support of interaction | Facilitator, moderator, initiator of distributed leadership, participant in the team process | Used not only as a channel of interaction, but also as a means of structuring roles, stages, agreements, and feedback | Requires specific preparation in facilitation, a high level of digital communication culture, and clear rules for shared work |
|-----------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------|----------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------|

Source: Authors' own work.

Thus, teacher teamwork in a digital educational environment should be understood not as any form of joint activity, but as organized professional interaction that combines a shared goal, role distribution, coordination of actions, collective responsibility, and the creation of a common outcome through the use of digital tools. At the same time, the most productive approach for this study is one that complements teamwork with a facilitative dimension, as this enables explaining how participant engagement, constructive communication, coordination of contributions, and the achievement of a shared goal are supported in a digital environment.

In the contemporary school, teamwork takes on particular importance precisely because educational tasks are increasingly less individual in nature. Teaching requires integrating subject content, combining didactic approaches, adapting to diverse educational needs, coordinating with administration and parents, and working in conditions of constant change. Under such conditions, teachers must be able not only to carry out their own part of professional activity effectively, but also to see themselves within the broader structure of shared work. This means being able to relate one's own decisions to the team's overall strategy, adjust individual actions in line with the shared goal, take others' contributions into account, and build interaction on the basis of trust, predictability, and responsibility.

Teamwork as a professional characteristic of the teacher cannot be reduced to sociability or goodwill. Its content is much broader. It includes a cognitive dimension, that is, an understanding of the shared goal, the logic of team activity, and the role of each participant; an operational dimension associated with planning, coordination, joint implementation, and monitoring of tasks; a communicative dimension that includes the exchange of information, feedback, clarification of positions, and regulation of misunderstandings; as well as a value-motivational dimension, which is reflected in readiness for cooperation, acceptance of collective responsibility, and recognition of the importance of a shared outcome. It is precisely the combination of these components that makes teamwork a professionally relevant characteristic.

Research on Team-Based Learning, although mostly focused on instructional technologies for learners, also provides important grounds for understanding the nature of teamwork itself. These studies show that systematically organized joint activity contributes not only to task completion but also to the development of critical thinking, responsibility, the ability to justify decisions, and responsiveness to other participants' contributions (Brannan et al., 2019). For the teacher, this means that participation in teamwork is not only a tool for organizing activity, but also an environment for continuous professional growth. Through collective planning, joint analysis, development of materials, and reflection, teachers refine their own approaches, reconsider professional assumptions, learn to view problems from multiple perspectives, and gain a clearer awareness of the limits of their own competence.

It should also be emphasized that teacher teamwork is always connected with roles. In an educational environment, a team does not function as a collection of identical participants. On the contrary, its productivity depends to a large extent on how clearly roles are defined or situationally distributed: initiator, coordinator, facilitator, person responsible for a specific area of work, analyst, communication moderator, person responsible for digital resources, compiler of materials, and so forth. At the same time, role distribution should not turn into a rigid hierarchy. Contemporary educational teams are more typically characterized

by flexible role distribution, in which a teacher may take on different functions depending on the nature of the task, individual competence, experience, and the current situation. In this sense, teamwork is directly linked to distributed educational leadership.

The ability to work in a team is also reflected in the teacher's capacity to sustain productive group dynamics. This includes responding promptly to the overload of individual participants, reducing tension, preventing conflicts, ensuring the involvement of less active members, and maintaining a focus on the shared outcome. It is precisely here that professional teamwork intersects with facilitation. A teacher who possesses facilitation skills does not dominate the group or reduce collaboration to giving instructions. Rather, such a teacher creates conditions in which each participant can make a meaningful contribution, and the group decision emerges through discussion, clarification, and gradual alignment. This form of professional behavior is especially necessary under conditions of social uncertainty, when a team must adapt quickly to change without losing the quality of interaction.

Another important aspect is that teacher teamwork has an ethical dimension. It requires adherence to norms of professional respect, transparency of contribution, appropriate use of shared resources, responsible handling of information, willingness to acknowledge the authorship of others, and the ability to work on the basis of trust. In a digital educational environment, these requirements become even more evident, as a significant portion of interaction is recorded digitally. For this reason, teamwork requires not only organizational skill but also a well-formed culture of professional conduct. Without this, shared tools do not strengthen collaboration; instead, they merely make its weak points more visible: unclear roles, uneven contributions, superficial communication, avoidance of responsibility, or latent conflicts.

Contemporary studies on virtual team building and collaborative learning emphasize that even in digitally mediated forms of interaction, the basic characteristics of an effective team remain essential: trust, a sense of shared purpose, motivation to participate, clear rules of interaction, and a sense of a safe professional space (Kuznetsova et al., 2023). This conclusion is

especially important for educational settings. A teacher may formally know how to use collaborative tools, but without experience in teamwork, such work will remain superficial. Therefore, teamwork should be developed not only through instruction in tools but also through the creation of practices of joint planning, shared responsibility, professional reflection, and mutual support.

No less significant is the connection between teamwork and teachers' professional resilience. In situations of uncertainty, the team often serves as a resource that helps reduce individual overload, adapt more quickly to change, find shared solutions, and maintain the quality of pedagogical activity. An individualized model of work under conditions of crisis or instability proves to be far less sustainable. By contrast, teamwork enables the distribution of the workload, the exchange of resources, the drawing on participants' diverse professional strengths, and the preservation of the continuity of the educational process. In this sense, teamwork is not only pedagogically appropriate but also an organizationally protective characteristic of the profession.

All of the above provide grounds for interpreting teamwork as an integral professional characteristic of the contemporary teacher. It is reflected in the readiness and ability to carry out coordinated activity with other participants in the educational process, take part in joint planning and product creation, sustain productive communication, assume distributed responsibility, perform different roles within a team, contribute to the achievement of a collective outcome, and preserve the quality of interaction under changing conditions. In what follows, this understanding will serve as the basis for examining the specific features of the digital educational environment as a space in which teacher teamwork acquires new forms, tools, and assessment criteria.

### *1.3. The Digital Educational Environment as a Space for Collective Pedagogical Activity*

In scholarly and practice-oriented publications, the digital educational environment is often described as a set of technical platforms, electronic resources, communication services, and

means of accessing instructional content. This understanding is necessary, but insufficient for analyzing the contemporary teacher's professional activity. If attention is focused only on the instrumental aspect, the digital educational environment appears as a set of software solutions that support separate functions of the educational process. In actual pedagogical practice, however, it plays a much broader role. It organizes modes of interaction, sets the pace of communication, records the results of collaborative work, makes participants' contributions visible, supports coordination of actions, and thus becomes a space for collective pedagogical activity.

For this reason, the digital educational environment should be viewed not only as a technological infrastructure, but as a socio-pedagogical system within which digital tools, professional roles, rules of interaction, types of communication, forms of coordination, and mechanisms for the joint creation of educational products are combined. In this understanding, the environment is not a neutral backdrop for the teacher's activity. It directly affects how planning is carried out, how information exchange is structured, how tasks are recorded, how implementation is monitored, how intermediate results are stored, and to what extent reflection on shared activity is possible. Thus, the digital environment is not an external shell of the educational process, but one of its structural components.

This idea is especially consistent with contemporary approaches to analyzing teachers' digital competence. If digital competence is reduced merely to command of services, its professional meaning is lost. Research, by contrast, shows that the productive use of digital technologies requires integrating pedagogical, communicative, organizational, and professional elements (Tzafilkou et al., 2023). This means that the environment should be assessed not only by technical parameters but also by the extent to which it supports teaching, interaction, collaborative design, professional development, and innovation. For the topic of teamwork, this conclusion is directly relevant: collective activity in a digital space becomes possible only when tools and pedagogical logic do not contradict one another, but instead reinforce each other.

In a traditional face-to-face educational environment, a substantial part of teachers' teamwork remains situational and often undocumented. Discussions may take place orally, decisions may be made informally, and particular stages of joint work may leave no material trace. The digital educational environment changes this situation. It makes collective activity more structured, more visible, and more open to analysis. Shared documents preserve revision histories, digital boards display task distribution and completion status, chats capture the intensity and nature of communication, cloud-based environments enable tracing the contributions of individual participants, and commenting tools allow the logic of decision-making to be reconstructed. As a result, the digital environment not only supports teamwork but also creates conditions for observing, assessing, and improving it.

This is especially important in cases where teachers' professional interaction involves joint planning of instructional topics, development of materials, interdisciplinary projects, coordination of assessment, creation of adapted resources, or organization of comprehensive support for learners. In such situations, the digital environment performs at least three functions. First, it serves as a communication space where participants align on positions, exchange messages, clarify tasks, and provide feedback. Second, it functions as a space of joint production, where texts, presentations, instructional materials, templates, tables, analytical reports, and other digital products are created. Third, it serves as an organizational space where roles are distributed, work stages are planned, deadlines are set, and implementation is monitored. Taken together, these functions provide grounds for speaking of the digital environment as a space for collective pedagogical activity.

From a methodological perspective, it is useful to distinguish several levels at which such an environment functions. The first level consists of tools for synchronous interaction, including videoconferencing, online meetings, interactive sessions, and real-time decision-making. At this level, skills are developed for rapid coordination of actions, participation in collective discussion, facilitation, and sustaining group dynamics. The second level is associated with asynchronous interaction, in which chats, forums,

shared comments, task management systems, and project boards play a leading role. It is here that precision of formulation, the culture of written communication, the ability to negotiate deadlines, and responsibility become especially important. The third level is the environment for collaborative product creation, which includes cloud-based documents, presentations, spreadsheets, visual boards, online courses, and shared repositories. It is in this space that teamwork becomes most tangible, because it is captured in a concrete outcome.

Importantly, all of these levels are interconnected. Effective collaborative activity is rarely limited to a single tool. For example, collective planning may begin with a synchronous meeting, continue in an asynchronous chat, and conclude with a shared document or a digital board where tasks are assigned and responsible persons are identified. Thus, the digital environment functions as an integrated system in which different tools do not merely coexist but support distinct phases of a single collective activity. For the teacher, this means seeing the environment as a whole rather than as a set of isolated services.

It is precisely here that another important feature of the digital educational environment becomes evident. It not only supports existing forms of collaboration, but also changes the very ways pedagogical work is organized. Through digital platforms, professional interaction becomes less tied to a single time and place, which is especially important under conditions of instability, blended work formats, and the need to rapidly reorganize the educational process. Teachers can work on shared materials at different times, return to earlier versions of documents, view colleagues' comments, and participate in discussions without all participants being present simultaneously. Such asynchronous flexibility expands the possibilities for teamwork but, at the same time, creates new demands on the organization of interaction. It requires greater discipline, transparency, clarity in communication, and an understanding of collective responsibility.

Studies on virtual team building and intelligent collaborative environments emphasize that a digital environment can strengthen cohesion, motivation, and interest in shared activity if it supports psychological safety, clear interaction rules, and opportunities for each participant to make a real contribution

(Kuznetsova et al., 2023). For a pedagogical team, this means that the technical availability of tools does not in itself guarantee high-quality collaboration. What also matters are the culture of interaction, role distribution, clarity of expectations, timely feedback, and the perception of the environment as a space for genuinely shared rather than merely parallel work. Accordingly, teacher preparation for activity in a digital environment must include experience of real teamwork, not only training in how to use digital services.

From a pedagogical point of view, it is also important that the digital educational environment enables connecting the process and the result of teamwork. Under traditional conditions, only the final product is often assessed, while the course of interaction itself remains outside attention. In a digital environment, the process of collective work can become the subject of separate analysis. It becomes possible to assess not only what has been created, but also how the team moved toward the result: how tasks were distributed, how meaningful the communication was, whether there were attempts to coordinate revisions, how facilitation was carried out, whether delays occurred, and how participants responded to difficulties. It is precisely this analytical openness of the digital environment that makes it one of the most promising features in preparing teachers for teamwork.

Another important aspect is that the digital educational environment is gradually becoming a space for teachers' professional development. This involves more than participation in formal online courses or webinars. Professional growth also takes place within everyday collective practice itself: when teachers co-edit materials, observe how colleagues organize their work, receive comments, participate in digital planning, learn to justify their decisions, and encounter different styles of facilitation and resource use. In this way, the digital environment takes on the character not only of a workspace, but also of a learning space for the teacher. It supports the accumulation of practical experience that is difficult to develop through theoretical instruction alone.

In this connection, the institutional organization of the digital environment becomes fundamentally important. It can either support teamwork or make it more difficult. If, within an

educational institution, tools are fragmented, interaction rules are unclear, responsibility for coordination is undefined, and digital communication is overloaded or chaotic, the environment does not support collective pedagogical activity, even when technical resources are available. Conversely, when the use of platforms is aligned, access to shared spaces is organized, communication rules are clear, and teachers have experience in joint planning and reflection, the digital environment becomes a true organizational foundation for professional interaction. This is why researchers emphasize the importance of systemic institutional support for digital transformation rather than merely individual mastery of separate services (Hodges et al., 2026; Soroko & Shymon, 2025).

Thus, the digital educational environment should be understood as a multidimensional space for collective pedagogical activity. It brings together communication tools, resources for collaborative product creation, coordination mechanisms, and opportunities for the analytical support of shared work. Within it, teachers' teamwork takes on new forms, becoming more structured, visible, and reflective. At the same time, this environment places new demands on the teacher's professional role: the ability to work collaboratively, organize collective activity, sustain productive communication, and leverage digital tools to achieve a shared pedagogical outcome. For this reason, the next stage of analysis should focus on how teamwork in a digital educational environment is connected with educational leadership, facilitation, and role distribution in teachers' professional interaction.

#### *1.4. Educational Leadership and Facilitation in Digital Team Interaction*

Educational leadership in contemporary pedagogical scholarship is increasingly less likely to be understood solely as administrative influence or the performance of formal managerial functions. Instead, there is growing recognition of leadership as the ability to initiate change, organize joint activity, support professional interaction, guide a group toward a shared goal, and create conditions for the productive participation of others. In this sense, leadership is not exclusively an attribute of the head of an

educational institution. It also appears in everyday pedagogical practice, when a teacher takes responsibility for coordinating shared work, helps the group maintain the substantive coherence of its activity, supports constructive exchange of ideas, and contributes to the achievement of a collective result. In a digital educational environment, such manifestations become especially visible because interaction increasingly takes on an organized, recorded, and tool-mediated character.

For this reason, teacher teamwork in a digital environment cannot be fully understood without reference to the categories of educational leadership and facilitation. If the previous subsections addressed the changing professional role of the teacher and the digital environment as a space for collective activity, it is now important to clarify how coordination of actions is ensured within this space, how participant engagement is sustained, and how a shared result is achieved. It is precisely here that the question of the teacher's leadership function arises. This is not about dominating the group or exercising rigid control, but about the ability to structure interaction, sustain its productivity, and guide the team without undermining the professional autonomy of other participants.

In a digital environment, educational leadership has several specific features. First, it becomes more distributed. In teachers' teamwork, there is not always a single permanent center of influence. Depending on the stage of work, the type of task, and participants' professional competence, leadership functions may shift among team members. One teacher may initiate the topic and formulate the shared task, another may moderate the discussion, a third may organize the structure of digital materials, and a fourth may provide technical or methodological coordination. This approach is consistent with the contemporary understanding of distributed leadership, within which leadership is understood less as a property of a position and more as a way of organizing collective activity.

Second, in a digital environment, leadership takes on a more process-oriented character. In face-to-face interaction, part of the guiding influence can be exerted through nonverbal signals, intonation, and spontaneous adjustments in communication. In digital space, by contrast, the organization of group work depends

to a much greater extent on clarity of structure, transparency of tasks, visibility of roles, and timely feedback. This means that the teacher, as a leader, must be able not only to persuade or inspire, but also to design digital interactions effectively: to determine the sequence of steps, choose appropriate tools, establish communication rules, document agreements, and maintain the team's working rhythm. In this sense, leadership appears as the ability to structure a shared space for activity.

Facilitation becomes especially important in this process. It is useful to view facilitation as a specific professional action aimed at easing, sustaining, and purposefully guiding group interaction. Unlike directive management, facilitation is not limited to giving instructions or exercising unilateral control over the process. Its essence lies in creating conditions in which team members can interact productively, clearly understand the shared goal, participate in discussion, propose solutions, align positions, and take responsibility for the outcome. In digital teamwork, facilitation helps transform formal presence in a shared space into genuine collaboration.

For the teacher, this means possessing a range of facilitation skills. First of all, it involves the ability to formulate a shared goal and make it understandable to all participants. Without this, digital interaction easily breaks down into parallel individual actions that do not produce a coherent outcome. Equally important is the ability to sustain each participant's involvement and avoid situations in which activity is concentrated in only a few individuals while others remain peripheral observers. No less significant is the ability to structure discussion, that is, to distinguish what is essential from what is secondary, bring the group back to the subject of work, summarize interim results, and document decisions. In a digital environment, this is particularly important, since an excess of messages, parallel communication threads, and asynchrony can quickly blur the shared logic of activity.

Another important feature of facilitation is the support of constructive feedback. In a digital educational environment, communication often takes a text-based or hybrid form, which increases the risk of misunderstanding, formality, emotional detachment in responses, or, conversely, excessive fragmentation of discussion. A teacher in a facilitative role must do more than

simply respond to messages; they must shape the quality of communication itself by formulating questions that move the group forward, prompting clarification of positions, supporting well-grounded decisions, encouraging mutual respect, and reducing tension when disagreements arise. In this sense, facilitation becomes not an auxiliary technique, but an important expression of the professional culture of teamwork.

The digital environment makes facilitative activity more transparent and, at the same time, more demanding. In face-to-face interaction, part of the facilitator's work may be carried out intuitively. In digital space, by contrast, it often requires explicit structuring. It is necessary not only to organize a discussion, but also to choose the communication channel, determine where decisions are recorded, establish how a shared document is edited, clarify how task completion is tracked, decide when the team moves from discussion to implementation, and specify deadlines and responsible persons. Thus, facilitation in a digital environment is simultaneously a communicative, organizational, and tool-mediated practice.

It follows from this that educational leadership in digital team interaction should not be interpreted too narrowly. It includes several interrelated dimensions. The first may be called the meaning-oriented dimension: it concerns the ability to define the direction of activity, help the group understand the purpose of shared work, and maintain focus on the goal. The second dimension is organizational and relates to building the structure of team activity, distributing roles, selecting tools, and coordinating stages of work. The third dimension is communicative: it involves sustaining dialogue, providing feedback, fostering mutual understanding, and working through differences. The fourth has a reflective character and is expressed through the ability to analyze the course of shared work, notice difficulties, adjust the interaction format in a timely manner, and stimulate reflection on the experience gained. Together, these dimensions form the leadership-facilitation component of the teacher's team interaction.

It is telling that contemporary studies of teachers' digital competence increasingly include, within their structure, not only operational and technological components but also professional

and innovative components related to school development, professional collaboration, and the improvement of educational practice (Tzafilkou et al., 2023). This means that educational leadership in a digital environment is not external to digital competence. On the contrary, it constitutes one of the forms through which that competence is realized at the level of collective professional activity. A teacher who knows how to use digital services but is unable to organize interactions around them has not yet realized the full potential of the digital environment. Only the combination of instrumental proficiency with leadership and facilitation skills enables a set of technologies to become a space for genuine teamwork.

Another important aspect concerns social uncertainty. Under unstable conditions, teams face increased workload, the need to rapidly change plans of action, reorganize channels of interaction, take participants' emotional states into account, and maintain effectiveness in the face of incomplete certainty. In such situations, facilitative leadership becomes especially important. It helps not only to distribute tasks but also to preserve the team's working coherence, prevent destructive fragmentation of communication, provide timely support to participants, and reduce the disorganizing effect of uncertainty. Thus, leadership in digital team interaction serves not only a productive but also a stabilizing function.

No less significant is the issue of roles in a digital team. As already noted, contemporary pedagogical interaction is rarely built on a rigid hierarchical scheme. At the same time, a lack of clear role definitions can lead to chaos, duplication of actions, unclear responsibility, or conflicts over the boundaries of participation. This is why educational leadership must be linked not simply to the ability to manage, but also to the ability to competently organize the team's role structure. This means being able to define participants' functions in a timely manner, align expectations, make each person's contribution visible, and, at the same time, preserve sufficient flexibility to shift roles as needed. In a digital environment, this can be realized through the structure of a task board, the revision system for shared documents, assignment of responsibility for particular stages, formats for moderating discussions, and other tool-based mechanisms.

From the standpoint of pedagogical ethics, the leadership-facilitation function is also of fundamental importance. A teacher who organizes digital team interaction effectively establishes norms of professional conduct: how disagreement should be expressed, how changes should be commented on, how others' contributions should be acknowledged, how delays or mistakes should be handled, and how conflict situations should be addressed. For this reason, educational leadership in a digital environment is connected not only with effectiveness but also with the formation of a culture of collaboration. If that culture is not supported, even a well-designed technical system will not ensure high-quality teamwork. Facilitation, by contrast, helps move interaction from the plane of purely functional task completion to that of conscious professional partnership.

Thus, educational leadership and facilitation in digital team interaction should be regarded as integral components of the contemporary teacher's professional role. They provide not administrative dominance, but meaningful, organizational, communicative, and reflective structuring of shared activity. In a digital educational environment, it is precisely these qualities that enable transforming a multiplicity of tools and channels of interaction into a coherent space of collaboration in which orientation toward a shared goal, coordination of actions, visibility of participants' contributions, and professional responsibility for the outcome are preserved. This enables moving from a general theoretical understanding of the problem to a more precise clarification of the structure and content of teachers' digital teamwork skills, which are the subject of further analysis in the next section.

## **2. Structure and Content of Teachers' Digital Teamwork Skills**

### *2.1. The Author's Clarification of the Concept of "Teachers' Digital Teamwork Skills"*

Clarifying the concept of teachers' digital teamwork skills is necessary because several lines of inquiry intersect in contemporary scholarship: research on teachers' digital competence, studies on professional collaboration and teamwork,

and work on facilitation, distributed leadership, and the organization of shared activity in digital environments. Each of these lines provides important reference points, yet none alone fully captures the phenomenon at the focus of our analysis. For this reason, there is a need not simply to describe related concepts, but to formulate a working, conceptually coherent understanding of teachers' digital teamwork skills.

First of all, it should be emphasized that this study is not concerned with just any use of digital tools in teachers' professional activity. Nor is it concerned with just any form of group interaction in an educational environment. The focus is on a specific type of professional activity that combines three features. First, the activity is team-based, meaning that it involves a shared goal, coordinated actions, role distribution, and orientation toward a collective outcome. Second, it is digitally mediated, meaning that it takes place through shared documents, digital boards, cloud services, communication platforms, and tools for commenting, planning, and monitoring. Third, this activity has pedagogical content, since it concerns the development, organization, coordination, or improvement of the educational process. Thus, teachers' digital teamwork skills should be understood as a professionally grounded category rather than a purely technical or interpersonal one.

In the broadest sense, teachers' digital teamwork skills can be defined as the educator's ability to engage effectively in coordinated professional interaction with other participants in the educational process within a digital environment for the purpose of jointly planning, organizing, creating, revising, and evaluating educational decisions and products. This definition requires further elaboration. Above all, it points to the action-oriented nature of these skills. The issue is not merely knowledge of digital services or a positive attitude toward collaboration, but the ability to act: to communicate, negotiate, coordinate, edit, structure, facilitate, monitor the progress of shared work, work with digital artifacts, and sustain a productive team process.

It is fundamentally important that these skills not be equated with teachers' overall digital competence. Digital competence is a broader construct that includes work with resources, assessment, safety, professional development, content

creation, innovative activity, and other dimensions (Tzafilkou et al., 2023). By contrast, digital teamwork skills constitute a distinct and more specific segment of professional readiness that becomes visible precisely in situations of shared activity. They are grounded in digital competence, but they are not exhausted by it. A teacher may demonstrate a sufficient level of individual proficiency with digital tools and, at the same time, experience difficulties in teamwork, for example, being unable to distribute tasks, provide meaningful feedback, coordinate the editing of a shared document, or facilitate a group discussion. Thus, digital competence is a foundation, but not a direct synonym for digital teamwork.

These skills should likewise not be reduced to communication alone. Without question, the communicative component is central. However, it covers only part of a broader system of actions. Teachers' digital teamwork involves not only exchanging messages or participating in video meetings, but also the ability to jointly create a product, work with document versions, engage in mutual editing, record decisions, track task completion, meet deadlines, prevent duplication of actions, and maintain the team's working coherence. For this reason, within our approach, digital teamwork skills are best understood as an integrated combination of communicative, cooperative, organizational, and facilitative actions carried out in a digital environment.

Within this definition, the word *skills* is of particular importance. It points to relatively stable, practiced ways of acting that can be reproduced across different, though similar, professional situations. A skill differs from a one-time successful performance in that it has the features of transferability, repeatability, and functional reliability. Thus, when referring to teachers' digital teamwork skills, we mean not accidental successful episodes of interaction, but developed capacities that a teacher can apply in jointly planning lessons, creating interdisciplinary materials, coordinating project activity, organizing methodological collaboration, developing shared approaches to assessment, or designing educational solutions in digital environments.

At the same time, these skills are not purely operational. They cannot be interpreted as the mechanical execution of a set of instructions. They always depend on the goal of the shared activity, the team's composition, the nature of the tools, the type of educational task, and the level of participants' autonomy. For this reason, their structure includes not only the technique of execution, but also the ability to choose an appropriate mode of interaction, align means with the task, change the work format when needed, and move in a timely manner from discussion to implementation and from implementation to reflection. This interpretation is consistent with approaches that view digital pedagogical activity as a combination of technological, pedagogical, professional, and organizational dimensions (Lin et al., 2022; Tzafilkou et al., 2023).

For our study, the connection between digital teamwork and educational leadership is also essential. In real practice, team interaction rarely sustains itself on its own. As a rule, actions are needed to structure the process: someone formulates the goal, initiates discussion, records decisions, reminds the team of deadlines, summarizes interim results, engages less active participants, helps overcome communication breakdowns, or prevents conflict. Thus, digital teamwork skills include the ability to facilitate and exercise micro-leadership, even when the teacher does not hold a formal leadership position. This is precisely what distinguishes digital teamwork from the mere technical co-presence of several individuals on the same platform.

In refining the proposed concept, it is also important to emphasize its outcome-oriented dimension. Team interaction in a digital environment is not an end in itself. It is directed toward creating or improving a shared product or decision. Such a product may take the form of jointly developed instructional materials, the structure of an educational project, an assessment system, an event plan, an integrated course, a set of methodological recommendations, a digital resource, or an agreed pedagogical decision regarding the organization of work with learners. For this reason, digital teamwork skills should be assessed not only by participation in interactions but also by the ability to move the team toward a concrete shared result.

It is precisely from this perspective that, within our approach, the concept of teachers' digital teamwork skills includes several essential features. First, it is goal orientation, that is, subordination to a shared professional purpose. Second, it is coordination, expressed in the ability to align one's own actions with those of other participants. Third, it is instrumental appropriateness, that is, the ability to use digital services in accordance with the logic of the team task rather than in a purely formal way. Fourth, it is role flexibility, whereby a teacher may perform the functions of participant, coordinator, editor, facilitator, or person responsible for a specific segment of the work. Fifth, it is reflectiveness, which enables the analysis of the process of shared work, the identification of difficulties, and the adjustment of modes of interaction. Sixth, it is a responsibility for the shared result rather than only for one's own portion of the work.

In view of the above, the author's clarification of the concept may be formulated as follows: teachers' digital teamwork skills are an integrated set of practiced professional actions that ensure effective interaction between the educator and other participants in the educational process within a digital environment in order to achieve a shared goal through communication, coordination, role distribution, collaborative product creation, facilitation of the group process, and reflective adjustment of shared activity.

This definition has several advantages. First, it does not reduce the concept to technical mastery of tools. Second, it does not dissolve it into the broader concept of digital competence. Third, it includes the organizational and facilitative dimensions, without which team activity in a digital environment remains fragmented. Fourth, it emphasizes the professional and outcome-oriented nature of interaction. This is precisely what makes it possible to use the concept as a methodological foundation for the further structuring of the phenomenon under study.

Within the logic of our study, this means that teachers' digital teamwork skills should be understood not as a homogeneous construct, but as a system of interrelated components. One of these components ensures the quality of digital communication and facilitation; another is connected with the collaborative creation of a digital product; and a third concerns

the organization of the team process, planning, and coordination of actions. For this reason, the next part of the chapter will focus on identifying the structural components of this phenomenon and clarifying their content. The next step is to examine the communication-facilitation component as the first and indispensable element of teachers' digital teamwork skills.

## *2.2. The Communication-Facilitation Component*

The communication-facilitation component is the first and foundational element of teachers' digital teamwork skills, as it enables coordinated professional interaction in a digital environment. Without well-established communication, a team is unable to define a shared goal clearly, distribute roles, sustain the workflow, or achieve a coherent result. At the same time, digital teamwork cannot be reduced merely to exchanging messages or participating in online meetings. For it to function productively, communication must do more than transmit information; it must organize interaction, guide it, sustain participants' engagement, and help the group move toward a shared outcome. For this reason, within this study, the communicative dimension is considered inseparable from the facilitative one.

The communication-facilitation component can be understood as a set of practiced actions and professional behaviors that ensure meaningful digital communication, coordinated interaction, participant engagement in shared work, constructive feedback, aligned decision-making, and the team's movement toward a common goal. In this interpretation, the issue is not merely the technical use of communication channels, but the teacher's ability to make communication functional, pedagogically appropriate, and structurally productive. This means that the component includes both communicative actions proper and facilitative actions that prevent shared interaction from fragmenting and instead preserve its internal coherence.

The need to identify such a component is determined by the specific nature of the digital educational environment. In digital formats, much of the interaction loses the immediate support of nonverbal signals, spontaneous clarification of meaning, and situational correction of misunderstandings, all of which often

occur almost unnoticed in face-to-face communication. Instead, the role of text messages, comments, digital markers, brief reactions, video meetings with a clearly limited time, asynchronous discussion, and the digital recording of decisions becomes stronger. Under such conditions, effective teamwork requires a particularly high degree of communicative precision, well-considered feedback, clarity in task formulation, and the ability to maintain the team's working rhythm even in the absence of constant simultaneous contact. This is why the communication-facilitation component is not auxiliary, but system-forming.

Its importance is also confirmed by contemporary studies of digital pedagogical activity. In research on teachers' digital competence, communication and collaboration occupy a central place because they are the means through which professional interaction, learner support, collaboration with colleagues, and participation in the development of the educational environment are realized (Tzafilkou et al., 2023). Studies also show that technical ICT skills alone do not ensure a positive impact on educational practice unless they are combined with the ability to organize pedagogical interaction, communication, and support for other participants in the process (Lin et al., 2022). For our study, this means that teachers' digital teamwork begins not with the tool itself, but with the ability to fill it with meaningful, shared interaction.

Within the communication-facilitation component, it is useful to distinguish several interrelated elements. The first concerns the initiation and maintenance of digital communication. This refers to the ability to begin discussion in a timely manner, define the topic, engage participants in interaction, sustain a working pace of communication, and create conditions in which communication does not stop after the first contact, but develops into an ongoing professional discussion. In teamwork, this is especially important because passivity at the initial stage or a vague first message often leads to reduced engagement across the entire group. Thus, initiating interaction is not a formal beginning, but an action that sets the tone and structure of subsequent teamwork.

The second element concerns the clarity and structure of communication. In a digital environment, overly general or vague messages make coordination of actions difficult. Productive

teamwork, by contrast, requires statements that clearly communicate meaning, provide understandable reference points, define the expected format of a response or action, and allow others to quickly align their contributions with the overall task. A teacher who possesses this aspect of the communication-facilitation component can formulate tasks not only informatively but also in an organized manner. Such a teacher does not simply inform, but structures shared work through a text, comment, announcement, digital marker, or brief moderating remark.

The third element concerns maintaining meaningful feedback. In digital teams, feedback largely determines the quality of interaction. Formal responses, one-word reactions, or silent editing without explanation often create an impression of fragmentation and weaken the sense of shared work. Meaningful feedback, by contrast, helps participants better understand the logic of the shared decision, feel the value of their own contribution, adjust their actions in time, and maintain trust within the team. For the teacher, this means the ability to provide comments that are constructive, respectful, and at the same time practically useful: to clarify, suggest, justify, summarize, and support. It is precisely this kind of communication that creates the conditions not only for stronger team productivity, but also for the development of a professional culture of collaboration.

The fourth element has a directly facilitative character. It refers to the ability to sustain participants' engagement and keep the group moving toward a result. In digital formats, this includes the ability to notice when the discussion is losing focus, when part of the team is dropping out of interaction, when too many parallel comments are emerging, or when the communication process is no longer leading to a decision. In such situations, the teacher, as facilitator, must bring the team back to the subject of discussion, define the next step, summarize what has been said, move the discussion toward concrete agreements, or invite participation from those whose contributions have remained peripheral. In this sense, facilitation is not a separate option but a way of sustaining communication as a shared activity.

The fifth element concerns the regulation of the communicative atmosphere. In professional interaction, what matters is not only what is said but also how the communication

style is organized. A digital environment can either foster an open and productive atmosphere or intensify detachment, fragmentation, or tension, especially when interaction occurs asynchronously or under time pressure. For this reason, the communication-facilitation component includes maintaining appropriateness, respect, a predictable tone, attentiveness to how disagreement is expressed, tact in correcting mistakes, sensitivity to tension, and the ability to prevent conflict from escalating. For the teacher, this is fundamental, since a professional team functions effectively only when there is at least a minimal level of psychological safety.

The sixth element concerns the recording and alignment of decisions. In teamwork, digital communication cannot be limited to mere discussion. It must lead to a certain degree of clarity: what exactly has been decided, who is responsible for what, in what format the work will continue, what deadlines have been set, and where the agreed result has been recorded. The absence of such a transition from discussion to agreement is often a cause of organizational breakdowns in digital team interaction. Thus, an important indicator of a developed communication-facilitation component is the ability to turn communication into decisions, and decisions into a clearly articulated basis for further action.

To define this component more precisely, it is also useful to refer to empirically observable manifestations. At the practical level, it can be observed through the frequency and quality of the use of interaction channels, the substance of contributions in the team chat, the nature of comments in shared documents, the presence of personalized and constructive feedback, and the participant's ability to moderate a short discussion, ask clarifying questions, summarize interim results, involve others in participation, and identify next steps. These manifestations enable not only a theoretical description of the component but also the determination of its indicators and levels of development in subsequent analysis.

It is also important to emphasize that the communication-facilitation component is not isolated from the other elements of digital teamwork. It is directly connected with the collaborative creation of a digital product, since the quality of communication affects the coordination of editing, the alignment of revisions, and

the making of content-related decisions. It is likewise closely connected with the organizational-projective component, because without clear communication, it is impossible to distribute roles, monitor deadlines, coordinate stages, and sustain the structure of team activity. However, it is the communication-facilitation component that creates the primary conditions for the realization of the others, because it is through this component that the very mechanism of team interaction is formed.

In view of this, the communication-facilitation component can be defined as an integrated system of actions that ensures the initiation, maintenance, structuring, and advancement of teachers' digital professional interaction within a team through meaningful communication, constructive feedback, participant engagement, alignment of decisions, and the maintenance of a productive atmosphere of collaboration. This understanding makes it possible to regard communication not as a technical accompaniment to teamwork, but as its functional core, performing informational, organizational, coordinative, and facilitative functions simultaneously.

Thus, the communication-facilitation component serves as the foundation of teachers' digital teamwork skills, enabling productive, coordinated, and professionally appropriate interaction in a digital environment. Through it, engagement, coordination, support, clarification, alignment, and the movement of shared activity toward a result are realized. The next stage of analysis should be directed toward the second component of this phenomenon, namely the cooperative-productive component, which reflects the teacher's ability not only to interact, but also to participate in the collaborative creation of a digital product.

### *2.3. The Cooperative-Productive Component*

The cooperative-productive component reflects the element of teachers' digital teamwork skills associated not only with participation in interactions but also with the collaborative creation of a concrete outcome in a digital environment. If the communication-facilitation component ensures the possibility of coordinated professional communication, sustained engagement, and the movement of the group toward a decision, then the

cooperative-productive component makes it possible to move this interaction into the sphere of shared activity that results in the creation of an educational product, document, resource, project-based solution, or another outcome of professional value. It is through this component that digital teamwork becomes tangible, and team interaction ceases to be merely a process of discussion.

In teachers' professional activity, this component acquires particular importance because the contemporary digital educational environment increasingly requires not individual, but collective creation of materials and solutions. These may include jointly designed lessons, interdisciplinary tasks, presentations, digital exercises, methodological recommendations, event plans, analytical tables, assessment systems, visual schemes, curated collections of learning resources, models of project-based activity, or other products created not by a single teacher but by a pedagogical team. Under such conditions, what becomes important is not only readiness to participate in collective work, but also the development of specific modes of action that allow one's own contribution to be effectively integrated into a shared digital result.

For this reason, the cooperative-productive component can be understood as a set of practiced actions that ensure the teacher's participation in the collaborative creation, editing, refinement, structuring, and improvement of a digital product within team interaction. In this interpretation, the central issue is not simply the shared presence of several people in a digital environment, but their ability to work on a single professionally significant object in a way that involves aligning content, coordinating actions, transparency of changes, and responsibility for the quality of the result. This means that the cooperative-productive component has, at the same time, an action-oriented, content-related, and outcome-oriented character.

Its identification is based on the fact that teamwork in a digital environment differs fundamentally from mere task division. In many cases, work that appears outwardly collective may in fact remain a set of parallel individual actions, in which each participant completes only their own segment without any real substantive intersection with others. However, such a form of interaction does not yet ensure fully developed digital teamwork.

By contrast, the cooperative-productive component presupposes interdependence of contributions, joint formation of the product's structure, alignment of changes, discussion of quality, adaptation of individual elements to the overall concept, and willingness to work not only on "one's own part," but on the integrity of the shared result as a whole. It is precisely here that the shift from formal cooperation to substantively rich productive interaction becomes visible.

In contemporary approaches to teachers' digital competence, the creation of digital content, the adaptation of resources, and professional work with them are regarded as important dimensions of pedagogical readiness to function in a digital environment (Alom & Ramalingappa, 2025; Tzafilkou et al., 2023). For our study, however, it is important to emphasize that within teamwork, this process becomes more complex. It is not enough for a teacher simply to be able to create a digital resource independently. The teacher must be able to create it with others, taking colleagues' contributions into account, aligning the material's structure with its logic, adapting personal decisions to a shared format, and maintaining the coherence of the final result. Thus, the cooperative-productive component should be understood as a specific manifestation of digital professional competence, specifically in team activity.

Within this component's structure, it is useful to distinguish several interrelated elements. The first concerns the ability to collaborate on the creation of a digital product. This means readiness to work not in an isolated mode, but in an open space of shared work where each participant's contribution is visible, can be continued by others, and is subject to joint discussion. For the teacher, this is reflected in the ability to work with cloud-based documents, boards, spreadsheets, presentations, and collaborative planning and material development platforms, so that their activity is not private editing but part of a team process.

The second element concerns the coordination of editing and change management. In a digital environment, collaborative work on a product almost always involves repeated clarification, commenting, additions, restructuring, versioning, and editing by different participants. Accordingly, the development of the cooperative-productive component is reflected in the ability to

work with revision history, comment on edits, propose changes in an appropriate and transparent way, and do so without disrupting another person's contribution, but instead integrating it into the shared result. This also involves the ability to avoid duplication, chaotic changes, uncoordinated editing, and the loss of important elements of the shared product.

The third element encompasses the substantive alignment of contributions. The collaborative creation of a digital product is impossible without understanding how individual parts relate to one another and how they function within the whole. Therefore, the teacher must not only create their own segment of the material, but also see it within the structure of the overall result. This means the ability to follow a shared logic, align style and format, adapt material to the overall concept, revise individual elements for the sake of coherence, and participate in the joint refinement of the product even beyond the function originally assigned. It is precisely this approach that transforms a sum of separate contributions into an integrated professional result.

The fourth element concerns the integration and adaptation of digital resources. In real practice, teachers' teamwork often involves not the creation of entirely new material from scratch, but the selection, evaluation, combination, adaptation, and reinterpretation of existing resources. In this regard, the cooperative-productive component includes the ability not merely to add links or fragments of materials, but to integrate them meaningfully into a shared product, align them with the team's goal, revise them when necessary, and ensure pedagogical appropriateness, proper attribution, and structural coherence. This is especially important in a digital environment, where access to a large number of ready-made resources makes searching easier, but does not guarantee meaningful use.

The fifth element is connected with productive responsibility. In teacher teamwork, it is not enough to complete one's own part of the task formally. It is necessary to relate one's contribution to the quality of the final result, to be ready to improve what has been created in response to colleagues' comments, to return to earlier stages if this is necessary for the coherence of the product, and to treat the shared result as a zone of responsibility rather than as a mechanical sum of individual fragments. In this sense,

the cooperative-productive component combines technological proficiency with the professional ethics of shared authorship.

The sixth element concerns the ability to engage in shared reflection on the product. The quality of digital teamwork is determined not only by the creation of shared material but also by the willingness to evaluate its strengths and weaknesses, identify inconsistencies, refine quality criteria, relate the product to the original goal, and make revisions when needed. Thus, the cooperative-productive component includes not only the production phase, but also the phase of jointly interpreting and evaluating the result. It is at this stage that the team moves from completing the task to professionally improving the outcome.

At the practical level, the development of this component can be observed through several specific manifestations. These include active participation in collaborative editing of documents, use of comments and suggestion mode, appropriate revision practices, adherence to an agreed format, the ability to integrate one's own material into a shared structure, work with version history, meaningful responses to colleagues' suggestions, and participation in refining the product after interim discussion. Equally revealing is the ability to work in shared presentations, spreadsheets, visual boards, digital collections of resources, and cloud storage spaces without losing the logic of the shared product and without generating organizational chaos.

It is also important to emphasize that the cooperative-productive component is directly connected with the teacher's professional growth. In situations of collaboratively creating a digital product, the teacher does not merely complete a task, but also learns through interaction: by observing colleagues' ways of working, adopting more effective ways of structuring material, learning to formulate content more precisely, seeing alternative styles of organizing a resource, and refining personal understandings of the quality and appropriateness of a digital product. Thus, this component has not only a productive, but also a developmental significance, because through it, teamwork becomes a form of professional learning in action.

At the same time, the cooperative-productive component cannot be regarded as autonomous from the other elements of

digital teamwork. It depends directly on the quality of the communication-facilitation component, because without meaningful communication, it is impossible to align the product's structure, editing modes, and quality criteria. It is likewise closely connected to the organizational-projective component, since the collaborative creation of a digital product requires planning stages, the distribution of functions, temporal coordination, and monitoring progress. However, it is precisely the cooperative-productive component that represents the level at which teamwork takes on its most visible form, because it is embodied in a jointly created outcome.

In view of the above, the cooperative-productive component can be defined as an integrated system of actions that ensures the teacher's participation in the collaborative creation, substantive alignment, editing, refinement, and reflective improvement of a digital product within team-based professional interaction. This definition shows that teachers' digital teamwork is realized not only through communication but also through productive joint activity, in which each contribution acquires meaning only within the integrity of the shared result.

Thus, the cooperative-productive component is the second essential element of teachers' digital teamwork skills. It reflects the teacher's ability not only to interact with others in a digital environment, but also to build with them a professionally meaningful product while maintaining its coherence, quality, logic, and pedagogical appropriateness. The next stage of the discussion should focus on the organizational-projective component, which ensures planning, role distribution, coordination of stages, and maintenance of the structure of team activity in a digital environment.

#### *2.4. The Organizational-Projective Component*

The organizational-projective component reflects that element of teachers' digital teamwork skills that ensures the structured nature of shared activity, its temporal and substantive coordination, the distribution of roles, the alignment of work stages, and the team's movement toward a planned result. If the communication-facilitation component creates the conditions for

meaningful interaction, the cooperative-productive component ensures the collaborative creation of a digital product, and the organizational-projective component provides the structural framework for the entire teamwork process, then the organizational-projective component provides that framework. It is through this component that shared activity acquires sequence, predictability, and manageability, and that team interaction does not break down into separate episodes.

In teachers' professional activity, this component becomes especially important because the digital educational environment significantly expands the possibilities for teamwork while simultaneously increasing the risks of disorganization. Open access to shared documents, asynchronous modes of work, a large number of communication channels, parallel tasks, and the flexibility of digital tools can support team productivity only when clear organization is in place. If such an organization is absent, typical difficulties arise: duplication of functions, uncertainty about responsibility, delayed completion of stages, loss of the logic of shared work, overload of particular participants, blurred deadlines, and a decline in the quality of the final result. Thus, the organizational-projective component is not a technical supplement to digital teamwork, but a necessary condition for it.

This component can be understood as a set of practiced actions that ensure the planning, structuring, coordination, distribution, and monitoring of team activity in a digital environment to achieve a shared professional goal. In this interpretation, the issue is not merely formal management of the process, but the teacher's ability to build the logic of shared work, connect separate stages into a coherent sequence, understand the interdependence of tasks, adjust the course of work in a timely manner, and maintain the team's functional coherence. For this reason, this component should be viewed as a combination of organizational culture, project thinking, time discipline, and digitally mediated coordination.

The need to identify such a component is also connected with broader changes in the teacher's professional role. Contemporary pedagogical activity increasingly includes participation in team initiatives, short- and medium-term projects, collaborative planning, interdisciplinary interaction, joint creation

of instructional materials, and coordinated decision-making. Under these conditions, the teacher must be able not only to join an already organized process but also to sustain its structure independently at the level of a micro-team, creative group, methodological association, or shared digital task. Thus, the organizational-projective component is directly linked to micro-leadership, distributed responsibility, and the practical enactment of educational leadership in everyday professional interaction.

Within this component's structure, it is useful to distinguish several interrelated elements. The first concerns the planning of shared activity. This refers to the ability to define the goal of a team task, break it down into stages, outline the logical sequence of actions, set deadlines, and understand the interdependence of individual parts of the work. In a digital environment, this ability is reflected in the capacity to work with project boards, task lists, calendars, trackers, and other tools for visualizing the team's process. What matters here is not the mere use of a service, but the ability to design activities so that each participant can see the overall logic of the work and their own place within it.

The second element covers the distribution of roles and functions. Effective digital teamwork requires not only a shared goal but also a clear division of responsibility. Within this component, the teacher must be able to determine who is responsible for each stage, who coordinates progress, who collects materials, who carries out final editing, who moderates discussion, and who works on visualization or technical formatting. At the same time, the issue is not the rigid fixation of roles, but their functional clarity. It is precisely this that makes it possible to avoid disorder, duplication of actions, and situations in which a task "belongs to everyone" and therefore in practice is completed by no one.

The third element concerns the coordination of stages of shared work. Planning in itself does not guarantee productivity if the team does not maintain a connection between the original plan and actual progress. For this reason, the organizational-projective component includes the ability to track what stage a shared task has reached, which actions have already been completed, what requires further refinement, where delays are emerging, and where the team needs to regroup its efforts. In a digital

environment, this may be realized by updating task statuses, marking completion stages, entering interim results into shared tables, posting comments on project boards, or using other coordination tools. In all cases, however, the essence remains the same: the teacher must view teamwork as a process that requires continuous alignment.

The fourth element concerns the temporal organization of activity. Digital teamwork often occurs asynchronously, with participants working at different times and varying levels of intensity. This expands the possibilities for flexible collaboration but, at the same time, requires a clearer approach to deadlines, intermediate milestones, and the implementation rhythm. Thus, the organizational-projective component includes the ability to work with time frames not formally, but functionally: to set realistic deadlines, make them visible to the team, provide timely reminders about critical points, adjust the plan when changes occur, and relate the pace of work to the actual complexity of the task. In teachers' professional activity, this is especially important because digital collaboration is often combined with heavy workload and multitasking.

The fifth element covers the ability to prevent and manage organizational disruptions. In any team activity, delays, misunderstandings, overlapping functions, uneven distribution of contributions, or changes in implementation conditions may occur. In a digital environment, these difficulties do not disappear and may even become more acute due to asynchronous formats, the lack of immediate feedback, or a disconnect between communication and execution. For this reason, the organizational-projective component includes the ability to notice such disruptions in a timely manner, clarify agreements, redistribute actions, bring the team back to the agreed plan, or simplify the work structure if it proves excessively complex. In this sense, the issue is not organization as such, but flexible organizational sensitivity.

The sixth element concerns the use of digital tools to visualize and sustain the structure of team activity. In contemporary digital teamwork, it is important not simply to reach agreements orally or in a chat, but to document the logic of the activity in a form accessible to all participants. These may include

Kanban boards, responsibility charts, checklists, calendars, shared folders, stage maps, role-distribution templates, or digital status markers. What is fundamental is that such tools perform not a supplementary, but an organizational function. They make shared work transparent, reduce the risk of losing track of agreements, allow participants to navigate the process more quickly, and support a common understanding of the task. Thus, the organizational-projective component includes not only the ability to use such tools, but also the ability to select them in accordance with the specific task's logic.

The seventh element concerns the reflective adjustment of the process. Any project-based format involves not only carrying out work according to plan, but also considering how effective the chosen activity structure actually is. A teacher with a developed organizational-projective component is able not simply to proceed according to the initial scheme, but to assess whether it is working, whether it needs revision, whether particular stages are overloaded, whether some roles remain undefined, or whether the team is losing momentum because of excessive complexity or, conversely, insufficient detail. This kind of reflectiveness is especially important in a digital environment, where changes may occur quickly, and an excess of tools can sometimes complicate rather than facilitate activity.

At the practical level, the development of this component can be observed through several specific manifestations. These include the ability to structure tasks on a digital board, mark work stages, set deadlines, assign responsibility, update completion statuses, relate the course of work to the initial plan, respond to delays, clarify functions, conduct short project discussions, and turn them into operational decisions. Also revealing is the ability to use checklists, calendars, role-distribution matrices, and shared resource storage spaces without losing the task's logic. All of this makes it possible not only to describe the organizational-projective component theoretically, but also to determine its indicators and levels of development in later analysis.

It is important to emphasize that the organizational-projective component is not something external to the pedagogical essence of the teacher's activity. On the contrary, it is through this component that teamwork acquires professional reliability. In an

educational environment, it is not enough to merely foster a collaborative atmosphere or provide access to shared documents. The team must work within a clear logic, keep sight of its goals, move from intention to implementation in a timely manner, and deliver shared activities to completed results. For this reason, the organizational-projective component is a manifestation of the teacher's professional maturity in a digital environment and a condition for the teacher's educational leadership within the team.

This component is closely connected with the previous elements of digital teamwork. Without the communication-facilitation component, it is impossible to align the plan, distribute roles, and adjust actions. Without the cooperative-productive component, the organization loses its substantive center, since it no longer leads to the creation of a shared result. However, it is precisely the organizational-projective component that brings these elements together into a functionally coherent system, because it provides the framework within which communication becomes work-oriented and the collaborative creation of a product gains sequence and completion.

In view of the above, the organizational-projective component can be defined as an integrated system of actions that ensures planning, distribution of functions, temporal and substantive coordination, maintenance of structure, adjustment of the process, and completion of the teacher's digital teamwork aimed at achieving a shared professional goal. This definition makes it possible to view digital teamwork not only as communication or collaborative product creation, but as a structured process that requires project-based thinking, organizational discipline, and the ability to act under conditions of change.

Thus, the organizational-projective component is the third essential element of teachers' digital teamwork skills. It ensures the internal orderliness of shared activity, makes it transparent, manageable, and outcome-oriented, supports the connection between intention and implementation, and reduces the risks of disorganization in a digital environment. Taken together, the communication-facilitation, cooperative-productive, and organizational-projective components provide grounds for moving

toward a broader synthesis of their interaction within the overall structure of teachers' digital teamwork skills.

### *2.5. The Interrelationship of the Components and the Logic of Their Development*

Teachers' digital teamwork skills do not constitute a mechanical combination of separate abilities, but rather an integrated system of interrelated components, each performing its own function and fully realized only in interaction with the others. For this reason, they should be viewed not in isolation, but as a structurally integrated construct within which the communication-facilitation, cooperative-productive, and organizational-projective components do not merely coexist, but mutually support and reinforce one another. This structuring is consistent with contemporary studies of pedagogical activity in digital environments, which emphasize the combination of several interdependent dimensions of professional action: digital communication, interaction design, collaborative work organization, product creation, and reflective support. This provides grounds for considering teamwork skills not as a single behavioral response but as a systemic, multi-component phenomenon (Amelia et al., 2024; Hrechanyk et al., 2024). Such an approach is fundamental for further analysis because it enables moving from describing separate elements to understanding the internal logic of teachers' digital teamwork as a coherent professional phenomenon.

The first and most evident connection is the one between the communication-facilitation and cooperative-productive components. The collaborative creation of a digital product cannot be effective without high-quality interaction among team members. If communication remains fragmented, unstructured, or merely formal, the team is unable to align on the product's logic, coordinate contributions, respond to changes, and ensure the substantive coherence of the shared result. At the same time, communication itself loses its professional completeness if it is not directed toward a concrete productive outcome. Thus, there is a direct interdependence between these two components: communication provides the conditions for the cooperative

creation of a product, while collaborative work on the product gives communication substance, specificity, and professional direction.

The connection between the communication-facilitation and organizational-projective components is no less close. Planning, coordination of stages, role distribution, and monitoring of implementation cannot be effective without meaningful digital communication, clear agreements, and timely feedback. Even a well-designed organizational scheme loses its effectiveness if the team lacks the skills to sustain productive interaction, clarify tasks, respond to delays, and coordinate adjustments to the process. In turn, communication itself requires an organizational foundation. If stages, roles, deadlines, and the logic of progress are not defined, even active discussion can remain scattered and fail to lead to coordinated decisions. For this reason, the organizational-projective component performs a structuring function in communication, while the communication-facilitation component sustains the viability and flexibility of the team process within the organization.

The cooperative-productive and organizational-projective components are also in a direct, mutually reinforcing relationship. The collaborative creation of a digital product requires not only substantive alignment of contributions but also a clear structure of activities: a sequence of stages, distribution of responsibilities, defined deadlines, transparency of changes, and visibility into the current status of the task. Without such organization, cooperative work quickly loses coherence, and the product becomes fragmented or internally inconsistent. At the same time, the organization itself acquires meaning only when it serves the creation of a concrete shared result. Otherwise, the team risks focusing on technical maintenance of the process rather than sufficient substantive content. Thus, the organizational-projective component creates the framework for productive joint activity, while the cooperative-productive component fills that framework with professionally meaningful content.

Thus, all three components are in a relationship of functional interdependence (Figure 2.1). The communication-facilitation component enables meaningful interaction and sustains participants' engagement. The cooperative-productive component

is responsible for the collaborative creation, alignment, and improvement of the digital product. The organizational-projective component gives team activity structure, sequence, and manageability. The absence or weak development of even one of these components disrupts the integrity of the entire system. If high-quality communication is lacking, the team is unable to coordinate shared activity effectively. If the productive dimension is underdeveloped, interaction yields no concrete result. If organizational structure is absent, even meaningful discussion and readiness for collaboration do not ensure steady movement toward the goal.

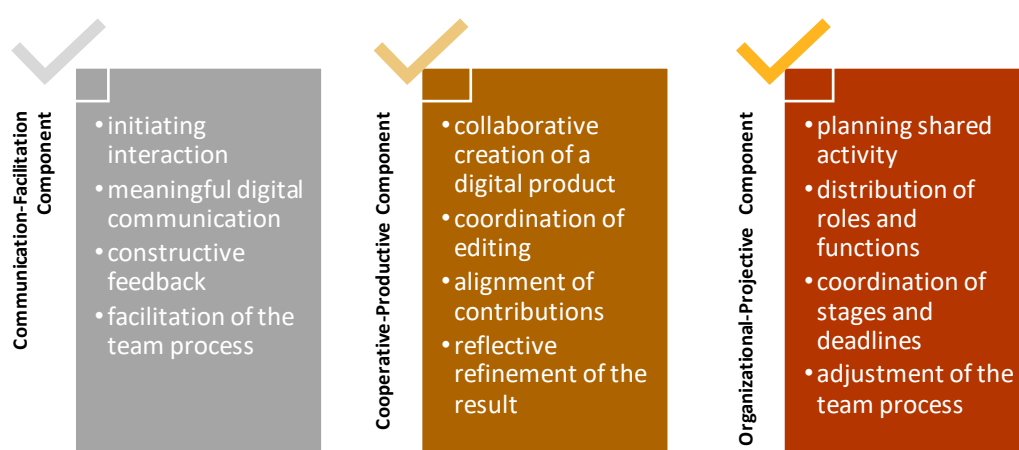


Figure 2.1  
**Structural Model of Teacher Teamwork**

*Source: Authors' own work.*

The interrelated nature of these components also means that they should not be developed sequentially as fully autonomous stages of professional preparation. Although they were examined separately for analytical clarity, in actual pedagogical practice and, accordingly, in teachers' professional development, they are formed in interaction with one another. For example, working on a shared digital document simultaneously requires communication, coordination of editing, and adherence to a certain organizational logic. Participation in team planning through a digital board requires meaningful discussion, agreement on roles, and the ability to collaboratively create a working product in the form of a task structure or project scheme. For this reason,

the development of teachers' digital teamwork skills must be comprehensive and rely on activities in which teachers simultaneously communicate, collaborate on a shared product, and organize the process.

It is precisely for this reason that short-term or overly narrow digital training formats do not always produce a noticeable effect in preparing teachers for teamwork. If teachers' professional development is reduced merely to familiarization with individual services, a coherent understanding of how these services function within a team process is not formed. If the emphasis is placed only on communication without a productive shared task, experience in the cooperative creation of a result does not develop. If, on the other hand, attention is focused only on project structure or the mechanical use of trackers, but without meaningful interaction and facilitation, teamwork takes on a formal character. Thus, the logic of developing these skills lies not in accumulating isolated micro-skills, but in gradually building the ability to act within an integrated digital team environment.

In this sense, it is useful to speak of a certain internal logic in the development of the components. At the initial level, the teacher usually masters basic forms of digital communication and individual use of particular services. The next important step is the transition to elementary shared activity: exchanging materials, participating in collaborative editing, responding to comments, and performing clearly defined roles. The following step involves working in more complex forms of team organization, where not only the participation and execution of separate actions are required, but also the coordination of stages, facilitation of discussion, alignment of changes, maintenance of the logic of the shared product, and reflective improvement of the process. Thus, the development of digital teamwork skills proceeds from partial instrumental participation to integrated professional collaboration.

It is important to emphasize that this logic of development is not purely linear. In real practice, individual components may develop unevenly. A teacher may be quite confident in using digital communication tools but may experience difficulties facilitating group interaction. Another may be able to work on a shared product, but may not plan stages and distribute roles with sufficient clarity. Still another may organize the process well but

may not always sustain a constructive atmosphere of digital interaction. For this reason, the system of components is important not only for the theoretical description of the phenomenon, but also for subsequent assessment, since it enables identification of both the overall level of skill development and the relatively stronger or weaker elements within its structure.

This leads directly to the next analytical step. If teachers' digital teamwork skills have a complex, internally interconnected structure, their development cannot be described solely in terms of general categories such as "possesses" or "does not possess." A more precise system of assessment is needed, one that makes it possible to determine the exact criteria, indicators, and levels by which the development of each component and of the system as a whole can be identified. Thus, the logic of examining the structure of teachers' digital teamwork skills naturally leads to the development of instruments for their assessment, which is the subject of the next section.

Thus, the communication-facilitation, cooperative-productive, and organizational-projective components form an integrated system in which each component performs its own function, yet can fully realize that function only in interaction with the others. This approach makes it possible to view teachers' digital teamwork not as a sum of disconnected skills, but as an integrated professional capacity for coordinated, structured, productive, and technologically mediated interaction in a digital educational environment. It is precisely this that provides the methodological foundation for further identification of criteria, indicators, and levels of development for the corresponding skills.

### **3. Criteria, Indicators, and Levels of Development of Teachers' Teamwork Skills in a Digital Educational Environment**

#### *3.1. Methodological Foundations for Building the Assessment System*

Building an assessment system for teachers' digital teamwork skills requires a clear methodological foundation, since the issue involves a complex professional phenomenon that

cannot be reduced to either separate technical skills or a general impression of a teacher's participation in shared activity. The previous section substantiated that teachers' digital teamwork has an integrated character and includes communication-facilitation, cooperative-productive, and organizational-projective components. This, in turn, makes it necessary to develop an assessment system capable of identifying not only the overall level of development of these skills, but also the structure of their manifestation, the internal links among components, and the strengths and weaknesses of teachers' professional behavior in a digital environment.

A methodologically important point is that the object of assessment is not isolated knowledge of digital tools and not the formal use of services, but the teacher's actual ability to act within conditions of team-based professional interaction. For this reason, the assessment system should be oriented not only toward the declarative level, that is, what the teacher reports about themselves, but also toward the action-oriented level, where specific manifestations of interaction, coordination, collaborative creation of a digital product, process organization, and facilitation of group work are documented. This approach is consistent with contemporary models of teachers' digital competence, which emphasize the need to combine professional, pedagogical, and behavioral dimensions of assessment (Tzafilkou et al., 2023). For our study, this means the assessment system must go beyond traditional questionnaire-based procedures and include methods of documentation that allow observation of the actual functioning of skills in digital teamwork.

One of the basic methodological foundations for constructing such an assessment system is a competence- and action-oriented approach. Its essence lies in the fact that what is assessed is not an isolated set of operations, but the teacher's ability to act effectively in professionally significant situations. For this reason, the focus of the system should not be on individual services or technical techniques, but on the typical actions that constitute the substance of digital teamwork: initiating and sustaining communication, providing constructive feedback, coordinating editing, aligning contributions, planning stages, distributing roles, maintaining deadlines, responding to difficulties, and reflectively

refining the result. This understanding makes it possible to assess the professional adequacy of the relevant skills, rather than merely the fact of familiarity with digital tools.

The second essential methodological foundation is the structured nature of assessment. Since teachers' digital teamwork skills have an internally differentiated structure, the assessment system must reflect that structure rather than dissolve it into a single generalized indicator. Otherwise, the results will have limited interpretive value: a high or medium overall score will not indicate exactly where a teacher's professional strengths or difficulties lie. For this reason, the system should be built using the components identified earlier. This means that the criteria, indicators, and assessment descriptors should correspond to the communication-facilitation, cooperative-productive, and organizational-projective dimensions of the phenomenon under study. Such an approach enables combining the overall integrity of assessment with analytical sensitivity.

The third methodological foundation is the use of multiple data sources. Research on digital competence has repeatedly emphasized that relying solely on self-assessment does not provide a sufficiently reliable picture, since respondents may either overestimate or underestimate their own abilities, basing their judgments not on actual practice, but on a general impression of themselves or on socially desirable responses (Alom & Ramalingappa, 2025; Tzafilkou et al., 2023). This is especially relevant for assessing digital teamwork, because some of the relevant skills are context-dependent and become visible only in actual interaction. Thus, it is methodologically justified to construct the assessment system using multiple data sources. In our case, this means combining self-assessment, observation of performance during a practical task, and analysis of digital artifacts produced during the shared activity. It is precisely this form of triangulation that makes it possible to bring assessment closer to the actual professional functioning of the skills.

The fourth foundation is the combination of process- and outcome-oriented assessment dimensions. In digital teamwork, what matters is not only whether a team has produced a particular product, but also how that product was created. A team may achieve an acceptable result because of the high activity of one

participant and the minimal involvement of the others, or through chaotic, inefficient actions that only accidentally lead to the desired outcome. In such cases, the product itself does not provide complete information about the level of development of the relevant skills. For this reason, the assessment system must take into account both process indicators, which characterize the course of interaction, and outcome indicators, which concern the quality of the shared product or the completeness of the team task. This approach is particularly important for the analysis of digital activity, where the process itself leaves numerous recorded traces: version histories, comments, status changes, board structures, the temporal dynamics of completion, and so forth.

The fifth methodological foundation is contextuality of assessment. Digital teamwork skills do not exist outside specific professional interaction situations. Their manifestation depends on the task type, the tools selected, the team size, the degree of role clarity, time constraints, the product's complexity, and the participants' prior experience. For this reason, the assessment system cannot be abstract or based on test questions artificially detached from practice. It must rely on tasks and procedures that model real or as close to real professional situations as possible. This means that assessment instruments should be embedded in team activities rather than imposed from the outside. That is why, in our study, the practical task is regarded not as an additional element but as one of the central means for identifying the level of development of the skills under investigation.

The sixth foundation is criterion-based clarity. The assessment system must be designed so that each result can be interpreted on the basis of clear criteria and indicators rather than the evaluator's general impression. This is especially important for complex professional phenomena, where the risk of subjectivity is high. In our case, criterion-based clarity means that concrete manifestations must be formulated for each component of digital teamwork skills: what exactly counts as meaningful digital communication, what constitutes evidence of coordinated editing, how the organizational structure of teamwork is identified, what indicates the presence of facilitation, how the coherence of a shared product is assessed, and so forth. In this way, the assessment system gains not only research value but also

methodological value, as it can serve as a tool for feedback and professional development.

The seventh methodological foundation is level-based interpretation of results. For professional development, it is not enough to simply identify the presence or absence of a particular skill. It is necessary to assess its degree of development, the dynamics of its growth, and its potential for further improvement. For this reason, assessment results should be interpreted through a system of levels that reflect the gradual transition from an initial, situational, or unstable manifestation of a skill to its confident, integrated, and professionally productive application. This approach aligns with contemporary frameworks for assessing digital competence, which interpret the outcome as a level of development rather than a binary state of “present or absent” (Tzafilkou et al., 2023). For our study, this allows not only measuring changes after the training intervention but also showing their nature in a more nuanced way.

The eighth foundation is the combination of quantitative and qualitative assessment logics. Although results can be conveniently summarized through scales, scores, or levels, the phenomenon of digital teamwork cannot be fully described by numerical indicators alone. For example, two teachers may receive the same total score while demonstrating different interaction styles: one may be stronger in coordination, while the other is stronger in facilitation or collaborative editing. For this reason, quantitative results should be supplemented by a qualitative description of the nature of the observed manifestations. Such an approach not only increases the interpretive value of the results but also helps avoid excessive simplification of a complex professional phenomenon. In this sense, the assessment system must be analytically flexible: sufficiently structured to allow comparison of results, yet sufficiently substantive to explain their nature.

The ninth important foundation is the developmental character of assessment. Within our study, the assessment system is not limited to a control function. It should not only document the current level of skill development but also lay the foundation for further growth. This means that assessment must perform diagnostic, analytical, and feedback functions: helping the

teacher identify strengths, recognize problematic areas, relate personal practice to clear professional benchmarks, and understand the directions in which improvement is possible. This approach is especially important in the context of short-term training programs, where assessment should be integrated into the learning process rather than reserved for the final stage.

Taking these foundations into account, the assessment system for teachers' digital teamwork skills in our study is constructed as a comprehensive, multi-component, and criterion-based model that draws on several data sources, combines process-oriented and outcome-oriented dimensions, takes the professional context into account, and provides for level-based interpretation of results. Such a design enables assessment not only of the teacher's overall readiness for digital teamwork, but also of its concrete manifestations in real or simulated professional interaction.

It is precisely on this methodological basis that the criteria, indicators, descriptors, and levels of development of teachers' digital teamwork skills can be identified in the sections that follow. The next logical step, therefore, is to specify this system by describing the assessment criteria and indicators in accordance with the phenomenon's structural components.

### *3.2. Assessment Criteria and Indicators*

The identification of assessment criteria and indicators for teachers' digital teamwork skills is a necessary stage in building a coherent diagnostic system, as it is through these that the methodological foundations of assessment take on an operational form. If the previous subsection substantiated the general principles for constructing the assessment system, at this stage, it is important to move toward specifying the exact features through which the development of the phenomenon under study can be identified. Such specification is needed not only for analytical precision, but also to ensure the transparency, repeatability, and practical applicability of the assessment in teachers' professional development. The relevance of this approach is confirmed by studies of teamwork in digital and blended educational formats, where one of the main problems

identified is not a lack of interest in teamwork, but insufficient clarity in the criteria for its instruction and assessment. Therefore, the development of a system of indicators in our study is not merely a methodological step, but also a response to a broader difficulty documented in contemporary digital pedagogy (Espejo et al., 2023; Amayou et al., 2025).

Since, within this study, teachers' digital teamwork skills are understood as an integrated system that includes communication-facilitation, cooperative-productive, and organizational-projective components, the system of criteria and indicators must reflect this very structure. Accordingly, it is advisable to construct the criteria not according to the logic of individual digital tools, but according to the logic of the professional functions that the teacher performs in shared activity. Such an approach allows avoiding a situation in which assessment effectively replaces the professional substance of the activity with a list of technical actions. Instead, the focus falls on the manifestations that characterize the quality of collaboration: readiness to initiate interaction, sustain constructive communication, coordinate contributions, organize teamwork, and jointly bring a digital product to completion. In this sense, the system of criteria should reflect not a set of services, but the internal logic of the teacher's professional teamwork activity (Navio-Marco et al., 2025; Shuppe et al., 2024). This makes it possible to avoid a technocratic narrowing of assessment and to focus on the actual substance of teamwork in a digital educational environment. In this connection, our study identifies three main criteria: communication-facilitation, cooperative-productive, and organizational-projective. Each of them is specified through a system of concrete indicators that reflect observable or documentable manifestations of the corresponding component.

The first is the communication-facilitation criterion, which characterizes the teacher's ability to ensure meaningful digital interaction, sustain constructive communication, engage participants in shared activity, provide feedback, and help move the team toward a common decision. This criterion is of fundamental importance because it is through it that the basic function of interaction is realized, without which neither coordination of actions, nor collaborative product creation, nor

organization of the team process is possible. Its assessment enables identification not merely of the teacher's presence in a digital space, but also of the nature of that teacher's participation in professional interaction.

The main indicators of this criterion should include, first, the initiation and maintenance of digital interaction. This refers to the teacher's ability to initiate professional discussion, define its subject, set a productive tone for communication, sustain its rhythm, and prevent interaction from fading at the outset. The second indicator is the clarity and structure of digital messages, that is, the ability to formulate messages, comments, or instructions so that they are understandable, functionally appropriate, and connected to the logic of the shared task. The third indicator is the quality of feedback, which includes the ability to provide meaningful, constructive, well-grounded, and respectful comments that help other team members adjust or continue their work. The fourth indicator is related to facilitation of the team process, that is, the ability to sustain participants' engagement, summarize interim results, bring the group back to the subject of discussion, and help move from discussion to decision. The fifth indicator is the maintenance of a constructive communicative atmosphere, which includes respect for others' positions, appropriate behavior in situations of disagreement, prevention of communicative tension, and the ability to preserve a productive character of interaction. Taken together, these indicators make it possible to assess the extent to which the teacher is able not merely to participate in digital communication, but to organize it as an instrument of professional teamwork.

The second is the cooperative-productive criterion, which reflects the teacher's ability to engage in the collaborative creation of a digital product, coordinate their own contributions with those of others, and participate in the editing, alignment, and improvement of the shared result. If the first criterion captures the quality of interaction as a process, this criterion moves the assessment into the sphere of collaborative productive activity. It is precisely this criterion that allows us to determine whether the teacher is capable of working within the logic of shared authorship, rather than merely commenting, observing, or completing an isolated part of the task.

Among the main indicators of the cooperative-productive criterion, the first is involvement in the collaborative creation of a digital product. This indicator characterizes the teacher's level of activity and the substantive quality of participation in a shared document, board, presentation, spreadsheet, or other collaboratively developed resource. The second indicator is coordination of editing and management of changes, that is, the ability to work with comments, versions, clarifications, and revisions without losing the logic of the shared product and without generating chaotic changes. The third indicator concerns alignment of one's own contribution with the overall structure of the result. This refers to the ability to relate one's own materials, suggestions, or revisions to the overall goal, format, style, and substantive logic of the product, and to adapt them when necessary. The fourth indicator is the integration and adaptation of digital resources, manifested in the ability to select, reinterpret, and appropriately incorporate ready-made materials into the shared result without undermining its coherence or pedagogical appropriateness. The fifth indicator is the reflective refinement of the product, that is, the teacher's willingness to participate in the collective improvement of the result after receiving comments, engaging in discussion, or completing an interim review. Taken together, these indicators enable assessment of the extent to which the teacher can function in a mode of genuine productive collaboration, where value lies not only in an individual contribution but also in its integration into a coherent shared outcome.

The third is the organizational-projective criterion, which characterizes the teacher's ability to plan team activity, structure its stages, distribute roles, coordinate implementation, sustain the temporal logic of the process, and respond to organizational disruptions. This criterion is especially important in a digital educational environment, where the flexibility of tools and the asynchronous nature of interaction create both broad opportunities and significant risks of disorganization. For this reason, the level of development of the corresponding component is determined not by the number of services used, but by the teacher's ability to ensure the orderliness and completeness of the team process.

The key indicators of the organizational-projective criterion include, first, planning of shared activity, that is, the ability to define the goal, break it down into stages, understand the sequence of actions, and determine the logic of progress toward the result. The second indicator is the distribution of roles and functions, which reflects the ability to identify responsible participants, align functional areas, and maintain a clear structure of participation within the team. The third indicator concerns coordination of implementation stages: the ability to track the status of the task, record completed and problematic segments, and coordinate transitions between stages in a timely manner. The fourth indicator is the temporal organization of activity, which includes the ability to work with deadlines, intermediate time points, the rhythm of implementation, and maintaining the pace of teamwork. The fifth indicator is responsiveness to organizational difficulties and adjustment of the process, including the ability to notice delays, clarify agreements, revise the structure of activity, redistribute functions, or change the sequence of actions when necessary. A sixth indicator may be defined as the use of digital tools to support the structure of team activity, that is, the ability to use boards, trackers, calendars, checklists, spreadsheets, or other visualized forms of organization not formally, but in accordance with the logic of a specific task. It is precisely these indicators that enable us to assess the extent to which the teacher can ensure the organizational viability of shared digital work.

It is important to emphasize that the proposed criteria do not function as three completely isolated dimensions. They are analytically distinct, but in practice, they manifest themselves through interaction. For example, clarity in digital communication supports the coordination of work stages; the quality of editing a shared document is related to both the cooperative-productive and the communication-facilitation dimensions; and timely responses to delays combine organizational-projective and facilitative aspects. At the same time, it is precisely the differentiation by criteria that makes assessment more sensitive and methodologically sound. It allows you to see not only a general impression of the teacher's work in a team, but also its specific characteristics.

From a methodological perspective, it is worth emphasizing that each indicator should be linked to particular forms of documentation. Thus, the indicators of the communication-facilitation criterion may be identified through the analysis of messages in chats, comments in documents, the substance of feedback, and the nature of participation in discussions. The indicators of the cooperative-productive criterion may be documented through analysis of version history, the structure of the shared product, the quality of integration of contributions, and participation in refining the result. The indicators of the organizational-projective criterion are best identified through the structure of the digital board, task statuses, the distribution of responsibility, the visibility of stages, adherence to deadlines, and the nature of responses to organizational difficulties. In this way, criteria and indicators do not remain an abstract scheme but can be linked to specific data sources, which ensures the validity of the assessment system. Particularly promising in this regard is the use of digital artifacts as an empirical basis for assessment. Revision history, comments, messages, the structure of shared boards, task statuses, and other traces of digital interaction make it possible to move from purely declarative self-description to a more objective analysis of actual teamwork behavior. This logic corresponds to the contemporary understanding of the digital environment as a space where activity not only occurs but also becomes visible for further analysis and pedagogical reflection (Echeverría et al., 2024a).

For clarity and for further use in the study, we summarized the criteria and indicators in Table 3.1. This understanding of the communication-facilitation criterion is consistent with findings from studies on the communicative competence of future professionals in the information and digital educational environment, where the quality of interaction, the structure of messages, engagement in shared discussion, and the maintenance of a productive communicative mode emerge as important indicators of professional growth.

Thus, the communication-facilitation criterion has a robust scholarly foundation and aligns with the actual logic of digital teamwork (Shuppe et al., 2024).

Table 3.1

**Criteria and Indicators for Assessing Teachers' Digital Teamwork Skills**

| <i>Criterion</i>                  | <i>Criterion Content</i>                                                                                                                                       | <i>Main Indicators</i>                                                                                                                                                                                                                      |
|-----------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Communication-Facilitation</b> | Characterizes the teacher's ability to ensure meaningful digital interaction, sustain communication, feedback, and participants' engagement in shared activity | Initiation and maintenance of digital interaction; clarity and structure of messages; quality of feedback; facilitation of the team process; maintenance of a constructive communicative atmosphere                                         |
| <b>Cooperative-Productive</b>     | Reflects the teacher's ability to participate in the collaborative creation, editing, alignment, and improvement of a digital product                          | Involvement in collaborative product creation; coordination of editing and management of changes; alignment of contributions; integration and adaptation of digital resources; reflective refinement of the result                          |
| <b>Organizational-Projective</b>  | Characterizes the teacher's ability to plan, structure, coordinate, and adjust team activity in a digital environment                                          | Planning shared activity; distribution of roles and functions; coordination of implementation stages; temporal organization of activity; response to organizational difficulties; use of digital tools to support the structure of teamwork |

Source: Authors' own work.

The relevance of the cooperative-productive criterion is likewise confirmed by studies on digital educational practices, which treat the joint development of content, collaborative editing, integration of participants' contributions, and refinement of the result as independent indicators of mature collaboration. In a digital environment, the product becomes not simply an outcome of activity but a materialized expression of how effectively the team has organized its interactions (Balova-Tzvetkova & Panayotova, 2023; Amelia et al., 2024). It is the organizational-projective criterion that most clearly links digital teamwork with

the project culture of contemporary education. Studies of the digital transformation of the educational environment show that the effectiveness of activity depends to a considerable extent on how well access to resources, technical support, coordination of work stages, and management of educational processes are organized. For this reason, the organizational-projective criterion reflects not an auxiliary, but one of the central dimensions of digital interaction (Majdi et al., 2024; Hrechanyk et al., 2024).

Thus, the system of criteria and indicators enables moving from a general description of teachers' digital teamwork skills to their concrete assessment in professionally significant situations. The proposed structure allows identifying both the overall level of development of the relevant skills and the specific manifestations of each component. It is precisely this that provides the basis for further identification of levels of development in teachers' digital teamwork skills, which is the subject of the next subsection.

### *3.3. Levels of Skill Development*

A level-based characterization of the development of teachers' digital teamwork skills is needed not merely to complete the assessment system formally, but above all to provide a meaningful interpretation of the results obtained. If criteria and indicators enable determining the exact features by which the phenomenon under study is identified, levels enable describing the degree of its development, the stability of the corresponding actions, and the nature of their professional functioning in a digital educational environment. It is precisely through the level-based approach that assessment moves beyond the binary logic of the presence or absence of a particular skill and acquires the analytical depth that is especially important for the study of complex integrated skills.

Within our study, it is appropriate to use a four-level scale: initial, basic, advanced, and expert. Such a scale is sufficiently differentiated to reflect the gradual development of digital teamwork skills while remaining sufficiently general to avoid excessive detail, which helps preserve clarity of interpretation. Its use is consistent with the practice of applying level-based models in research on digital competence and teachers' professional

readiness, where a level is treated as an integral characteristic of the degree of development of a professional action rather than as a simple arithmetic sum of separate scores (Tzafilkou et al., 2023). For our approach, this means that each level should be described in terms of the qualitative characteristics of skill manifestation in digital teamwork.

From a methodological standpoint, it is important that the levels in this study should not be treated as rigidly separated states. They reflect the predominant mode of functioning of the skills and enable us to see the extent to which a teacher can act in a digital environment as a team member, and the degree to which those actions are independent, stable, deliberate, integrated, and productive. At the same time, in practice, individual components may be developed unevenly: for example, a teacher may demonstrate an advanced level on the communication-facilitation criterion but only a basic level on the organizational-projective criterion. This is precisely why the level-based characterization should be applied to both the overall assessment and the separate criteria.

The initial level reflects a state in which teachers' digital teamwork skills are manifested only episodically, and the actions themselves are mainly situational, unstable, and fragmented. At this level, participation in teamwork is usually reactive rather than initiative-driven. The teacher may engage in digital communication, use certain services, respond to messages, or perform basic actions in a shared document, but such participation does not yet ensure full-fledged team interaction. Communication often remains formal, feedback is brief or unclear, collaborative work on a digital product is reduced to a minimal contribution, and the organization of the team process is perceived more as an external requirement than as a conscious professional action.

The initial level is also characterized by dependence on external guidance. The teacher requires clear instructions, preassigned roles, carefully specified tasks, and ongoing support from a coordinator, facilitator, or more experienced participants. In situations of uncertainty or when independent initiation of interaction is required, such a teacher often shows passivity, difficulty, or a tendency to limit involvement to the individual completion of their own part of the work without deeper

engagement in the shared process. At this level, digital tools are used mainly instrumentally, without a sufficient understanding of their role in supporting team activity. Thus, the initial level indicates the presence of certain preconditions for digital teamwork, but not yet a developed capacity for its independent and sustained implementation.

The basic level characterizes a state in which the teacher is already able to participate in digital teamwork in typical and relatively structured situations, but their actions still lack sufficient flexibility, stability, and integration. At this level, the educator usually navigates the main channels of digital interaction, maintains work-related communication, participates in collaborative editing, follows assigned roles, and carries out tasks within a given structure. Their participation in teamwork is no longer purely formal, but it still depends largely on clear conditions, a limited range of tools, and the relative simplicity of the task.

The basic level assumes that the teacher can provide meaningful, elementary feedback, work with shared documents, take into account other participants' contributions, and follow the main organizational agreements. At the same time, noticeable difficulties remain at this level in situations that require independent facilitative intervention, more complex coordination of editing, flexible replanning of work, or team organization under changing conditions. The teacher may function productively within a clear digital structure, but is not yet always able to create or reorganize it independently. Thus, the basic level indicates the presence of functionally adequate, but still insufficiently developed, digital teamwork skills that require further strengthening and expansion in real professional practice.

The advanced level reflects a developed ability to engage in effective, relatively independent, and stable digital teamwork across a range of professionally significant situations. At this level, the teacher not only participates in shared activity but also actively supports its quality, coherence, and effectiveness. They are able to initiate and sustain meaningful digital communication, provide constructive feedback, facilitate discussion, coordinate their own contributions with those of others, work on a shared digital

product with attention to its overall logic, and follow the task's organizational structure and time parameters.

The advanced level is characterized by increasing integration of the components. The teacher no longer perceives communication, collaborative editing, and organization as separate technical actions, but acts within the logic of an integrated team process. They are able not only to use digital tools but also to select them based on the task, understand their role in supporting team interaction, respond to challenges, adjust specific stages of work, and contribute to achieving a shared result. At the same time, at this level, the teacher does not yet consistently demonstrate a high degree of leadership initiative or the ability to systematically model and improve others' digital teamwork. Thus, the advanced level indicates professionally mature, effective, and stable digital teamwork that can already serve as a foundation for more complex forms of educational leadership and facilitation.

The expert level characterizes the highest degree of development of teachers' digital teamwork skills, at which the educator not only acts confidently and effectively within a digital team environment but also consciously designs, sustains, improves, and transforms such activity in response to the professional situation. At this level, the communication-facilitation, cooperative-productive, and organizational-projective components function as an integrated system. The teacher does not merely participate in shared work, but serves as a carrier of team culture, an initiator of high-quality interaction, a facilitator of group processes, a coordinator of complex tasks, and a reflective participant in shared professional development.

The expert level is manifested in the educator's ability to adapt digital teamwork flexibly to new conditions, quickly reorganize channels of interaction, sustain the engagement of different participants, prevent organizational and communicative breakdowns, ensure the high quality of the shared digital product, and turn teamwork into a resource for the professional growth of others. At this level, the teacher demonstrates not only confident use of digital tools and stability of professional action, but also the capacity for meta-reflection, that is, reflection on the very logic of teamwork, its improvement, the generalization of experience, and the transfer of successful practices to new tasks. For this reason,

the expert level is associated not only with high effectiveness but also with a pronounced potential for distributed educational leadership.

For greater analytical clarity, a summarized level-based characterization is presented in Table 3.2.

Table 3.2

**Levels of Development of Teachers' Digital Teamwork Skills**

| <i>Level</i>    | <i>General Characterization</i>                                                               | <i>Features of Manifestation</i>                                                                                                                                                                    |
|-----------------|-----------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Initial</b>  | Skills are manifested in a fragmented, situational way, mainly under external guidance        | Formal or unstable participation in digital interaction; limited contribution to the shared product; difficulties with coordination, facilitation, and process organization                         |
| <b>Basic</b>    | The teacher is able to participate in digital teamwork in typical structured situations       | Sustains basic communication; performs an assigned role; participates in collaborative editing; follows an established organizational structure, but still depends on external support              |
| <b>Advanced</b> | Skills are sufficiently developed, stable, and functionally adequate for independent teamwork | Initiates and sustains meaningful interaction; coordinates contributions; works on a shared product; follows and partially adjusts the organizational logic of activity                             |
| <b>Expert</b>   | Skills are integrated, flexible, reflective, and leadership-facilitation oriented             | Designs and improves teamwork; flexibly adapts the process; sustains the quality of interaction and product; serves as a carrier of the culture of digital collaboration and distributed leadership |

*Source: Authors' own work.*

Thus, the level-based characterization of teachers' digital teamwork skills enables not only the identification of their level of development but also the understanding of the qualitative nature of their professional participation in a digital team environment. The proposed four-level model allows assessment results to be interpreted both holistically and by component, which is especially important for analyzing the dynamics of change within the framework of a training intervention. For this reason, the next

logical step is to describe the instruments for collecting and recording data that enable the specified criteria, indicators, and levels to be identified in real or simulated professional interactions.

### *3.4. Instruments for Data Collection and Recording*

The effectiveness of the assessment system for teachers' digital teamwork skills depends directly on the appropriateness of the instruments for data collection and recording. Since, within this study, the object of assessment is not only the teacher's perception of their own readiness for digital teamwork, but also their actual ways of acting in a shared digital environment, the instrumentarium must be multi-component and capable of combining the subjective, behavioral, and outcome-oriented dimensions of analysis. For this reason, the data collection system should be based not on a single universal instrument but on a set of complementary tools, each capturing a particular dimension of the phenomenon under study.

Within our approach, the main instruments are an adapted self-assessment questionnaire, a practical team task involving digital interaction, observation of the task performance process, and analysis of digital artifacts produced during the shared activity. This combination makes it possible, on the one hand, to take into account the teacher's reflective view of their own capabilities and, on the other hand, to compare it with actual manifestations in the digital team environment. Methodologically, this corresponds to the logic of data triangulation, in which the phenomenon under study is not reduced to a single source of information, but is examined through several interrelated channels of documentation. Such a design of the instrumentarium is especially important for the analysis of digital teamwork, where some manifestations remain hidden in general declarations and become visible only in real interaction.

The first instrument is the self-assessment questionnaire, which captures the teacher's subjective understanding of their readiness for digital teamwork. It is advisable to construct it as an adapted instrument focused specifically on team-based professional interaction rather than on general digital literacy. In

this sense, drawing on the logic of SELFIE for Teachers, as well as on frameworks of teachers' digital competence, is methodologically appropriate; however, the content of the statements must be specifically focused on the teamwork dimension. This means that the questionnaire items should not only address confidence in using digital services but also the ability to sustain digital communication, work on shared documents, coordinate contributions, follow roles, organize team processes, and respond to interaction-related difficulties.

In terms of structure, such a questionnaire may include three blocks corresponding to the identified components. The first block is aimed at self-assessment of communication-facilitation actions, including the ability to initiate discussion, provide constructive feedback, maintain a productive atmosphere, and facilitate digital interaction. The second block concerns the cooperative-productive dimension: collaborative editing, alignment of changes, adaptation of materials, and participation in refining the product. The third block covers the organizational-projective dimension: planning stages, assigning roles, meeting deadlines, coordinating the process, and addressing challenges. It is important that responses be recorded on a scale that captures the degree of a feature's expression, for example, a four- or five-point scale. In that case, the questionnaire not only provides a general picture of the teacher's self-assessment but also allows comparison of results across separate components.

At the same time, self-assessment cannot serve as the basis for a final conclusion about the level of development of digital teamwork skills. Its function is rather to identify the teacher's reflective position, their view of their own strengths, difficulties, and areas of confidence. For this reason, the second instrument, namely the practical team task, is central to the assessment system. Its advantage lies in modeling a professionally significant situation in which participants must not merely declare but actually demonstrate their digital teamwork skills. It is precisely in such a task that one can observe how the teacher communicates, responds to others' contributions, works on a shared digital product, coordinates the stages of activity, and sustains the organization of the process.

The practical task should be designed to require the simultaneous engagement of all three components. For example, participants may be asked, in micro-groups, to develop a shared educational product in a digital environment using a shared document, a digital planning board, a communication channel, and a specified time limit. It is fundamentally important that the task not be reduced to a mechanical division of parts, but rather that it requires alignment, mutual editing, decision-making, documentation of stages, and presentation of the result. In this design, the practical task becomes not merely a test of technical proficiency but a means of identifying the teacher's actual ability to act within a digital team.

The third instrument is the observation of the process of carrying out the practical task. This allows documentation of aspects of team interaction that are not always fully reflected in the final product or the self-assessment questionnaire. These include, above all, the nature of the teacher's participation in digital communication, initiative, the ability to engage others, ways of providing feedback, responses to difficulties, maintenance of the pace of work, and transitions from discussion to action. Observation should not be unstructured; it should be structured. For this purpose, it is advisable to use an observation chart or rubric that defines a list of features in advance and aligns them with the assessment criteria and indicators.

The advantage of structured observation is that it helps reduce subjectivity in interpretation. The observer records not a general impression of the participant's activity, but specific manifestations: whether the participant initiates discussion, responds meaningfully to others' messages, summarizes interim results, responds to delays, engages in collaborative editing, and sustains a constructive atmosphere. Such an approach creates a connection between theoretically defined indicators and actual behavioral manifestations. For this reason, observation should be regarded as one of the most sensitive instruments within the overall data collection system.

The fourth instrument is the analysis of digital artifacts produced during shared activity. This instrument is particularly valuable for studying digital teamwork, as the digital environment leaves substantial traces of interaction. Such artifacts include

shared documents, revision histories, comments on edits, chat records, the structure of project management boards, task statuses, calendars, responsibility tables, markers of stage completion, and the final digital product. Analysis of these materials makes it possible to trace not only the result itself, but also the logic of its creation: who made changes and how, how transparent the editing process was, how decisions were aligned, whether stages of activity were visible, and whether the team followed an organizational structure.

The analytical value of digital artifacts lies in their relative objectivity. Unlike self-description, they document actual activity, often in chronological sequence. For example, revision history in a shared document allows you to see the degree of a participant's involvement, the nature of their edits, the relationship between their contributions and those of others, and their willingness to refine the text. Comments enable analysis of feedback quality and alignment with change. The structure of a digital board or tracker provides a basis for assessing the organizational-projective dimension: the presence of stages, roles, deadlines, status markers, and responses to changes throughout the work. Thus, digital artifacts are an important source of data that combines the process-oriented and outcome-oriented dimensions of assessment.

It is especially important that all of the instruments named above should be used not in isolation, but in relation to one another. Only in this way can greater validity of conclusions be achieved. For example, if a teacher's self-assessment indicates a high level of confidence in organizing digital teamwork, but difficulties in planning stages or distributing roles are revealed during the practical task and through artifact analysis, the researcher gains grounds for a more precise interpretation of the result. Similarly, if a teacher modestly evaluates their own capabilities but demonstrates stable facilitative and cooperative actions in actual interaction, such a discrepancy also acquires analytical significance. For this reason, the data collection system should be built on the principle of complementarity among instruments.

To summarize the instrumentarium, we have presented it in Table 3.3.

Table 3.3

**Instruments for Data Collection and Recording in the  
Assessment of Teachers' Digital Teamwork Skills**

| <i>Instrument</i>                            | <i>Purpose</i>                                                                        | <i>What It Captures</i>                                                                                                              |
|----------------------------------------------|---------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------|
| <b>Adapted self-assessment questionnaire</b> | Identifying the teacher's reflective view of their own readiness for digital teamwork | Perceptions of one's own ability in digital communication, collaborative editing, and organization of the team process               |
| <b>Practical team task</b>                   | Modeling a professionally significant situation of shared digital interaction         | The actual functioning of skills in the process of teamwork on a shared digital product                                              |
| <b>Structured observation</b>                | Recording behavioral manifestations during task performance                           | Initiative, nature of communication, facilitation, coordination of actions, response to difficulties, and maintenance of interaction |
| <b>Analysis of digital artifacts</b>         | Identifying process-oriented and outcome-oriented traces of team activity             | Revision history, comments, chats, board structure, task statuses, and the final digital product                                     |

*Source: Authors' own work.*

Thus, the proposed instrumentarium enables examination of teachers' digital teamwork skills along several complementary dimensions: as an object of self-assessment, as actual behavior during team interaction, as a way of organizing shared activity, and as the recorded outcome of that activity in a digital environment. It is precisely this design of the data collection and documentation system that ensures sufficient analytical completeness of the assessment and creates a basis for the subsequent description of the methodology for developing the corresponding skills within a training intervention.

#### **4. Methodology for Developing Teachers' Teamwork Skills in a Digital Educational Environment**

After providing a theoretical rationale for the essence of teachers' digital teamwork skills and constructing a system for their assessment, the question of how to develop this professional

construct purposefully naturally arises. Whereas the previous sections focused on conceptualizing the phenomenon, clarifying its structure, and defining the criteria, indicators, and levels of its development, this section shifts attention to the practice-oriented dimension of the study. The aim here is to design a methodology suitable for the purposeful development of teachers' digital teamwork skills within a short-term yet substantively rich format of professional preparation.

The need for a special methodology arises because digital teamwork skills do not develop automatically from using digital tools. Access to shared documents, messengers, video communication platforms, or digital boards does not in itself mean that a teacher is ready for high-quality teamwork. In practice, one often encounters situations in which educators are familiar with individual tools but experience difficulties aligning roles, maintaining meaningful communication, collaboratively editing materials, planning work stages, or facilitating digital interaction. This means that the development of the relevant skills requires not technical instruction, but specially organized activity in which digital tools function not as an end in themselves, but as an environment for the shared completion of professionally meaningful tasks.

The methodology proposed in this study is based on the understanding of digital teamwork as an integrated professional capacity formed at the intersection of the communication-facilitation, cooperative-productive, and organizational-projective components. Accordingly, its design presupposes not isolated training in separate skills, but the creation of educational-professional situations in which the teacher must simultaneously communicate, coordinate interaction, participate in the collaborative creation of a digital product, plan work stages, align actions with other participants, and reflectively interpret the results. It is precisely this integration that constitutes the core logic of the methodology.

The general idea of the methodology is that the development of digital teamwork skills occurs most productively not through explaining "how to work in a team correctly," but through involving teachers in a series of specially designed team tasks in a digital environment that models real or near-real professional

situations. In such tasks, digital tools perform not a supplementary but a functionally significant role: they are the means through which communication, role distribution, documentation of stages, collaborative product creation, commenting, clarification of changes, monitoring of progress, and presentation of results occur. For this reason, the methodology is not primarily informational or lecture-based, but rather activity-oriented, training-based, and reflective.

From a methodological perspective, the proposed approach draws on several interrelated frameworks. First is the activity-based approach, according to which professional skills develop through the subject's involvement in specially organized activity rather than through passive absorption of information. Within our study, this means that the teacher develops digital teamwork skills by carrying out team-based digital tasks rather than merely discussing them. Equally important is the competence-based approach, which focuses not on isolated actions but on the ability to act effectively in a professionally significant situation. For this reason, the methodology is oriented not toward individual service training but toward developing comprehensive readiness for digital teamwork. The social constructivist approach is also essential, as these skills develop through joint decision-making, discussion, mutual editing, and the coordination of contributions. Finally, the reflective approach is important as well, since it presupposes reflection not only on the result, but also on the process of team activity itself.

In accordance with this logic, the methodology should be aimed at solving several interrelated tasks. First, it should help teachers understand digital teamwork not as a technical activity, but as a professional one. Second, it should create conditions for teachers' actual involvement in digital team interaction. Third, it should provide opportunities to gain experience in the collaborative creation of a digital product within coordinated roles, deadlines, and responsibilities. Fourth, it should stimulate reflection on one's own actions, difficulties, and ways of overcoming them. And fifth, it should create a basis for documenting changes in the level of development of the corresponding skills.

Structurally, the methodology includes target, content, processual, and outcome-reflective blocks. The target block defines the goal and objectives of developing teachers' digital teamwork skills. The content block covers the professional actions that constitute the focus of purposeful development: communication, facilitation, collaborative creation of a digital product, planning, role distribution, coordination of stages, and responses to difficulties. The procedural block concerns the selection of formats, tools, and task types used to implement the methodology. The outcome-reflective block includes assessing changes, participants' self-analysis, generalizing the experience, and laying a foundation for further professional development.

In practical terms, the methodology is implemented through a series of training sessions that gradually increase the complexity of digital teamwork activities. Their logic lies not in the sequential study of individual tools, but in the transition from initial engagement in digital interaction to more complex forms of collaborative product creation and team-organized activity. At the same time, each session is not isolated but cumulative: new actions build on participants' previous experience while simultaneously requiring greater independence, coordination, and reflection. It is precisely this dynamic that makes it possible to speak not merely of a series of exercises, but of a coherent methodology for skill development.

In addition, an important principle in constructing the methodology is its professional relevance. The tasks offered to participants must be substantively close to the teacher's actual work. These may include designing a fragment of a course, developing an interdisciplinary task, creating the structure of a shared methodological product, developing a coordinated assessment model, preparing a digital collection of resources, or collectively planning an educational event. Such professional relevance increases not only participants' motivation, but also the validity of the methodology itself, since it allows skills to be developed in the very forms in which they will actually be applied in subsequent pedagogical activity.

A particularly important role in the methodology is played by the combination of synchronous and asynchronous interaction formats. Synchronous forms enable practice in initiating

interaction, facilitating discussion, clarifying decisions, and sustaining group dynamics. Asynchronous forms, in turn, develop skills in written digital communication, working with shared documents, documenting agreements, planning, and adhering to deadlines. It is precisely the combination of these two formats that enables the training activity to be brought closer to the real conditions of the contemporary digital educational environment, where teamwork is rarely conducted in a single mode.

Another essential feature of the methodology is its reflective support. Without a stage of reflection, even well-organized teamwork may amount to only a completed task, lacking sufficient professional growth. For this reason, after each training stage, it is advisable to include a brief individual and group reflection during which participants analyze what helped or hindered their teamwork, which digital tools proved most functional, what difficulties arose in coordination, how each person's role in the team changed, and what requires further improvement. Such a reflective component strengthens awareness of professional development and ensures a connection between the completed activity and its further transfer into real pedagogical practice.

Thus, within our study, the methodology for developing teachers' teamwork skills in a digital educational environment is understood as a purposeful, structured, and professionally oriented system of training activity built on the integration of digital tools, team tasks, reflection, and assessment. Its purpose is not merely to activate separate digital skills, but to develop the teacher's integrated capacity for meaningful, productive, and well-organized teamwork in a digital educational environment. The next stage of the discussion should focus on specifying the principles underlying this methodology, as these principles determine its internal logic and ensure the coherence of its practical implementation.

#### *4.1. Principles for Constructing the Methodology*

The effectiveness of a methodology for developing teachers' teamwork skills in a digital educational environment depends to a large extent on the principles underlying it. It is precisely these principles that define the methodology's internal logic and ensure

alignment among its goals, content, organizational formats, instruments, and assessment methods. Without clearly defined principles, even a substantively rich system of training sessions risks becoming a set of separate activities that fail to produce an integrated professional outcome. For this reason, our study's methodology is built on a set of interrelated principles that reflect the nature of teachers' digital teamwork as an integrated professional phenomenon.

The first and foundational principle is professional relevance. Its essence lies in the fact that the development of digital teamwork skills should be based on tasks and situations that are substantively close to the teacher's actual activity. The issue is not abstract teamwork training "in general," but the development of the ability to interact in a digital environment to solve professionally significant pedagogical tasks. These may include collaborative lesson planning, creation of methodological materials, development of an interdisciplinary task, preparation of a digital educational resource, alignment of assessment criteria, or organization of an educational project. Such an orientation ensures not only participants' motivation, but also a high likelihood that the acquired skills will later be transferred into real practice.

The second principle is activity orientation. Digital teamwork skills cannot be developed solely through explanation, demonstration, or discussion. They develop through direct participation in shared digital activity, when the teacher must not only understand the logic of team interaction, but also actually carry it out: communicate, negotiate, work on a shared product, coordinate contributions, respond to difficulties, and follow roles and deadlines. For this reason, the methodology must be organized as a system of actions rather than as a set of messages about actions. This principle ensures a connection between professional learning and the participant's actual behavior in a digital team environment.

The third principle is integration of components. The previous sections showed that teachers' digital teamwork skills include communication-facilitation, cooperative-productive, and organizational-projective components. In real professional practice, these components do not function separately, but

manifest themselves in interaction. For this reason, the methodology should not be structured as a sequence of isolated exercises for separate micro-skills. Instead, it should create situations in which the participant simultaneously communicates, organizes, coordinates, collaborates on a product, and reflects on shared work. It is precisely this integration of components that brings the training activity closer to the real nature of teachers' digital teamwork.

The fourth principle is phased progression and gradual increase in complexity. The development of digital teamwork skills does not occur all at once. It requires movement from simpler forms of participation to more complex ones, from reliance on external organization to greater independence, and from carrying out individual roles to understanding the overall logic of the team process. For this reason, the methodology should provide for a gradual increase in task, tool, and interaction complexity. At the initial stages, it is advisable to focus on involving participants in digital communication and basic coordination, then move on to the collaborative creation of a digital product, and only after that proceed to more complex forms of organization, facilitation, and reflective improvement of the process. Such a principle allows avoiding overload while ensuring development rather than mere repetition of similar actions.

The fifth principle is instrumental appropriateness. Within the methodology, digital tools should be used not for the sake of demonstrating their technical capabilities, but in accordance with the logic of a specific team task. This means that the choice of a shared document, digital board, communication channel, task tracker, calendar, or other service should be functionally justified. An excessive number of tools or their purely formal use may complicate activity rather than support skill development. Thus, the methodology should teach not only how to use services, but also how to select them in light of the goal, structure, and type of teamwork. This is what brings digital training closer to the real conditions of pedagogical practice.

The sixth principle is collaborative product creation. Teacher teamwork in a digital environment should be oriented toward a concrete, jointly created result with professional value. Without this, interaction may remain communicatively active but

professionally unproductive. For this reason, the methodology should include tasks in which the shared digital product is not a secondary byproduct, but the central outcome of team activity. This makes it possible to connect interaction with responsibility for the result and to move teamwork from the level of discussion to that of real professional collaboration.

The seventh principle is distributed responsibility and role flexibility. Team activity becomes productive when participants understand both the shared goal and their own function in achieving it. At the same time, the contemporary digital environment requires not rigid role fixation, but the ability to shift or combine roles as work progresses. For this reason, the methodology should provide both a clear role definition within the team task and the possibility of role variation. The same teacher may, in different situations, act as an initiator, moderator, editor, coordinator, or performer of a particular stage. It is precisely this role dynamic that contributes to the development of deeper experience in teamwork and brings the learning situation closer to actual professional practice.

The eighth principle is reflective support. The development of digital teamwork skills is impossible without participants reflecting on their own experiences. The completion of a task does not in itself guarantee professional growth if no analysis is made of how the interaction was organized, what difficulties arose, which decisions proved effective, where the team lost momentum or coherence, and what requires improvement. For this reason, the methodology should include both individual and group reflection after completing tasks. Such reflection helps transfer experience from the level of situational action to the level of a conscious professional skill.

The ninth principle is the combination of synchronous and asynchronous interaction. Real digital teamwork among teachers is rarely limited to only one format. Some decisions are made during synchronous discussion, while others are implemented asynchronously through shared documents, comments, task boards, or correspondence. For this reason, the methodology should include both formats. This makes it possible to develop different aspects of the skills: the synchronous format is more supportive of facilitation, dynamic communication, and rapid

alignment, whereas the asynchronous format contributes to the development of written digital interaction, planning, documentation of agreements, and coordination of contributions over time. The combination of these two modes makes the methodology more viable and realistic.

The tenth principle is developmental assessment. Within the methodology, assessment should not be reduced merely to control or the final recording of the result. It should help participants see the dynamics of their own development, understand their strengths and problematic areas, relate their own activity to clear criteria, and gain a basis for further improvement. For this reason, assessment should be embedded in the methodology's logic and combine self-assessment, external observation, artifact analysis, and reflective interpretation of changes. In that case, it performs not only a diagnostic, but also a learning function.

The eleventh principle may be defined as the principle of variability in team tasks. Teachers' digital teamwork can be realized in various professional situations: developing materials, planning an event, preparing a joint project, organizing an assessment, creating a digital resource collection, or designing a lesson model. For this reason, the methodology should include tasks that vary in content and organizational form so that participants do not merely rehearse the same pattern, but gain experience in transferring their skills to different pedagogical situations. This increases the stability of the developed skills and reduces the risk of tying them to a single work format.

Finally, the twelfth principle is the principle of safe professional interaction. Teachers' digital teamwork requires not only tools and tasks, but also a learning space in which participants are not afraid to propose ideas, ask clarifying questions, acknowledge difficulties, respond to comments, and revise their own decisions. If interaction is built on a foundation of tension, competition, or evaluative pressure, it constrains genuine skill development. For this reason, the methodology should ensure respectful communication, mutual regard, visibility of each participant's contributions, and the understanding that mistakes are not failures but resources for growth. Such an atmosphere is a necessary condition for facilitation, team reflection, and productive digital collaboration.

Thus, the principles for constructing the methodology reflect not merely separate organizational preferences, but the internal logic of developing teachers' digital teamwork skills. Professional relevance, activity orientation, integration of components, phased progression, instrumental appropriateness, orientation toward a shared product, distributed responsibility, reflective support, the combination of interaction formats, developmental assessment, variability, and a safe professional atmosphere together form a coherent methodological foundation that ensures the practical effectiveness of the proposed system. It is on the basis of these principles that a more concrete description of digital tools, organizational formats, and the series of training sessions through which the methodology for developing teachers' teamwork skills in a digital educational environment is implemented can be further elaborated.

#### *4.2. Digital Tools as a Means of Developing Team Interaction*

Within the proposed methodology, digital tools should be viewed not as an independent goal of training, but as a means of organizing, sustaining, and developing teachers' teamwork. This approach is fundamentally important because, in professional training practice, one often observes a shift of emphasis from pedagogical appropriateness to the technical mastery of services. As a result, teachers may become quite confident in using specific platforms while still lacking experience in meaningful digital collaboration. For this reason, within our study, a digital tool is understood not as an object of learning in itself, but as a functional element of shared activity that should support communication, coordination, collaborative product creation, role distribution, and reflective interpretation of the process.

Under this understanding, the selection of tools is determined not by their popularity or by the number of available features, but by their ability to support a particular type of team action. One tool may be more appropriate for synchronously aligning decisions, another for asynchronous collaborative editing, and still another for visualizing work stages, distributing tasks, and tracking the team's progress. Thus, digital tools within the methodology's structure perform not only technical but also

organizational, communicative, productive, and analytical functions. It is precisely their functional differentiation that enables the construction of a coherent environment for the development of teachers' digital teamwork skills.

First, it is useful to distinguish between digital communication tools that support synchronous and asynchronous interaction among team members. This group includes video communication platforms, group chats, messaging channels, forums, commenting tools, and other services through which information is exchanged, tasks are clarified, feedback is provided, and working contact is maintained. Their role in the methodology is not simply to ensure connection among participants, but to create conditions for the development of the communication-facilitation component. It is through these tools that teachers learn to initiate discussion, formulate proposals, maintain a productive tone of interaction, summarize results, ask clarifying questions, and move discussion toward concrete agreements.

It is especially important that digital communication tools enable different modes of interaction. Synchronous means, in particular, videoconferencing and voice-based discussion, are appropriate for rapid alignment of positions, facilitating discussion, presenting interim results, and maintaining team dynamics. Asynchronous means, such as chats, comments, or forums, foster a different type of professional behavior: precision in written formulation, the ability to document decisions, maintaining the logic of discussion over time, and responding to colleagues' messages without all participants being present simultaneously. It is precisely the combination of these formats that enables the development of communicative flexibility, which is necessary in the contemporary digital educational environment.

The second important group consists of tools for the collaborative creation and editing of a digital product. These include cloud-based text documents, presentations, spreadsheets, shared folders, visual design services, and other platforms that allow several participants to work on a single resource. This group of tools is central to the development of the cooperative-productive component. They create the conditions for team interaction to have not only a communicative, but also a substantive character. Through work with such services, teachers

learn to align the structure of the product, coordinate editing, track changes, incorporate comments, adapt their own contributions to the overall logic of the result, and treat the shared digital resource as an object of collective responsibility.

The advantage of this group of tools is that they enable combining the process- and outcome-oriented dimensions of activity. On the one hand, participants create a specific product; on the other hand, the process of its creation becomes visible: one can trace the revision history, see comments, identify the nature of each participant's contribution, and document the dynamics of editing. Within the methodology, this has a dual significance. First, such tools provide a real space for the development of shared authorship. Second, they create a basis for subsequent assessment and reflection. Participants can not only complete the product but also analyze exactly how they arrived at it.

The third group consists of tools for organization and project management, including digital boards, task trackers, calendars, checklists, role-distribution tables, visual maps of activity stages, and similar resources. Their use within the methodology is especially important for the development of the organizational-projective component. With the help of such tools, team activity acquires a clear structure: the work stages, participants' roles, deadlines, current task status, and the interdependence of individual actions become clear. From a methodological perspective, this makes it possible not merely to talk about the importance of planning, but to embed planning directly into participants' activity.

Digital boards and trackers are especially valuable because they enable visualization of the teamwork process. This reduces the risk of vague agreements and helps participants see not only their own segment, but also the overall logic of the shared task. Within the training methodology, such tools are appropriately used to define the stages of a team task, record roles, mark deadlines, track progress, respond to delays, and conduct reflective analysis of the process after the work is completed. In this way, the digital environment becomes not only a space of activity, but also a space for organizing activity, which is especially important for teachers who do not yet have stable experience in digital teamwork.

The fourth group consists of tools for visualization and collective structuring of ideas, including digital boards for brainstorming, idea mapping, collaborative grouping of content, presentation of solution options, and modeling of the structure of the future product. Within the methodology, these tools perform an intermediate but very important function. They connect communication with design, help the team move from chaotic discussion to a shared structure, facilitate the inclusion of all participants, and create conditions for a shared understanding of the task. It is through these tools that teachers can learn to align content, visually record ideas, see connections among elements, and collectively develop a model of the future result.

Such tools are especially appropriate at the initial and intermediate stages of teamwork, when the team is still forming a shared vision or searching for the optimal structure of the future product. From a methodological standpoint, they are valuable because they lower the threshold for entering team interaction: it is easier for participants to join the work through short visual notes, markers, blocks, and diagrams than to move immediately to a complex text-based or project document. In this way, visualization tools support not only productivity but also engagement, which is important for the development of the communication-facilitation component.

A separate group consists of tools for documentation, analysis, and reflection, which enable returning to completed team activities and interpreting them. These may include revision histories, activity logs, comments, digital traces of participation, brief reflection forms, electronic observation journals, or self-analysis templates. Their significance within the methodology lies in their role in turning digital activity into an object of professional analysis. The teacher gains the opportunity to see how interaction unfolded, where difficulties arose, what their participation in the shared work looked like, and whether the chosen tools and coordination methods were effective. This analytical dimension is necessary because teamwork skills develop not only through action, but also through reflective interpretation of that action.

From a methodological point of view, it is important to emphasize that no instrument in itself guarantees the development of the relevant skills. What is decisive is how it is

incorporated into the team task. For example, a shared document may remain merely a place to exchange fragments of text if the team does not work to align the logic and structure. A digital board may become a mere collection of notes if it is not used for actual planning and role distribution. A chat may be full of messages yet professionally ineffective if communication does not lead to decisions or support shared activity. For this reason, the methodology's instrumental richness must be combined with a clear pedagogical logic for each service.

In this connection, it is useful to speak not of separate digital tools, but of a functionally organized digital environment for team interaction. Within the methodology, this environment should include at least four interrelated zones: a communication zone, a collaborative product-creation zone, a process-organization zone, and a reflection zone. Such an approach enables teachers not only to master services but also to see the architecture of digital teamwork as an integrated professional process. It is precisely this that brings the methodology closer to the real conditions of the contemporary educational environment, where professional interaction almost always unfolds simultaneously across several digital spaces.

For clarity and synthesis, it is useful to present the groups of digital tools in a table (Table 4.1).

Table 4.1  
**Groups of Digital Tools in the Methodology for Developing Teachers' Teamwork Skills**

| <i>Group of Tools</i>                                              | <i>Function in the Methodology</i>                                                         | <i>Examples of Use</i>                                                                                 |
|--------------------------------------------------------------------|--------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------|
| <b>Digital communication tools</b>                                 | Support synchronous and asynchronous interaction, feedback, and facilitation of discussion | Video meetings, group chats, comments, forums, messaging channels                                      |
| <b>Tools for collaborative creation and editing of the product</b> | Support cooperative-productive activity, shared authorship, and alignment of changes       | Cloud-based documents, presentations, spreadsheets, shared folders, and collaborative editing services |

|                                                                    |                                                                                         |                                                                                                        |
|--------------------------------------------------------------------|-----------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------|
| <b>Tools for organization and project management</b>               | Support planning, role distribution, coordination of stages, and control of deadlines   | Digital boards, task trackers, calendars, checklists, and responsibility tables                        |
| <b>Tools for visualization and collective structuring of ideas</b> | Help jointly model ideas, structure content, and develop a shared vision                | Digital brainstorming boards, idea maps, visual schemes, shared notes                                  |
| <b>Tools for documentation, analysis, and reflection</b>           | Make it possible to interpret the process of team activity and assess its effectiveness | Revision histories, digital artifacts, observation logs, self-analysis forms, and reflection templates |

Source: Authors' own work.

Thus, within the proposed methodology, digital tools function not as isolated technical means, but as a functionally organized environment for developing teachers' digital teamwork skills. Their use enables the integration of communication, collaborative product creation, process organization, and reflective interpretation of activity within a unified logic of professional interaction. This provides a basis for moving to a concrete description of the series of training sessions in which these tools are used to purposefully develop the corresponding skills.

### 4.3. Organization of the Training Series

The practical implementation of the methodology for developing teachers' teamwork skills in a digital educational environment within our study was carried out through a series of three weekly training sessions. This format was chosen in view of the need to combine the intensity of professional immersion with the possibility of gradually increasing the complexity of activity, conducting intermediate reflection, and documenting change. Unlike one-time introductory sessions, a series of interconnected trainings not only stimulates interest in digital team interaction but also creates conditions for the consistent development of individual skill components, their integration, and their testing in real or near-real professional situations.

The logic of organizing the training series was based on a gradual transition from initial involvement in digital team

interaction to more complex forms of collaborative product creation and organization of the team process. At the same time, each training session served a relatively independent function while remaining connected to the previous and subsequent ones. This sequence enabled the construction not of a fragmented set of exercises but of a coherent training pathway in which participants gradually moved from mastering individual forms of digital interaction to the integrated application of the communication-facilitation, cooperative-productive, and organizational-projective components.

The overall goal of the training series was to create conditions for the purposeful development of teachers' digital teamwork skills by involving them in shared professionally oriented activity using digital tools for communication, coordination, collaborative editing, and project management. This goal was specified through several objectives. First, it was necessary to activate participants' understanding of digital teamwork as a professional rather than merely a technical practice. Second, it was important to ensure experience in meaningful digital communication and in facilitating interaction. Third, conditions had to be created for the collaborative development of a digital product in a team-based mode. Fourth, the series was intended to develop initial or more advanced experience in planning, role distribution, coordination of stages, and monitoring of team progress. Fifth, it aimed to stimulate reflective analysis of participants' own roles, difficulties, and results in shared digital activity.

Organizationally, the training series involved teachers working in small groups, ensuring each participant had sufficient involvement in the team activity. It was precisely the micro-group format that was chosen as the most suitable for modeling real shared work, in which each participant makes a visible contribution while also bearing responsibility for the overall result. In addition, work in small groups facilitated observation, analysis of digital artifacts, and subsequent comparison of individual and group manifestations of the skills. In terms of structure, each training session combined a brief introductory stage, a main team task in a digital environment, intermediate points for alignment of actions, and a concluding reflective block.

The content of the training series was designed in accordance with the internal logic of skill development. The first training session focused primarily on the communication-facilitation component. Its task was to involve participants in meaningful digital interaction and to foreground the need for clear communication, constructive feedback, and coordination of discussion. At this stage, it was important not to overload participants with excessive complexity in either the product or the organizational scheme, but to create conditions for an initial understanding that even basic teamwork in a digital environment requires not spontaneous message exchange but structured professional interaction.

The second training session shifted the focus to the cooperative-productive component. At this stage, participants moved from a predominantly communicative mode to the collaborative creation of a digital product, requiring alignment of contributions, coordination of editing, adaptation of materials, and collective refinement of the result. An important feature of the second training was that participants were already building on their previous experience of digital interaction, but now had to act under conditions of greater substantive density and responsibility for the shared result. This made it possible not only to develop the capacity for cooperative work but also to reveal the connection between the quality of communication and the quality of the shared product.

The third training session was aimed at integrating all three components, with a stronger emphasis on the organizational-projective dimension. At this stage, it was no longer sufficient merely to communicate or collaboratively edit a document. Participants had to plan activity stages, assign roles, document tasks, monitor deadlines, and coordinate the team's progress using digital boards or other project management tools. This training served an integrative function, enabling participants to observe the extent to which they could combine meaningful communication, productive collaborative creation of a result, and the organizational structuring of the process within a coherent model of digital teamwork.

The forms of work used in the training series were selected to align with the content of each stage, but guided by a shared

logic. First and foremost, this involved work in micro-groups on a professionally oriented digital task. It was precisely this format that enabled the real interdependence of participants' actions and laid the basis for the manifestation of the skills under study. In addition, mini-discussions in a shared synchronous format were used, during which teams clarified their approach to the task, presented interim solutions, or received general guidance. An important place was also given to asynchronous digital interaction, in which participants worked with shared documents, comments, boards, spreadsheets, or other resources without constant simultaneous presence. Reflective discussion should also be mentioned separately, as it concluded each training session and was aimed at interpreting experience rather than merely summarizing formal results.

From a methodological perspective, it is important that within the training series, digital tools were used not as a topic for explanation, but as the immediate environment for action. Participants did not complete a separate instructional block devoted to the technical capabilities of the services, but instead worked with them as they carried out the team task. This made it possible to connect each tool directly to its function in team interaction. For example, a shared document was used not only for entering text but also for coordinating contributions and editing. A digital board served not only for visualizing ideas but also for planning and distributing roles. A communication channel performed not merely an informational function but also served as an environment for facilitating, clarifying, and documenting decisions. Such an approach strengthened the connection between training activity and real professional practice.

An essential feature of the training organization was the inclusion of intermediate checkpoints for alignment. This meant that teams did not simply receive a task and report a finished result, but also passed through several moments of pause during which they had to briefly align the current state of the work, identify difficulties, or adjust the plan. These checkpoints were especially important for the development of the organizational-projective component, because they trained participants to view team activity not as a spontaneous process, but as a sequence of stages requiring coordination. At the same time, they created

opportunities for individual participants' facilitative actions to emerge and provided natural conditions for observing the dynamics of teamwork.

No less important was the reflective component of each training session. After completing the main team task, participants had the opportunity to briefly reflect on how the interaction unfolded, which tools proved most functional, what was difficult to coordinate, how roles were distributed, what communicative difficulties arose, and how the team addressed them. In this way, the training acquired not only a practical, but also an analytical character. This is especially important for teachers, since professional development in digital teamwork involves not only accumulating experience but also understanding its structure and transferring it into subsequent practice.

To better systematize the training series, we present them in Table 4.2.

Table 4.2

**General Characteristics of the Training Series for Developing Teachers' Digital Teamwork Skills**

| <i>Training</i>   | <i>Main Focus</i>                                                                     | <i>Content Orientation</i>                                                                                                 | <i>Leading Forms of Work</i>                                                                                     |
|-------------------|---------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------|
| <b>Training 1</b> | Communication-facilitation component                                                  | Engagement in digital interaction, meaningful communication, feedback, and initial coordination of actions                 | Work in micro-groups, synchronous discussion, digital communication, and brief reflection                        |
| <b>Training 2</b> | Cooperative-productive component                                                      | Collaborative creation of a digital product, coordination of editing, alignment of contributions, refinement of the result | Work with shared documents, team editing, asynchronous interaction, and discussion of the result                 |
| <b>Training 3</b> | Integration of components with an emphasis on the organizational-projective dimension | Planning, role distribution, coordination of stages, use of digital boards and trackers, and completion of the team task   | Project-based work in micro-groups, digital task management, intermediate alignment points, and final reflection |

Source: Authors' own work.

Thus, the series of three weekly training sessions was organized as a coherent system of professionally oriented team tasks within which participants gradually moved from initial involvement in digital interaction to integrated digital teamwork. Such an organization made it possible not only to support the development of individual components of the relevant skills, but also to create conditions for their combination into a coherent professional experience. The next stage of the discussion requires a more specific description of the content of each training session, as this is what allows the internal logic of the methodology to be shown at the level of practical implementation.

#### *4.3.1. The First Training Session*

The first training session within the proposed methodology performed both an introductory-activation function and a foundational formative function. Its main purpose was not merely to familiarize participants with the logic of the subsequent work, but above all to involve them in real digital team interaction, where communication functions not as a secondary background element, but as the central mechanism for organizing shared activity. For this reason, the main emphasis of the first training session was on developing the communication-facilitation component, in particular the ability to initiate digital interaction, sustain meaningful discussion, provide constructive feedback, coordinate shared actions, and move from message exchange to an agreed decision.

The methodological relevance of such a starting point is determined by the internal logic of the development of digital teamwork skills. Without a well-formed foundation in digital communication and basic coordination of interaction, the subsequent transition to collaborative product creation and to more complex organizational-projective actions is ineffective. If participants are unable to negotiate, clarify the meaning of a task, respond to colleagues' messages, maintain the flow of discussion, and document preliminary agreements, shared activity quickly becomes chaotic or formal. For this reason, the first training session was designed as a space for practicing the basic logic of digital team interaction.

The goal of the first training session was to create conditions for acquiring an initial integrated experience of digital team communication, within which teachers could understand the importance of message structure, the quality of feedback, the role of facilitation, and the need to coordinate actions in a shared digital environment. This goal was specified through several tasks. First, it was necessary to activate participants' understanding of the difference between ordinary digital communication and professionally organized digital team interaction. Second, the training was intended to develop experience in meaningful discussion of a shared task in a small group. Third, it was meant to create conditions for the emergence and initial mastery of facilitative actions, such as clarifying the goal, summarizing, maintaining engagement, and documenting interim decisions. Fourth, it aimed to lead participants to understand that even at an initial level, digital teamwork requires alignment not only of content, but also of the mode of interaction.

The substantive basis of the training was a professionally oriented team task that did not require an overly complex final product but did require active digital communication, shared discussion, and coordinated action. It was advisable for such a task to have clear pedagogical content, for example, creating a short shared plan for an educational activity, agreeing on the structure of a small methodological product, generating a list of digital solutions for a particular professional situation, or constructing an agreed model of team action in response to a given case. What was essential was that the team should not merely discuss the issue, but arrive at a specific agreed result documented in digital form. Such a task design ensured a connection between communication and a minimal shared product, while avoiding overload from excessive complexity in editing or project management.

Structurally, the first training session consisted of several successive stages. At the initial stage, a brief introductory orientation was provided, during which the purpose of the training, the general rules of team interaction, the time frame, and the digital tools to be used were outlined. It was important that, at this stage, the emphasis be placed not on the technical description of the services, but on the functional role of each service.

Participants needed to understand which tool was used for communication, which for documenting the shared result, and which for brief intermediate alignments. Such an introduction established the framework for the entire session and immediately oriented participants toward perceiving the digital environment as a space of professional interaction rather than merely a set of services.

The second stage involved direct work in micro-groups. At this point, participants received a shared task and began discussing it through the designated digital interaction channel. For the development of the communication-facilitation component, it was important at this stage not to interfere excessively in the team's internal work, but to allow the group to develop its own mode of interaction. This made it possible to reveal the participants' natural communication strategies: who takes the initiative, who tends to wait for instructions, how proposals are formulated, the character of responses to others' messages, and whether there are attempts to summarize positions or document agreements. At the same time, the training moderator could provide brief guidance if the team lost focus too quickly or shifted into chaotic message exchange without moving toward a result.

The third stage involved an intermediate alignment point, during which groups were asked to briefly present the current state of their work or record what they had already achieved. This stage had a dual significance. First, it created a natural point for facilitation, since participants had to summarize the interim result and relate it to the initial task. Second, it was precisely here that the difficulties of digital coordination became visible: unclear wording, lack of documentation of decisions, uneven participation of individual team members, and an excessive tendency toward parallel individual solutions. In this way, intermediate alignment performed not only an organizational but also an instructional function, helping participants see that digital teamwork requires specific attention to the communication mode.

The fourth stage involved completing the team task and presenting the agreed digital result. Within the first training session, this result was intended to be compact and functional. Its value lay not so much in its scope or complexity, but in the fact

that it was the outcome of a shared communicative process. It was at this stage that participants could see to what extent their discussion had led to a genuine shared decision, whether the result was genuinely agreed upon, and whether it still retained traces of individual fragments that had not been integrated. This made it possible to shift attention from the mere fact of communication to its effectiveness.

The final stage of the first training session was reflective. Participants were invited to reflect briefly on how their digital team interactions had occurred, what had facilitated or complicated the shared work, who and how had supported the team's progress, how agreements had been documented, how clear the messages had been, and whether there had been enough constructive feedback. For this purpose, short written responses, electronic reflection forms, or a brief oral discussion in the whole group could be used. The methodological significance of this stage lies in participants' beginning to view their own digital communication as an object of professional analysis rather than a neutral accompaniment to task completion.

Given the content of the first training session, the main activities were micro-group work, synchronous and asynchronous elements of digital communication, brief intermediate alignment points, and a final reflection. It was precisely this combination that enabled the creation of a natural setting for the manifestation of the communication-facilitation component. Within this training, the goal was not to achieve a high level of complexity in either the digital product or project organization. Instead, the main focus was on enabling participants to experience real interdependent communication and to see how the quality of that communication affects the overall result of teamwork.

From a didactic perspective, the first training session served not only as a starting point but also as a diagnostic and orienting stage. It was during this session that participants' initial characteristics of digital team behavior became visible: tendency toward initiative or passivity, dominance or avoidance of participation, orientation toward meaningful discussion or toward formal messaging, capacity for brief facilitative intervention, and willingness to document decisions. This, in turn, made it possible to better understand which difficulties should be addressed in the

following training sessions, where teamwork would take on a more productive and organizationally complex character.

A summary of the structure of the first training session is presented in Table 4.3 below.

Table 4.3

**General Characteristics of the First Training Session**

| <i>Parameter</i>             | <i>Characteristic</i>                                                                                                                 |
|------------------------------|---------------------------------------------------------------------------------------------------------------------------------------|
| <b>Title</b>                 | Digital Communication and Coordination of Interaction                                                                                 |
| <b>Main focus</b>            | Development of the communication-facilitation component                                                                               |
| <b>Goal</b>                  | Development of experience in meaningful digital interaction, coordination of discussion, and initial facilitation of the team process |
| <b>Main tasks</b>            | Initiating digital communication; sustaining discussion; providing feedback; documenting agreements; coordinating shared actions      |
| <b>Leading forms of work</b> | Micro-group work, synchronous and asynchronous digital communication, intermediate alignment, and reflection                          |
| <b>Expected result</b>       | An agreed digital mini-product and initial experience of structured team interaction in a digital environment                         |

*Source: Authors' own work.*

Thus, the first training session aimed to lay the foundation for digital teamwork: meaningful communication, coordinated interaction, and initial facilitative actions. It created the conditions for moving from general ideas about digital collaboration to actual experience in team discussions and decision alignment in a digital environment. It was precisely this experience that became the basis for the second training session, within which the emphasis shifts from primarily communicative interaction to the collaborative creation of a digital product.

#### *4.3.2. The Second Training Session*

The second training session within the proposed methodology aimed to develop the cooperative and productive component of teachers' digital teamwork skills. If the first training session ensured participants' entry into meaningful digital interaction and highlighted the need for clear communication and initial coordination of actions, then at the second stage, the emphasis shifted to the collaborative creation of a digital product,

alignment of contributions, editing of a shared resource, and work with comments and revisions. It was precisely this stage that was needed for the transition from a team as a group that discusses to a team as a group that jointly produces a result in a digital environment.

The methodological relevance of the second training session stems from the fact that teachers' digital teamwork reaches professional completeness only when communication develops into productive collaboration. In contemporary pedagogical practice, this aspect is often lacking: teachers may communicate actively in a digital space, exchange ideas, and discuss possible solutions, yet still lack well-developed experience in collaboratively creating a material or shared document where the task is not merely to express an opinion, but to integrate one's own contribution into a coherent product. For this reason, the second training session was designed so that participants would face the need not only to negotiate, but also to work on a shared digital object, aligning changes in style, structure, and the overall logic of the result.

The goal of the second training session was to create conditions in which teachers could gain experience in collaboratively creating a digital product through team interaction, including coordination of editing, alignment of content, work with versions and comments, and collective refinement of the result. This goal was specified through several tasks. First, participants had to shift from predominantly communicative interaction to cooperative, productive activity. Second, it was necessary to develop experience in collaboratively editing a digital resource under conditions of open contribution by several participants. Third, it was important to highlight the significance of aligning changes, using comments appropriately, and understanding one's own contribution within the integrity of a shared result. Fourth, the training session was intended to lead participants to recognize that the quality of a shared digital product depends not only on individual proficiency but also on the ability to work within the logic of shared authorship.

As the substantive basis of the second training session, it was advisable to choose a team task that required the creation or substantial refinement of a professionally meaningful digital

material. This could include a collaboratively designed fragment of methodological recommendations, the structure of an integrated task, a template for a digital educational resource, a presentation for an instructional event, a curated set of materials with comments and an agreed logic of use, or a model for assessing a particular educational activity. It was essential that the product possess internal coherence and that the team not merely add separate fragments mechanically, but align structure, content, format, and mode of presentation. Only under such conditions does digital editing become a genuinely cooperative and productive activity.

Structurally, the second training session also consisted of several successive stages. At the first stage, a brief introductory orientation was provided, during which participants were informed about the task's content, the requirements for the shared product, the time frame, and the digital tools to be used. Unlike the first training session, the main emphasis here was placed on the rules of collaborative editing: the need to document the logic of changes, to use comments not only for remarks but also for aligning decisions, to take into account the contributions of others, and not to disrupt the coherence of the shared document through spontaneous or uncoordinated revisions. Thus, even before work began, the team received guidance not only on the task's content but also on the culture of shared digital authorship.

The second stage involved direct work in micro-groups on the shared digital product. It was here that participants moved into collaborative editing, adding elements, structuring content, commenting on each other's work, and aligning changes. At this stage, it was especially important to observe how the team organized its work. Some groups might choose a parallel model, in which each participant took responsibility for a separate segment, followed by later alignment. Others might work in a sequential editing mode, in which one participant creates the initial framework, and the others supplement and revise it. A mixed format was also possible. Methodologically, what mattered was not so much which model the team chose, but whether it could maintain the product's coherence and the transparency of interaction during its collaborative creation.

The third stage was followed by an intermediate review of the product's state and a brief alignment on the next steps. This stage had particular value for developing version management skills and coordinating editing. It was precisely here that participants could encounter typical difficulties: duplication of content, excessive fragmentation of the text, inconsistency of style, lack of alignment among separate parts, or the need to shorten or redistribute material. At such a moment, the team had to do more than simply notice these problems. It had to jointly develop a way to resolve them. In this way, intermediate alignment served not merely as a checkpoint, but as a learning moment in which the connection between communication, collaborative editing, and the quality of the result became visible.

The fourth stage involved the final refinement of the product. At this step, it was important not to rush toward the final form, but to ensure collaborative editing based on comments, clarifications, and interim analyses already received. It was here that the cooperative-productive component appeared most clearly in its more developed form: participants did not merely add their own elements, but returned to material already created, improved it, aligned the final logic with the team, and assumed responsibility for the coherence of the result. Particular attention was appropriately paid to whether teachers could perceive the shared product as collective rather than as a sum of individual parts, each defended only by its author.

The fifth stage had a presentation-reflective character. Teams presented the digital product they had created and briefly explained how collaborative editing had been organized, which tools had proven most functional, the difficulties they had encountered in aligning changes, and whether they had needed to revert to earlier versions or revise the material's structure. Such a presentation was important not only as a demonstration of the result, but also as a way to make the process of shared digital authorship itself visible. It was at this stage that participants began to understand that a high-quality digital product in team-based work results not only from content competence but also from a culture of editing, alignment, and shared responsibility.

From a methodological perspective, the second training session had several fundamentally important features. First, it

enabled the team to shift its work from a predominantly communicative level to joint action on a digital object. Second, it made visible the phenomenon of version management, which in ordinary practice often remains spontaneous or underestimated. Third, it demonstrated that cooperation in a digital environment cannot be reduced to the technical possibility of editing one document, but requires alignment of structure, transparency of revisions, meaningful commenting, and shared decision-making regarding the product. It was precisely this set of actions that constituted the content of the cooperative-productive component, the development of which stood at the center of the second training session.

In terms of work formats, the leading forms included micro-group activity on a shared document or another digital resource, use of comments and suggestion mode, brief intermediate alignment points, and a final presentation with elements of reflection. When needed, synchronous interaction could be combined with an asynchronous stage between parts of the training, allowing participants to refine the product outside the immediate meeting. This brought the work format even closer to real pedagogical practice, where collaborative creation of digital materials often continues over time and requires a combination of different modes of interaction.

It is equally important that the second training session also perform a diagnostic and prognostic function with regard to the transition to the third stage. It was during collaborative product creation that it became clear to what extent participants were ready not only to interact, but also to organize activity as a process: who was able to track the logic of the work, who coordinated editing, who tended to assume the role of integrator, and who required a clearer external structure. This laid a natural foundation for the third training session, which focused on project management, role distribution, and stage coordination in a digital environment.

To summarize the content of the second training session, it is presented in Table 4.4.

Table 4.4

**General Characteristics of the Second Training Session**

| <i>Parameter</i>             | <i>Characteristic</i>                                                                                                                                                            |
|------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Title</b>                 | Collaborative Content Creation and Version Management                                                                                                                            |
| <b>Main focus</b>            | Development of the cooperative-productive component                                                                                                                              |
| <b>Goal</b>                  | Development of experience in collaborative creation of a digital product, coordination of editing, alignment of changes, and collective refinement of the result                 |
| <b>Main tasks</b>            | Engagement in shared digital authorship; work with a shared document; alignment of contributions; use of comments and revisions; maintaining the coherence of the shared product |
| <b>Leading forms of work</b> | Micro-group work on a shared product, team editing, intermediate alignments, presentation of the result, and reflection                                                          |
| <b>Expected result</b>       | A collaboratively created digital product and developed experience of cooperative interaction under conditions of open editing and alignment of versions                         |

*Source: Authors' own work.*

Thus, the second training session was aimed at developing teachers' ability to act within the logic of shared digital authorship, align contributions, work with revisions, and manage a shared product as an object of collective responsibility. It was precisely this stage that ensured the transition from digital communication as the basis of interaction to cooperative-productive activity as the central form of teamwork. This experience became the foundation for the third training session, within which participants were expected to integrate the communicative and productive dimensions within an organizationally structured project-based format.

### *4.3.3. The Third Training Session*

The third training session within the proposed methodology served both an integrative and a concluding function. If the first training session supported participants' entry into digital teamwork through communication and initial coordination, and the second moved that interaction into the collaborative creation of a digital product, then the third stage aimed to combine all previously activated skills within a coherent team-based project

format. For this reason, the main emphasis of the third training session was on the organizational-projective component, although, in essence, it involved integrating the communication-facilitation and cooperative-productive dimensions within a single shared task.

The methodological relevance of this final stage lies in the fact that, in real professional practice, teachers' digital teamwork is rarely limited to communication alone or to collaborative editing of a single resource. In most cases, it involves some form of project-based organization: defining a goal, breaking the work into stages, distributing functions, aligning deadlines, documenting task status, addressing challenges, and ultimately bringing the shared task to completion. It is precisely this dimension that is often lacking in short-term digital training for teachers, where teams learn to use tools but do not gain experience in structured team activities. Thus, the third training session was designed to address this gap by making the digital board and related tools not an object of demonstration, but an environment for the real organization of the team process.

The goal of the third training session was to develop participants' experience in organizing and carrying out team activity in a digital environment on the basis of project logic, including planning, role distribution, coordination of stages, use of digital boards or trackers to visualize the process, and completion of the work in the form of an agreed shared result. This goal was specified through several objectives. First, participants needed to learn how to transform a shared task into a structured set of stages and actions. Second, it was important to activate experience in distributing roles and responsibilities. Third, participants needed to practice documenting team progress using digital boards, status labels, deadlines, and responsible persons. Fourth, situations had to be created in which the team would need to respond to organizational difficulties and adjust the process without losing the shared goal. Fifth, it was important to ensure the integration of all three components of digital teamwork within a single task.

As the substantive basis for the third training session, it was advisable to use a team project task that was structurally more complex than those in the previous two sessions and required not

only the creation of a shared product but also the explicit organization of the process. For example, participants could be asked, in micro-groups, to design a model of a short-term educational project, a structure for team preparation of a particular educational event, a digital plan for an interdisciplinary activity, or an algorithm for collaborative work on a methodological product. It was essential that the task involve several stages, require visualization of those stages on a digital board, specify role distribution, set deadlines, and produce a final result to be presented in an agreed format. Only such a design makes it possible to move team activity into a project-based logic.

Structurally, the third training session consisted of several interrelated stages. At the first stage, an introductory orientation took place, during which participants received the task, the time frame, a general understanding of the expected outcome, and a brief explanation of how to use the digital board or tracker. Unlike the previous training sessions, special emphasis was placed here on the fact that the board was not an additional visualization tool, but performed an organizational function. Participants were expected to perceive it as a space in which the stages of team activity, responsible persons, current task status, coordination points, and, if necessary, process adjustments were displayed. Thus, even before active work began, a project-based framework for the entire team activity was established.

The second stage involved initial planning in micro-groups. At this point, teams had to define the task's goal, break it down into subtasks, identify the main work stages, and represent them on the digital board. This stage was key to developing the organizational-projective component, as it translated a general understanding of the task into an explicit structure for shared activity. In practice, this was precisely the moment when typical difficulties became visible: a tendency to move immediately to execution without sufficient planning, lack of clarity in defining stages, overly general formulations, or, conversely, overloading the board with minor actions that made it difficult to see the whole. Work at this stage allowed participants to see, for the first time, that project logic requires not only enthusiasm but also structural thinking.

The third stage was connected with the distribution of roles and responsibilities. Once the general structure of the work had appeared on the board, the team had to determine who would be responsible for individual stages, who would coordinate interim transitions, who would work on content, who would be responsible for final formatting, and who would monitor time boundaries. The methodological value of this stage lies in moving participants beyond the informal understanding that “everyone does everything.” Instead, they had to relate their own actions to the shared structure and make each person’s contribution visible to the others. At the same time, it was important to preserve flexibility: roles were not meant to become rigid constraints, but they had to be sufficiently clear to ensure the process's functional organization.

The fourth stage consisted of direct work on the project task in the digital environment. At this point, teams were not only creating a substantive result but were also constantly sharing their work on the digital board, updating statuses, documenting completed and problematic areas, and adjusting the sequence of actions. It was here that all three components of digital teamwork were integrated. The communication-facilitation component manifested as a need for continual alignment, brief clarifications, maintenance of interaction, and support for group dynamics. The cooperative-productive component was realized through collaborative creation of the digital result. The organizational-projective component appeared through planning, coordination, and visualized process management. In this way, the training session acquired a character as close as possible to real professional practice.

The fifth stage was devoted to intermediate monitoring and process adjustment. This was a deliberately organized pause during which teams had to assess not only what had already been accomplished, but also compare the actual state of the work with the initial plan and identify possible delays, overloads, or misalignment. This stage was especially important for developing the ability to respond to organizational difficulties. In real team practice, it is precisely the ability to adjust the process, rather than merely plan it at the outset, that distinguishes a more mature level of team competence. During the training session, this allowed

participants to experience not an idealized but a realistic process management, where the activity's structure is not fixed once and for all but requires clarification in response to the actual course of events.

The sixth stage involved completing the team task and preparing an agreed final result. At this point, the digital board functioned not only as an organizational tool but also as a representation of the completed work's logic. The team could see how the individual stages had been completed, which decisions had been made, what had been adjusted, and how this had affected the final product. Thus, the results of the training session took two forms simultaneously: a substantive digital result and an organized process of achieving it, documented in the digital environment.

The final, seventh stage had a presentation-reflective character. Teams presented not only the result of their work, but also briefly explained how the team activity had been organized, how the digital board had been used, which roles had proven most significant, where difficulties in coordination had arisen, how the plan had changed during the work, and what had helped bring the task to completion. This format was fundamentally important because it shifted participants' attention away from the product alone and toward the process of achieving it. It was precisely this that created the basis for a deeper understanding of the organizational-projective component as an integral part of digital teamwork.

From a methodological perspective, the third training session had the greatest integrative potential. It made it possible not merely to activate communication, editing, or planning separately, but to unite them into a coherent experience of structured team activity in a digital environment. For this reason, this training session was the one most closely aligned with the real conditions of contemporary teachers' professional practice, in which team interaction almost always unfolds as a combination of communication, product creation, and project management.

No less important is the fact that the third training session created especially favorable conditions for evaluating the methodology's outcomes. It was precisely at this stage that it

became most feasible to observe the extent to which participants could act as a team in a digital environment rather than as a group of separate performers. The quality of communication, transparency of organization, the logic of the shared product, the nature of facilitation, attitudes toward deadlines, the distribution of responsibility, and the ability to adjust activity all became visible. All of this made the third training session not only the concluding formative stage, but also an important point of final diagnostic observation.

To systematize the content of the third training session, its summarized characteristics are presented in Table 4.5.

Table 4.5

**General Characteristics of the Third Training Session**

| <i>Parameter</i>             | <i>Characteristic</i>                                                                                                                                                                                               |
|------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Title</b>                 | Digital Boards and Team Project Management                                                                                                                                                                          |
| <b>Main focus</b>            | Integration of components with a stronger emphasis on the organizational-projective dimension                                                                                                                       |
| <b>Goal</b>                  | Development of experience in planning, role distribution, coordination of stages, and management of team activity in a digital environment                                                                          |
| <b>Main tasks</b>            | Structuring the task; visualizing stages of work; distributing roles and functions; documenting deadlines and statuses; adjusting the process; integrating communication, shared product creation, and organization |
| <b>Leading forms of work</b> | Micro-group project work, use of a digital board or tracker, intermediate monitoring, presentation of process and result, reflection                                                                                |
| <b>Expected result</b>       | An agreed digital result and developed experience of organized teamwork in a digital environment on the basis of project logic                                                                                      |

*Source: Authors' own work.*

Thus, the third training session ensured the integration of the communication-facilitation, cooperative-productive, and organizational-projective components within a coherent form of project-organized digital teamwork. It was precisely this stage that enabled the individual skills activated in the previous stages to mature into a more mature form of professional interaction, where digital tools are used not fragmentarily but as a unified environment for planning, coordination, creating results, and reflection. After examining the structure of the three training

sessions, the logical next step is to synthesize the pedagogical conditions that ensure the effectiveness of the proposed methodology.

#### *4.4. Pedagogical Conditions for the Effectiveness of the Methodology*

The effectiveness of the methodology for developing teachers' teamwork skills in a digital educational environment depends not only on the content of the training tasks or on the selection of digital tools. What is decisive is the set of pedagogical conditions under which this methodology is implemented. It is precisely these conditions that determine whether digital team activity will become genuinely developmental for participants or remain a formal completion of exercises in a shared online space. For this reason, within our study, pedagogical conditions should be understood as specially created circumstances and organizational-methodological characteristics of the educational process that ensure the purposeful and effective development of teachers' digital teamwork skills.

The first such condition is the professional and substantive motivation of team activity. Digital interaction among teachers becomes developmental only when it is built around tasks that participants perceive as substantively significant for their professional practice. If tasks are artificial or detached from pedagogical reality, participants may formally master individual tools, but they will not engage in genuine teamwork. By contrast, professionally relevant tasks stimulate a responsible attitude toward the shared result, activate teachers' own experience, encourage the exchange of practical solutions, and make digital teamwork personally and professionally meaningful. For this reason, the content of the training sessions should be connected with typical professional situations in which teachers genuinely need coordination, shared planning, alignment of actions, and collaborative creation of digital materials.

The second pedagogical condition is the organization of activity on the basis of real interdependence among participants. Teamwork does not develop when each person performs only their own part in isolation, and the sense of togetherness is merely

external. To develop the relevant skills, it is necessary to create tasks in which the progress of one participant is linked to the actions of others, and in which the final result cannot be achieved without alignment of contributions, agreement on decisions, and coordination of stages. Only under such conditions does the digital environment begin to function as a space of team activity rather than as a technical channel for parallel individual work. It is precisely real interdependence among participants that makes meaningful communication, facilitation, collaborative editing, process visualization, and role distribution necessary.

The third condition is the functionally appropriate use of digital tools. Within the methodology, digital services should be selected not based on technological novelty or diversity, but rather on the types of actions that need to be developed. Communication tools should support meaningful interaction and feedback, collaborative editing services should support cooperative product creation, and digital boards or trackers should support project-based organization of activity. If tools are used randomly or excessively, they may complicate teamwork, overload participants, and shift attention away from the professional task toward technical difficulties. Thus, the effectiveness of the methodology depends to a large extent on whether the digital environment is not merely available, but functionally organized and pedagogically justified.

The fourth condition is the combination of synchronous and asynchronous interaction formats. The development of digital teamwork skills requires experience in participating in different modes of team activity. Synchronous formats are important for practicing facilitation of discussion, rapid alignment of decisions, brief coordination of actions, and maintenance of group dynamics. Asynchronous formats, by contrast, make it possible to develop written digital communication, document agreements, work with shared documents, plan, and distribute tasks over time. If the methodology is limited to only one of these formats, skill development remains partial. For this reason, their combination is an important pedagogical condition that brings training activity closer to the real conditions of the contemporary digital educational environment.

The fifth condition is the presence of a structured yet flexible team process. In order to develop digital teamwork skills, participants must act under conditions in which, on the one hand, there are clear frameworks, stages, time references, roles, and criteria for the result, while on the other hand, there remains space for independent alignment, decision-making, and adjustment of the process. An excessively rigid structure turns teamwork into mere execution of instructions and reduces opportunities for initiative and facilitation. By contrast, a complete absence of structure leads to chaos and overload. For this reason, the methodology is most effective when participants work within a sufficiently organized, but not overly regulated, process.

The sixth pedagogical condition is reflective support of team activity. The development of digital teamwork skills cannot be reduced to the accumulation of experience in shared digital tasks. That experience must become the subject of reflection. Reflection allows participants to see how they communicated, what helped or hindered collaborative editing, how roles were distributed, why coordination difficulties arose, which tools were truly functional, and which only made the work more complicated. Without such reflection, activity may remain situational and fail to reach the level of a conscious professional skill. For this reason, it is important that each training session conclude with individual and group reflection on both the process and the results.

The seventh condition is the combination of formative and developmental assessment. Within the methodology, the assessment should perform not only a controlling, but also a supportive function. Participants should have the opportunity to relate their own activity to clear criteria, identify strengths and difficulties, and recognize the dynamics of their own development. For this reason, the effectiveness of the methodology increases when self-assessment, observation, analysis of digital artifacts, and brief feedback are integrated into the learning process rather than postponed until the final stage. Under such conditions, assessment becomes a means of professional self-understanding and further skill development.

The eighth condition is the creation of a safe atmosphere of professional interaction. Digital teamwork requires participants to be open to collaboration, willing to express proposals, respond to

colleagues' revisions, acknowledge difficulties, revise their own decisions, and take part in the joint refinement of the result. If the environment is perceived as overly evaluative, conflictual, or psychologically unsafe, participants may avoid active interaction, limit their contributions to the minimum, or tend to individualize their work. By contrast, an atmosphere of mutual respect, appropriateness, and professional support creates conditions for facilitation, responsible feedback, and genuine shared authorship. For this reason, psychological safety is not a background feature, but a full pedagogical condition for the effectiveness of the methodology.

The ninth condition may be defined as the gradual increase in the complexity of content and modes of teamwork. The effectiveness of the methodology increases as participants move from relatively simple forms of digital interaction to more complex, integrated forms of activity. At first, they learn to negotiate, sustain communication, and record interim decisions; then they move on to collaborative product creation; and later to full project-based organization of teamwork. It is precisely this dynamic that helps avoid both overload at the outset and stagnation later. For this reason, phased progression and logical increase in complexity are not only principles of the methodology, but also independent pedagogical conditions for its effectiveness.

The tenth condition is the visibility of both process and result within the digital environment. One of the advantages of digital tools is the ability to document not only the final product but also the course of shared work itself: comments, revisions, status changes, stages on the board, version history, and the task structure. The effectiveness of the methodology increases when these digital traces serve not only as a resource for assessment but also for learning. Visibility into the process helps participants become aware of their own role, see the contributions of others, understand the team's movement, and identify points at which interaction was productive or, conversely, difficult. For this reason, the digital environment should be organized so that the process of activity is available for analysis and reflection.

To summarize the pedagogical conditions that ensure the effectiveness of the methodology, they are presented in Table 4.6.

Table 4.6

**Pedagogical Conditions for the Effectiveness  
of the Methodology for Developing Teachers' Teamwork Skills  
in a Digital Educational Environment**

| <i>Pedagogical condition</i>                               | <i>Content of the condition</i>                                                                                        |
|------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------|
| <b>Professional and substantive motivation of tasks</b>    | Orientation of team activity toward real pedagogical situations and professionally significant outcomes                |
| <b>Real interdependence among participants</b>             | Design tasks so that the achievement of the result requires alignment of contributions and shared decisions            |
| <b>Functionally appropriate use of digital tools</b>       | Selection of services in accordance with the logic of communication, collaborative editing, planning, and coordination |
| <b>Combination of synchronous and asynchronous formats</b> | Creation of experience in different modes of digital teamwork                                                          |
| <b>Structured but flexible organization of the process</b> | Presence of clear frameworks, stages, roles, and deadlines while preserving space for independent alignment            |
| <b>Reflective support</b>                                  | Systematic reflection by participants on the process, difficulties, and results of team activity                       |
| <b>Developmental assessment</b>                            | Use of self-assessment, observation, and artifact analysis as means of supporting professional growth                  |
| <b>Safe atmosphere of professional interaction</b>         | Ensuring respect, appropriateness, openness to revisions, discussion, and collaborative refinement                     |
| <b>Gradual increase in the complexity of activity</b>      | Movement from basic digital interaction to integrated project-organized teamwork                                       |
| <b>Visibility of process and result</b>                    | Use of digital traces of activity for analysis, reflection, and assessment of teamwork                                 |

*Source: Authors' own work.*

Thus, the effectiveness of the methodology for developing teachers' teamwork skills in a digital educational environment is ensured not by a single factor, but by a set of interrelated pedagogical conditions. It is these conditions that create the foundation for transforming digital tools into a means of professional interaction and training tasks into a space for the real development of the communication-facilitation, cooperative-productive, and organizational-projective components. After substantiating the methodology and its effectiveness conditions,

the next logical step is to analyze the pilot experiment in which it was tested.

## **5. Pilot Experiment on the Development of Teachers' Teamwork Skills in a Digital Educational Environment**

### *5.1. Purpose and Objectives of the Pilot Experiment*

After providing a theoretical rationale for the essence of teachers' digital teamwork skills, defining their structure, constructing an assessment system, and developing a methodology for their growth, the next logical stage of the study was its practical testing. For this purpose, a pilot experiment was organized. Its aim was not so much to confirm a completed model through large-scale statistical measurement, but rather to test the functionality of the proposed methodology, the sensitivity of the diagnostic instruments, and the overall possibility of purposefully developing teachers' digital teamwork skills within a short-term training program. Such a pilot-testing format is consistent with the logic of contemporary research on pedagogical innovations, in which initial testing of a new methodology primarily aims to assess its functionality, methodological appropriateness, and potential for further scaling. This is especially important in areas where teamwork and the digital environment intersect within a single field of inquiry, since in such cases it is necessary to examine not only the final outcome, but also how the very organization of collaborative activity functions (Amelia et al., 2024; Espejo et al., 2023). This research format is methodologically justified because it allows combining the testing of instruments, the initial identification of change dynamics, and the clarification of aspects of the methodology that require further elaboration within a broader research design.

The pilot nature of the experiment also shaped the study's specific logic. The focus was not on comparing large samples or identifying universal patterns, but on determining whether the developed methodology enabled the activation and development of the communication-facilitation, cooperative-productive, and organizational-projective components of teachers' digital teamwork skills. Accordingly, the pilot experiment performed several interrelated functions. The formulation of precisely this

research question is also justified by the fact that existing studies indicate different levels of sensitivity among the components of teamwork to pedagogical interventions. Communicative and organizational practices may change most rapidly, whereas stable cooperation, trust, depth of alignment of contributions, and a culture of shared responsibility require longer-term development. For this reason, a component-based analysis within a pilot study is a methodologically strong decision (Navio-Marco et al., 2025; Xu et al., 2026). First, it enabled verification of the extent to which the theoretical propositions were confirmed in participants' actual professional interactions. Second, it allowed us to determine whether the proposed assessment system was sufficiently sensitive to capture change. Third, it created a basis for interpreting which elements of the methodology proved most effective and which required further refinement.

After the theoretical substantiation of the essence of teachers' digital teamwork skills, the identification of their structure, the construction of an assessment system, and the development of a methodology for their growth, the logical next stage of the study was its practical testing. For this purpose, a pilot experiment was organized. Its aim was not so much to confirm a finished model through large-scale statistical measurement, but rather to test the feasibility of developing teachers' digital teamwork skills within a specially organized series of training sessions based on the use of digital tools for collaborative communication, editing, and project management, as well as to identify the dynamics of change in the development of these skills based on two assessment points. This formulation of the aim reflects the experiment's dual nature. On the one hand, it had a formative orientation, since it involved a purposeful intervention through the training methodology. On the other hand, it had a diagnostic orientation, since it was intended to document changes and analyze their character.

In accordance with this aim, several main objectives of the pilot experiment were identified. First, it was necessary to determine the initial features of participants' digital teamwork during the first training session, including the nature of their communication, the level of coordination of actions, and their ability to collaboratively create a product and organize the

process. The second objective was to pilot the series of three weekly training sessions as an integrated methodology for developing the skills under study. The third objective involved collecting and comparing data obtained after the first and third training sessions to identify changes in the development of the corresponding components. The fourth objective was to test the functionality of the assessment instruments, which included self-assessment, observation, and analysis of digital artifacts. The fifth objective concerned the interpretation of the pilot experiment results to further refine the methodology and design a broader study.

The pilot experiment was designed as a short-term formative study comprising three weekly training sessions. This format was chosen for several reasons. First, it enabled a relatively intensive intervention without placing excessive time or organizational demands on participants. Second, the three-week sequence created an opportunity to unfold the three substantive emphases of the methodology in a consistent manner: digital communication, collaborative creation of a digital product, and project-organized teamwork. Third, such an organization enabled us to conduct two assessment points, structured as “after the first training session” and “after the third training session,” which allowed us to evaluate not only the final state but also the dynamics of skill development during participation in the training series.

A distinctive feature of the research design was that measurement was conducted not at the beginning of the program, but after the first and third training sessions. This approach is methodologically justified in this case because the first training session performed both diagnostic and activation functions. It made it possible to identify participants’ actual initial features of digital teamwork, already under conditions of active participation, rather than only through abstract self-reports. For this reason, the first assessment point after the initial training session captured the state of the skills at the stage of first entry into digital teamwork, whereas the second assessment point after completion of the entire series made it possible to evaluate the changes that had occurred as a result of participating in the three interconnected training sessions.

In terms of content, the experiment was organized around three interrelated lines. The first line was formative and included the training sessions themselves as a system of activity-based interventions. The second line was diagnostic and involved the use of a set of instruments to collect data on the manifestations of digital teamwork skills. The third line was analytical and reflective, including the interpretation of the results obtained, the comparison of data from different sources, and the identification of the characteristics of team interaction that underwent the most pronounced changes. This combination made it possible to view the pilot experiment not as a purely formal test, but as a space for the simultaneous implementation, observation, and interpretation of the methodology.

The participants in the experiment worked in small teams, which was of fundamental importance for preserving the real interdependence of their actions. It was precisely the micro-group format that made it possible to observe the character of each teacher's teamwork behavior without dissolving it in an overly large group and without reducing the activity to an individual response to a task. Work in small teams also facilitated the recording of communicative manifestations, editing actions, role distribution, and the use of digital boards or shared documents. Methodologically, this created favorable conditions for both skill development and subsequent analysis.

An important organizational aspect was also that all three training sessions were conducted within a unified digital environment. This meant that participants worked with tools that enabled communication, collaborative editing, planning, visualization of stages, and analysis of digital artifacts. Thus, the experiment tested not an individual digital service, but the very possibility of creating a functionally organized environment within which teachers could develop teamwork skills. It was precisely this coherence of the digital environment that made the experiment as close as possible to the real conditions of professional interaction.

From a research perspective, it is important to emphasize that the pilot experiment used several data sources. After the first and third training sessions, self-assessment results were recorded, structured observations of work in micro-groups were conducted, and the digital artifacts produced during the shared

activity were analyzed. Such an organization of data collection made it possible to move beyond general impressions of participation in the training sessions and to observe specific manifestations of change: in the character of communication, the quality of feedback, the ways of editing a shared product, the level of organization of the process, the use of digital boards, and the team's ability to adjust its own activity.

For greater clarity, the pilot experiment's organization is summarized in Table 5.1.

Table 5.1

**General Organization of the Pilot Experiment**

| <i>Parameter</i>              | <i>Characteristic</i>                                                                                                                               |
|-------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Type of study</b>          | Pilot formative experiment                                                                                                                          |
| <b>Aim</b>                    | testing the possibility of developing teachers' digital teamwork skills within a series of training sessions and identifying the dynamics of change |
| <b>Duration</b>               | Three weeks                                                                                                                                         |
| <b>Format of intervention</b> | A series of three weekly training sessions                                                                                                          |
| <b>Main content emphases</b>  | Digital communication and coordination of interaction; collaborative creation of a digital product; project-organized teamwork                      |
| <b>Format of work</b>         | Micro-group activity in a digital environment                                                                                                       |
| <b>Assessment points</b>      | After the first training session, after the third training session                                                                                  |
| <b>Data sources</b>           | Self-assessment, structured observation, and analysis of digital artifacts                                                                          |
| <b>Purpose of the results</b> | Evaluation of dynamics, piloting of the methodology, refinement of the instruments, and clarification of prospects for further research             |

*Source: Authors' own work.*

Thus, the pilot experiment was organized as a short-term formative test of the methodology for developing teachers' digital teamwork skills in a functionally organized digital environment. Its aim was not only to document change but also to test the methodology's viability, the logic of its staged implementation, and the sensitivity of the assessment system developed. Such an organization laid the groundwork for further specification of the sample's characteristics and the experiment's conditions, which is the subject of the next subsection.

## *5.2. Organization and Characteristics of the Sample*

In the 2025 pilot experiment, the participants were future master's students in secondary education at Sumy State Pedagogical University. The total number of participants was 26. In terms of gender composition, the group included 18 men and 8 women. The average age of the participants was 22 years. This composition of the sample makes it suitable for a pilot study, as it involved learners at the stage of professional formation, already engaged in preparation for pedagogical activity, and at the same time sufficiently open to mastering new formats of digital interaction in the educational environment.

The choice of this particular category of participants was methodologically justified. Future master's students in secondary education already have some experience in educational and professional interactions, working with digital resources, and participating in shared educational tasks, yet their digital teamwork skills remain open to purposeful development. For this reason, such a sample is suitable for piloting a methodology aimed not at a retrospective description of established professional practice, but at developing skills significant for future pedagogical activity. In this sense, the pilot experiment was oriented not only toward documenting the current state of digital teamwork but also toward testing the extent to which these skills can be purposefully activated within a short-term training program.

The conditions of the experiment were determined by the logic of the study itself and, at the same time, corresponded to the nature of the phenomenon under investigation. All training sessions were conducted online. This was of fundamental importance, since the object of the study was precisely teachers' digital teamwork skills; therefore, the interaction itself had to take place in a digital educational environment rather than merely simulate some of its elements. The online format enabled the practical use of digital communication channels, collaborative editing tools, visual work-stage tools, and digital boards for team planning. As a result, participants did not simply discuss the possibilities of digital interaction, but acted directly within the environment that served as the space for developing the skills under study.

To organize the training sessions and team activity, platforms and tools functionally suited to different types of teamwork were used. The main synchronous interaction platform was Zoom, which supported shared meetings, short introductory sessions, intermediate alignment, and final reflective discussions. Messengers were used for rapid, asynchronous communication, through which participants maintained contact, clarified individual actions, aligned on decisions, and exchanged short messages between synchronous work stages. For visualization of shared activities, planning, structuring ideas, and coordinating stages, digital boards such as Miro and related tools were used. It was precisely this combination of platforms that made it possible to create a multi-component digital environment in which the communication-facilitation, cooperative-productive, and organizational-projective dimensions of team activity were naturally combined.

From a methodological perspective, the online format had another significant advantage. It ensured the visibility of digital traces of activity, which was important for subsequent analysis. Comments, revision history, the structure of shared boards, communication on digital channels, the logic of task progression, and documentation of work stages provided material for analyzing digital artifacts as a data source within the pilot experiment. Thus, the conditions of implementation not only corresponded to the nature of the training work but also strengthened the research possibilities of the assessment procedure itself.

It is important to emphasize that the pilot experiment was conducted in accordance with the relevant ethical requirements. Ethical consent for participation in the study was obtained from all participants. This means they were informed about the nature of the experiment, its educational and research purposes, the format of participation, the use of the results for scholarly purposes, and the voluntary nature of their involvement. Compliance with this condition is fundamentally important, since the study documented not only final products of activity, but also features of teamwork, communication, work with shared digital resources, and other manifestations of professional behavior in a digital environment.

In addition to individual participant consent, the pilot experiment was approved by the university's academic council.

This gives the study additional institutional legitimacy and indicates its compliance with the academic and organizational requirements of the higher education institution. In this case, the experiment is regarded not as a local initiative of an individual teacher or researcher, but as a scientifically grounded and institutionally recognized form of research-based educational activity.

Given the sample composition and implementation conditions, it is appropriate to note that the pilot experiment's results do not claim broad statistical representativeness across all categories of teachers or learners. However, for the purposes of a pilot study, this sample is entirely sufficient, as it allows testing the internal logic of the methodology, assessing the sensitivity of the data collection instruments, identifying typical difficulties, and detecting initial positive changes in the dynamics of digital teamwork skills. This research position corresponds to the nature of a pilot experiment as a stage of piloting rather than the final verification of a model on a large sample.

To summarize the participants' characteristics and the experimental conditions, they are presented in Table 5.2.

Table 5.2

**Characteristics of the Participants and Conditions of the Pilot Experiment**

| <i>Parameter</i>                    | <i>Characteristic</i>                                                                   |
|-------------------------------------|-----------------------------------------------------------------------------------------|
| <b>Year of implementation</b>       | 2025                                                                                    |
| <b>Site</b>                         | Sumy State Pedagogical University                                                       |
| <b>Participant category</b>         | future master's students in secondary education                                         |
| <b>Total number of participants</b> | 26                                                                                      |
| <b>Gender composition</b>           | 18 men, 8 women                                                                         |
| <b>Average age</b>                  | 22 years                                                                                |
| <b>Format</b>                       | online                                                                                  |
| <b>Main digital tools</b>           | Zoom, messengers, Miro-type shared boards, and other digital tools for team interaction |
| <b>Ethical conditions</b>           | Ethical consent obtained from participants                                              |
| <b>Institutional approval</b>       | The experiment approved by the university's academic council                            |

Source: Authors' own work.

Thus, the pilot experiment was conducted under conditions of online interaction with master 's-level learners who were at the stage of active professional development and were engaged in teamwork in a digital environment through functionally selected platforms and services. Compliance with ethical requirements and institutional approval ensured an appropriate organizational foundation for the study. This creates the basis for moving to the next subsection, which specifies the diagnostic instruments and assessment procedure used within the pilot experiment.

### *5.3. Diagnostic tools and assessment procedure*

The diagnostic block of the pilot experiment was constructed in accordance with the methodological foundations substantiated in Chapter 3, namely the principles of multiple data sources, the combination of process-oriented and outcome-oriented dimensions, criterion-based clarity, and level-based interpretation of results. Since the object of assessment was teachers' digital teamwork skills as a complex, integrated construct, the diagnostic instrumentarium could not be limited to a single data-collection method. For this reason, the pilot experiment employed a set of complementary instruments that enabled capturing both participants' reflective self-perception and the actual manifestations of their activity in a digital team environment.

The diagnostic instrumentarium included three main tools: an adapted self-assessment questionnaire, structured observation of performance during team tasks, and analysis of digital artifacts produced during teamwork. This combination was selected as the most appropriate for assessing digital teamwork skills in the context of a pilot study. On the one hand, it enabled participants to identify their subjective views of their readiness for digital team interaction. On the other hand, it allowed these perceptions to be compared with actual behavior, the nature of interaction, and the material traces of shared activity in a digital environment.

The first instrument was an adapted self-assessment questionnaire designed to assess participants' self-evaluations of their digital teamwork abilities. Its function was not to determine the final level of skill development, but rather to document participants' reflective perception of their own role in the team,

their confidence in using digital tools, and their readiness for shared activity. The structure of the questionnaire corresponded to the three identified components of the phenomenon under study. Accordingly, it included statements related to the communication-facilitation, cooperative-productive, and organizational-projective dimensions of digital teamwork.

The first block included statements related to the ability to initiate digital interaction, sustain meaningful discussion, provide constructive feedback, facilitate shared communication, and contribute to decision alignment. The second block covered participation in the collaborative creation of a digital product, coordination of editing, alignment of changes, adaptation of digital resources, and readiness for joint refinement of the result. The third block concerned planning work stages, distributing roles, meeting deadlines, tracking task progress, and adjusting difficulties in the team process. To record responses, a scale of manifestation intensity was used, allowing participants to evaluate the degree of their own confidence or the regularity of the corresponding actions. This design not only enabled obtaining an overall result but also allowed identifying the specific features of self-assessment across the separate components.

The second instrument was a structured observation of participants' work during the training tasks. This instrument was particularly important for the study because it enabled the documentation of actual manifestations of digital teamwork in a direct activity context. Observation was conducted not in a free-form manner, but on the basis of a previously developed observation chart that included behavioral indicators linked to the assessment criteria. This approach helped reduce excessive subjectivity and made the data documentation process more transparent and comparable.

Within the communication-facilitation criterion, the following manifestations were observed: initiation of digital discussion, substantive quality of contributions, ability to clarify positions, provision of constructive feedback, summarizing interim results, and maintenance of a productive atmosphere of interaction. Within the cooperative-productive criterion, the following were documented: involvement in collaborative editing, coordination of one's own contribution with those of others, work with comments,

participation in refining the result, and orientation toward the coherence of the shared product. Within the organizational-projective criterion, attention was focused on the ability to structure the task, align work stages, document roles, follow time markers, respond to disruptions, and use digital boards or other means of process visualization. It was precisely this level of detail in the behavioral indicators that enabled alignment of the observations with the previously substantiated system of criteria and indicators.

The third instrument was the analysis of digital artifacts, which played a particularly important role in this study because the digital environment enabled the documentation of both results and the course of shared activity in a relatively stable form. These digital artifacts included shared documents, revision histories, comments on edits, messages in team channels, the structure of task-management boards, stage-completion statuses, and the final digital products created by the teams. Analysis of these materials made it possible not only to see the final result, but also to trace how it had been created: the intensity of participation, the transparency of editing, whether substantive commenting took place, how the logic of project organization was represented, and whether roles and stages of work were visible.

Within the analysis of digital artifacts, particular attention was paid to three aspects. The first concerned the procedural visibility of teamwork, that is, the extent to which participants' actions were documented in the digital environment as an interconnected process. The second aspect concerned the degree of integration of the shared product, namely, whether the final result appeared as a coherent collective output rather than as a mechanical sum of separate fragments. The third aspect concerned the organizational orderliness of digital activity, in particular the presence of stages, the structure of the board, the marking of tasks, and the visibility of the team's progress logic. This constituted the particular value of artifact analysis as an instrument that combined both the outcome-oriented and process-oriented dimensions of assessment.

The assessment procedure in the pilot experiment was organized around two assessment points: after the first and after the third training sessions. Such an arrangement made it possible

to compare not abstract pre-experimental expectations with final results, but two states of skill development during participants' actual inclusion in digital teamwork. The first assessment point, conducted after the initial training session, reflected the level of skills at the stage of first engagement in digital interaction, when participants had already gained experience of real work in micro-groups but had not yet completed the full cycle of formative intervention. The second assessment point, conducted after the third training session, documented the state upon completion of the entire series and enabled identification of changes resulting from participation in the methodologically organized training process.

At each assessment point, the procedure included several successive steps. First, participants completed the self-assessment questionnaire, which documented their reflective perceptions of their readiness for digital teamwork at each stage. Next, a structured observation was conducted during the team task embedded in the training process, enabling identification of the actual manifestations of the skills under study. After the team activity, the digital artifacts created by the teams were analyzed. This sequence enabled comparison of participants' self-perceptions, behavior, and the results of the shared activity, thereby ensuring greater objectivity in the conclusions.

A four-level model substantiated in the previous subsection was used to interpret the results: initial, basic, advanced, and expert levels. Data from self-assessment, observation, and artifact analysis were compared, enabling the determination of both the overall level of development of digital teamwork skills and the specific manifestations of the individual components. At the same time, it is important that, within this pilot study, the levels be interpreted not as rigidly fixed states but as the predominant pattern of a participant's professional behavior in the digital team environment at a given stage of the experiment. This made it possible not only to identify changes, but also to describe them qualitatively.

From a methodological perspective, it is important to emphasize that the assessment procedure had not only a diagnostic, but also a developmental function. Participation in self-assessment, comparing one's own actions against the criteria, the

visibility of team interaction, and subsequent reflection increased participants' awareness of what high-quality digital teamwork actually means. Thus, the assessment procedure was integrated into the methodology's logic as an important component rather than as an external control mechanism.

The diagnostic instrumentarium and assessment procedure are summarized in Table 5.3.

Table 5.3

**Diagnostic Instrumentarium and Assessment Procedure  
in the Pilot Experiment**

| <i>Diagnostic<br/>component</i>      | <i>Characteristic</i>                                                                                                                              |
|--------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Self-assessment</b>               | An adapted questionnaire aimed at identifying participants' subjective evaluation of their own digital teamwork skills across the three components |
| <b>Observation</b>                   | Structured recording of behavioral manifestations during the performance of team tasks in a digital environment                                    |
| <b>Analysis of digital artifacts</b> | Analysis of shared documents, revision histories, comments, messages, digital boards, and final products                                           |
| <b>Assessment point 1</b>            | Conducted after the first training session                                                                                                         |
| <b>Assessment point 2</b>            | Conducted after the third training session                                                                                                         |
| <b>Logic of comparison</b>           | Comparison of the results of the two assessment points by criteria, indicators, and levels of development                                          |
| <b>Interpretive result</b>           | Identification of the dynamics of development of digital teamwork skills overall and across individual components                                  |

*Source: Authors' own work.*

Thus, the diagnostic instrumentarium for the pilot experiment was constructed as a system of complementary tools that enabled documentation of teachers' digital teamwork skills at the levels of self-assessment, actual behavior, and digital traces of shared activity. The two-stage assessment procedure, conducted after the first and third training sessions, enabled identification not only of the current state of development of the relevant skills, but also of their growth dynamics during participation in the methodologically organized training series.

This lays the groundwork for analyzing the results of the first assessment point, namely the characterization of the state of digital teamwork skills after the first training session.

#### *5.4. Results after the first training session*

The first assessment point, conducted after completion of the first training session, made it possible to document the state of digital teamwork skills that had developed at the stage of participants' initial engagement in specially organized digital team interaction. Its significance lies in the fact that it reflects not an abstract "baseline" level determined outside activity, but the initial state of the skills after the first experience of real work in micro-groups using digital communication channels, collaborative alignment, and elementary coordination of actions. For this reason, the results of this assessment have particular analytical value: they reveal which skills are most readily accessible to rapid activation and which still require purposeful development in subsequent training stages.

Overall, the results from the first training session showed that participants entered digital team interaction quickly, at the level of basic communicative actions. In most micro-groups, there was active engagement in discussion, attempts to define a shared goal, maintenance of contact through digital channels, and alignment of initial decisions. This provides grounds for concluding that the digital team task's format already activates a certain potential for interaction at the outset, especially when the task has a clear professional meaning and requires an agreed result. At the same time, the results of the first assessment indicated that such activity was not always sufficiently structured, and that communication, although quite lively, often remained unstable in terms of the depth of facilitation, clarity in documenting decisions, and the maintenance of the logic of shared progress.

The most pronounced results after the first training session were observed within the communication-facilitation component. This proved to be the component most sensitive to the initial training intervention. Participants generally demonstrated readiness to engage in digital interaction, respond to one another's messages, sustain discussion, and participate in brief position

alignment. In most teams, active communication was observed, though it was often uneven: initiative was usually taken by one or several participants, while others joined mainly reactively. This suggests that, even in the first training session, elements of micro-leadership and facilitation begin to emerge, though they are not yet a stable characteristic of the whole team and often depend on the individual activity of particular participants.

According to self-assessment data, most participants rated their digital communication ability as moderate to sufficient after the first training session. As a rule, they indicated they could participate in shared discussions, respond to digital messages, and sustain team interaction. However, comparing these data with the observation results showed that confidence in one's own communication did not always indicate a sufficient level of structure. In actual interaction, there was often a lack of summarizing statements, clear transitions from discussion to decision, meaningful documentation of agreements, and deliberate inclusion of less active participants. Thus, after the first training session, one can speak of a clear activation of communicative interaction, but not yet of its full facilitative maturity.

The results related to the quality of feedback were also revealing. In many cases, participants responded quite willingly to colleagues' messages and suggestions, yet these responses were often brief, confirmatory, or situationally supportive. Constructive feedback, which not only approves but also clarifies, proposes, justifies, or helps improve a shared decision, was still unstable after the first training session. This indicates that basic communicative openness develops more quickly than a culture of meaningful digital interaction. At the same time, even at this stage, some examples of facilitation-valuable behavior could be observed: attempts to summarize what had been said, bring the group back to the task, clarify a proposal, or formulate an interim decision. These manifestations can be regarded as early indicators of the development of the communication-facilitation component.

The cooperative-productive component after the first training session proved less developed than the communication-facilitation component, which is entirely natural. Since the first training was oriented primarily toward interaction, coordination,

and alignment rather than toward complex collaborative editing, the results in this dimension reflected more an initial readiness for collective result creation than a stable command of the corresponding actions. Analysis of digital artifacts showed that teams arrived at a shared mini-product, but in most cases, it still bore signs of being assembled from separate fragments rather than constituting a fully integrated digital outcome. This means that participants were already beginning to act according to the logic of shared creation, but were not yet sufficiently confident in coordinating contributions, style, and the product's structure.

This was especially evident when it was necessary to quickly document a collective decision in a shared digital space. Some groups chose the path of dividing elementary tasks, where individual participants proposed fragments of content that were then mechanically combined. Such an approach enabled an acceptable result but did not yet indicate sufficiently developed cooperative-productive interaction. At the same time, in some teams, attempts at substantive alignment of the product were already noticeable: participants returned to earlier formulations, revised them in line with the overall logic, asked clarifying questions about content, and tried to make the result more coherent. It is precisely such manifestations that can be regarded as the first signs of the emergence of the cooperative-productive component.

The organizational-projective component after the first training session proved to be the least pronounced, which is consistent with the study's logic. At the initial stage, participants were mainly focused on the very act of interaction and on finding a shared solution, whereas in the planning stages, explicit role distribution, deadline setting, or structured progress tracking had not yet taken a stable form. Observation of teamwork showed that some organizational decisions were made implicitly or spontaneously: someone began acting as an initiator, someone summarized, and others joined the work, following the logic already established. Such a format is typical of the initial stage of team interaction, when the organization is not yet understood as a separate and necessary dimension of activity.

At the same time, the first training session already revealed preconditions for further development of this component. In a

number of teams, attempts appeared to define the sequence of actions, clarify who would document the result, who would formulate the final version, who would track messages, or who would initiate brief alignment points. Although these actions did not yet have a fully project-based character, they indicated that the need for organizational structuring was already being recognized at the stage of the first digital team experience. For this reason, the low degree of expression of the organizational-projective component after the first training session should not be treated as a weakness of the methodology, but rather as an important diagnostic signal regarding the direction of further work.

If the results of the first assessment point are summarized in level-based terms, it can be stated that after the first training session, the initial and basic levels of development of digital teamwork skills predominated. The initial level manifested in cases where digital interaction was mainly reactive, unstable, and dependent on external organizational support. The basic level appeared in those cases where participants were already able to take part in shared discussion, maintain elementary coordination, and arrive at a simple shared result within a clear task structure. The advanced level after the first training session was represented only by isolated manifestations, mainly in the communication-facilitation dimension, where some participants demonstrated the ability not only to participate, but also to sustain the logic of group interaction. The expert level did not appear at this stage, which is natural for the initial stage of a formative experiment.

The results of the comparison among the three data sources are also of particular value. Self-assessment after the first training session was often somewhat higher than what followed from observation and analysis of digital artifacts. This suggests that initial engagement in digital teamwork creates in participants a sense of readiness, yet actual behavior does not always confirm this readiness at the level of stable and coordinated actions. At the same time, such a discrepancy is not a negative phenomenon. On the contrary, it demonstrates the importance of combining self-assessment with activity-based diagnostic methods. It is precisely because of this combination that the first assessment point provided not only a general impression of participants' engagement, but also a more precise picture of which components

of digital teamwork had already begun to develop and which still remained within the zone of proximal development.

A summary of the results after the first training session is presented in Table 5.4.

Table 5.4

**Summarized Characteristics of the Results After the First Training Session**

| <i>Component</i>                  | <i>General characteristics of manifestation</i>                                                                                               | <i>Preliminary conclusion</i>                                                                                       |
|-----------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------|
| <b>Communication-facilitation</b> | Participants actively engage in digital discussion, respond to messages, and attempt to align decisions, but facilitation remains unstable    | The component proved to be the most sensitive to the initial training intervention                                  |
| <b>Cooperative-productive</b>     | Teams are able to create a shared mini-product, but integration of contributions and coordination of editing remains insufficiently expressed | An initial readiness for shared digital authorship has been formed                                                  |
| <b>Organizational-projective</b>  | Planning, role distribution, and structured coordination appear fragmentarily and mostly implicitly                                           | The component requires further purposeful development                                                               |
| <b>Overall level</b>              | initial and basic levels predominate                                                                                                          | A starting foundation has been formed for the further development of skills within the subsequent training sessions |

*Source: Authors' own work.*

Thus, the results of the first training session showed that, even at the initial stage of specially organized digital teamwork, participants begin to activate basic forms of interaction, primarily in the communication-facilitation dimension. At the same time, the cooperative-productive and especially the organizational-projective components do not yet reach a sufficient level of stability and structure. This confirms the appropriateness of

constructing the training series according to a logic of gradual increase in complexity and creates the basis for analyzing how these components change after completion of the entire program. It is precisely this that constitutes the subject of the next subsection.

### *5.5. Results after the third training session*

The second assessment point, conducted after completion of the third training session, enabled documentation of teachers' digital teamwork skills after they had completed the full series of formative sessions. Unlike the first assessment point, which reflected the level of development of these skills at the stage of participants' initial engagement in digital team interaction, the second made it possible to evaluate the extent to which the purposeful training work had contributed to the development of the components under study and whether those components had acquired greater stability, awareness, and integration. For this reason, the results after the third training session have a summative character within the pilot experiment, although they do not claim to provide a final or exhaustive confirmation of the methodology's effectiveness on a broader scale.

Overall, the results of the second assessment point showed positive dynamics in the development of digital teamwork skills. Compared with the data collected after the first training session, participants demonstrated more structured, purposeful, and professionally meaningful interaction in the digital environment. This was evident not merely in increased activity or confidence, but above all in a change in the quality of teamwork itself: communication became less situational and more meaningfully organized, the collaborative creation of digital products became more coherent, and the organization of the process ceased to be spontaneous and increasingly relied on explicit mechanisms of planning, role distribution, and coordination. These changes make it possible to conclude that the series of training sessions performed not only an activating, but also a genuinely developmental function.

The most noticeable changes after the third training session were observed in the communication-facilitation component.

Whereas after the first training session, participants' digital interaction was already quite active but often remained uneven and not always sufficiently structured, after completion of the full series, the quality of team communication was clearly higher. Participants more often formulated messages not simply as reactions, but as elements of shared movement toward a decision. Interaction became more purposeful: the number of substantive clarifications, brief summaries, suggestions for the next step, attempts to bring the discussion back to the task, and efforts to involve less active participants all increased. In some teams, one could already observe not merely situational, but fairly stable facilitative actions.

The changes in the quality of feedback were especially revealing. After the first training session, feedback was often brief, supportive, or confirmatory. After the third training session, however, comments increasingly served a constructive, task-oriented function: participants clarified content, proposed ways to improve it, justified the appropriateness of changes, aligned formulations, and helped the team achieve substantive coherence. This indicates that digital communication had begun to perform not only an informational but also a coordinating and facilitating function. Accordingly, one may speak of a significant proportion of participants transitioning from the basic to a more stable advanced level within this component.

The dynamics of the cooperative-productive component are no less important. After the third training session, the collaboratively created digital products in most teams became much more coherent in structure, logic, and style. Analysis of digital artifacts showed that participants were less inclined to mechanically combine separate fragments and more often acted within the logic of collective editing, changing alignment, and refining the result as a shared product. The ability to work with revisions, comments, and earlier versions, to return to previously created material, and to adjust it in accordance with the overall logic of the task became more evident. In this way, the digital product increasingly acquired the features of genuine shared authorship rather than merely a sum of individual contributions.

It is also significant that not only technical but also substantive coordination of contributions increased. Participants

more often related their own actions to what others had already done, duplicated content less frequently, paid closer attention to the consistency of format, and better recognized the need to adapt their own material to the integrity of the shared result. This provides grounds for stating that after the third training session, the cooperative-productive component no longer amounted merely to readiness to “add something of one’s own,” but had begun to develop into the ability to jointly construct and improve a digital product. This type of change is of particular methodological importance because it indicates the formation in participants not only of digital activity, but also of a culture of shared digital authorship.

The most substantial dynamics were observed in the organizational-projective component. This component had been the least pronounced after the first training session, but after the third, it showed the most visible growth. Participants demonstrated the ability to structure tasks, distribute roles, mark stages of work, use digital boards or other tools to visualize the process, and relate the actual course of activity to the initial plan much more often. Unlike the initial stage, when the organization often remained implicit, by the end of the training series, it had increasingly become a conscious and visible element of teamwork.

Particular attention should be drawn to the fact that teams not only began planning but also began adjusting their own processes. During the third training task, participants in a number of cases independently returned to the digital board, updated statuses, clarified roles, revised the sequence of actions, or responded to delays without external intervention. This is an important indicator of the transition from initial dependence on external structure to more autonomous organization of team activity. It is precisely this ability to coordinate and adjust the process on an ongoing basis that may be regarded as one of the most significant signs of development in the organizational-projective component.

Comparison of the three data sources after the third training session also showed that participants’ self-assessments became more closely aligned with actual behavior than they had after the first assessment point. Whereas at the initial stage some participants assessed their abilities somewhat more highly than

was confirmed by observation and analysis of digital artifacts, by the end of the program, this discrepancy had decreased. This may indicate an increase in reflective adequacy: participants began to understand more clearly what high-quality digital teamwork actually means and to align their own actions more accurately with the relevant criteria. Such a change is no less important than the development of behavioral manifestations themselves, because it reflects a transition from an intuitive to a more conscious attitude toward digital team interaction.

In level-based terms, the results after the third training session indicate that the predominance of the initial level decreased, while the positions of the basic and advanced levels strengthened. A significant proportion of participants, after completing the training series, already demonstrated the ability not only to take part in digital teamwork within a given structure, but also to sustain its substantive logic, coordinate their own contribution with others, engage in collaborative editing, and partially organize the process. The expert level did not become widespread even at this stage, which is natural given the study's pilot character, the short duration of the intervention, and the characteristics of the sample. At the same time, the behavior of certain participants already showed elements approaching that level, especially in facilitating the team, maintaining the process's logic, and flexibly organizing shared activity.

The overall pattern of results after the third training session allows several substantive conclusions to be drawn. First, within a short-term program, the communication-facilitation component develops most quickly, though its sustained quality requires systematic teacher involvement in meaningful team interaction. Second, the cooperative-productive component develops when participants are given the opportunity to work not on a formal task, but on a shared digital product that requires alignment and refinement. Third, the organizational-projective component is especially sensitive to methodically organized tasks involving digital boards, trackers, and explicit project logic. This means that precisely this type of activity is the most productive for developing structured digital teamwork.

A summary of the results of the second assessment point is presented in Table 5.5.

Table 5.5  
**Summarized Characteristics of the Results After the Third Training Session**

| <i>Component</i>                  | <i>General characteristics of manifestation</i>                                                               | <i>Final conclusion</i>                                                                                       |
|-----------------------------------|---------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------|
| <b>Communication-facilitation</b> | Interaction became more meaningful and structured; the quality of feedback and facilitative actions increased | The component acquired a more stable and more conscious character                                             |
| <b>Cooperative-productive</b>     | Shared digital products became more coherent and aligned; coordination of editing and refinement increased    | The capacity for collective digital authorship was strengthened                                               |
| <b>Organizational-projective</b>  | There was a visible increase in planning, role distribution, use of digital boards, and process adjustment    | This component demonstrated the most pronounced positive dynamics                                             |
| <b>Overall level</b>              | The proportion at the initial level decreased, while the basic and advanced levels strengthened               | The series of training sessions contributed to the development of an integrated capacity for digital teamwork |

*Source: Authors' own work.*

Thus, the results after the third training session demonstrated positive changes across all three components of teachers' digital teamwork skills. Participants became more confident in working as a team in the digital environment, and their interactions became more structured, coherent, and effective. This creates the basis for a direct comparison of the two assessment points and for a generalized analysis of the dynamics of change, which constitutes the subject of the next subsection.

#### *5.6. Comparative analysis of the results from two time points*

The comparative analysis of results from the two assessment points revealed a clear positive trend in the development of digital teamwork skills among participants in the

pilot experiment. The analysis used the individual scores of 26 participants across three components: communication and facilitation, collaborative creation of digital content, and team project management. All indicators were recorded on a four-point scale, where 1 corresponded to the initial level, 2 to the basic level, 3 to the advanced level, and 4 to the expert level. The first assessment point was conducted after the first training session, and the second after the third.

At the descriptive statistics level, mean values increased across all three components. For the communication and facilitation component, the mean score increased from 2.04 to 3.12, representing a gain of 1.08 points. For the collaborative creation of the content component, the mean score also rose from 1.77 to 2.85, again by 1.08 points. The largest increase was recorded for the team project management component: the mean score rose from 1.77 to 3.04, an increase of 1.27 points. In the aggregate dimension, the mean integrated indicator across the three components increased from 5.58 to 9.00 points out of a maximum possible 12, indicating an average gain of 3.42 points.

Median values also indicated a positive shift. For each separate component, the median increased from 2 to 3, while the overall median increased from 6 to 9 points. This means that the changes affected not only a few more successful participants, but the group as a whole. In other words, after completing the training series, the typical participant no longer demonstrated an initial-basic level but rather a predominantly basic-advanced or advanced level of digital teamwork. The distribution of total scores also shifted toward higher values: whereas after the first training session, individual totals ranged from 3 to 8 points, after the third, they ranged from 6 to 12 points.

Analysis of individual dynamics confirmed the stability of the positive changes. For the communication and facilitation component, improvement was demonstrated by 24 of the 26 participants (92.3%); the remaining 2 participants maintained the same level, and no decline was observed. The same pattern was observed for the collaborative content creation component: 24 participants (92.3%) improved their results, while 2 remained at the previous level. For the team project management component, growth was observed among all 26 participants (100% of the

sample). In the aggregate dimension, the overall score increased for every participant.

The changes are also visible in the redistribution of levels. For the communication-facilitation component, after the first assessment point, the group included 6 participants at the initial level, 13 at the basic level, and 7 at the advanced level; after the third assessment point, the initial level disappeared, the basic level remained in only 5 participants, while 13 participants reached the advanced level, and 8 reached the expert level. For the cooperative-productive component, the number of participants at the initial level decreased from 9 to 0, at the basic level from 14 to 9, while the advanced level increased from 3 to 12, and the expert level included 5 participants. For the organizational-projective component, the initial level decreased from 8 to 0, the basic level from 16 to 4, while the advanced level rose from 2 to 17 participants, and the expert level to 5 participants. This redistribution confirms that the most pronounced changes occurred precisely in the components that were weakest at the start, especially the organizational-projective one.

For brief statistical verification of the dynamics, a paired pre-post analysis was appropriate. Given that the scale was ordinal with four levels, the most appropriate procedure was the nonparametric Wilcoxon signed-rank test for dependent samples. It showed statistically significant changes across all three components and for the total score: for communication and facilitation,  $p = 0.000004$ ; for collaborative content creation,  $p = 0.000004$ ; for team project management,  $p = 0.000003$ ; and for the total score,  $p = 0.000005$ . Thus, the probability that the observed changes were random is extremely low. An additional paired t-test also confirmed the statistical significance of the differences; however, in this study, it is more appropriate to treat it as supplementary rather than primary, precisely because of the ordinal nature of the scale. The results of both approaches converge and indicate a reliable positive dynamic.

The data obtained allow several general conclusions to be drawn. First, the series of three training sessions proved sufficient to achieve noticeable growth across all three components of digital teamwork, even within a short-term pilot format. Second, the organizational-projective component proved the most sensitive to

the training intervention, as evidenced by the largest mean gain and by the fact that all participants showed progress. Third, the communication-facilitation and cooperative-productive components also increased substantially, although their development was somewhat more even. Fourth, the results confirm that the combination of meaningful digital communication, collaborative product creation, and project-based organization of activity is methodologically productive for developing an integrated capacity for teamwork in a digital educational environment.

The summarized quantitative data are presented in Table 5.6.

Table 5.6

**Comparative Results of the Two Assessment Points**

| <i>Indicator</i>                                      | <i>After the 1st<br/>training session</i> | <i>After the 3rd<br/>training session</i> | <i>Gain</i> |
|-------------------------------------------------------|-------------------------------------------|-------------------------------------------|-------------|
| <b>Communication and<br/>facilitation, mean score</b> | 2.04                                      | 3.12                                      | +1.08       |
| <b>Collaborative content<br/>creation, mean score</b> | 1.77                                      | 2.85                                      | +1.08       |
| <b>Team project management,<br/>mean score</b>        | 1.77                                      | 3.04                                      | +1.27       |
| <b>Total indicator, mean score</b>                    | 5.58                                      | 9.00                                      | +3.42       |
| <b>Total indicator, median</b>                        | 6                                         | 9                                         | +3          |

*Source: Authors' own work.*

Thus, the comparative analysis of the two assessment points demonstrated a statistically significant positive dynamic across all components of digital teamwork skills. The most pronounced growth occurred in the organizational-projective dimension, although substantial changes were also recorded in the communication-facilitation and cooperative-productive components. This provides grounds for considering the piloted methodology an effective means of developing digital teamwork among future master's students in secondary education in online interaction.

### *5.7. Interpretation of Results and Limitations of the Pilot Study*

The results of the pilot experiment provide grounds for stating that the proposed methodology for developing teachers' digital teamwork skills is methodologically well-grounded and practically workable. The positive dynamics recorded across all three components indicate not merely an increase in participants' activity in the digital environment, but also qualitative changes in the nature of their teamwork. This means that the series of three weekly training sessions created conditions not simply for episodic use of digital services, but for the development of more structured, conscious, and effective shared activity in which communication, collaborative product creation, and project-based organization of the process are combined.

First, the results confirm the validity of the initial theoretical proposition regarding the integrated nature of digital teamwork skills. Within the pilot study, it became clear that the communication-facilitation, cooperative-productive, and organizational-projective components do not develop in isolation. Growth in the quality of digital communication was accompanied by better coordination during collaborative product creation, while a more structured process organization strengthened the meaningfulness of interaction and the alignment of contributions. For this reason, the results obtained should be interpreted not as a sum of separate improvements, but rather as a manifestation of the gradual formation of an integrated capacity to act as a team member in a digital educational environment.

It is especially revealing that the largest increase was recorded in the organizational-projective component. This may have several explanations. First, this component was the least developed at the initial stage, and therefore, its potential for change was the greatest. Second, the third training session, built around the use of digital boards, visualization of stages, role distribution, and process adjustment, directly activated those actions that had previously remained implicit or situational for most participants. Third, for future master's students in secondary education, the very idea of project-organized teamwork in a digital environment was likely new and therefore especially sensitive to purposeful formative intervention. In this sense, the results

suggest that the organizational-projective dimension is among the most promising avenues for further improving teachers' professional preparation.

No less important is the interpretation of the growth of the communication-facilitation component. Although this component proved the most readily activated, it only acquired greater structure and awareness after completion of the entire program. The data obtained indicate that digital communication within a team develops from a simple activity and mutual responsiveness into a more meaningful facilitative interaction in which summaries, clarifications, support for the logic of the discussion, constructive feedback, and orientation toward a shared decision begin to appear. This means that communication skills in a digital environment should be understood not merely as technical readiness to communicate, but as a professionally significant capacity to sustain the team process.

The cooperative-productive component also showed substantial growth, allowing an important conclusion to be drawn about the role of the shared digital product in preparing future teachers. It was precisely work on an agreed result that could not be produced through individual effort alone that proved methodologically productive for the transition from formal interaction to genuine collaboration. Collaborative editing, commenting, alignment of structure, and refinement of the digital product gave participants experience of collective authorship that has direct relevance for future pedagogical practice. In this regard, the results of the study confirm that digital teamwork skills are most effectively developed when the team works not around abstract discussion but around a shared, professionally meaningful result.

Another significant outcome is the convergence between participants' self-assessments and their actual behavior, as documented through observations and analyses of digital artifacts. At the initial stage, there was a certain discrepancy between subjective confidence and the actual quality of team interaction. After the program, this discrepancy decreased, suggesting an increase in reflective maturity among participants. They not only began to act more effectively in the digital team environment, but also came to better understand what high-quality teamwork

actually entails. This has particular value because it indicates growth in awareness and, therefore, strengthens the likelihood that the acquired experience will transfer into real professional practice.

The results of the pilot experiment should be considered in the broader field of contemporary research on teachers' digital competence, teachers' professional development, and collaborative activity in a digital educational environment. The overall positive dynamics recorded across all three components of digital teamwork skills are consistent with the conclusions of researchers who emphasize that teachers' professional readiness for digital activity develops most productively not through isolated mastery of tools, but through participation in systematic, practice-oriented, and collaborative formats of professional learning. This conclusion is articulated in the systematic review by Amemasor et al. (2025), which stresses that the most effective professional development programs combine practical digital training, collaborative environments, mentoring, and institutional support. In this sense, the results of our pilot study confirm the effectiveness of an approach in which the development of teachers' digital teamwork is built on real, shared activity rather than merely on instructional familiarization with platforms.

The data obtained also align with the conclusions of Hodges et al. (2026), who highlight the long-standing deficit in systematic teacher preparation for digital teaching and emphasize the fragmented nature of many initiatives in this area. Our results show that even a short-term, substantively and methodologically coherent series of training sessions can produce a pronounced developmental effect. This provides grounds for arguing that the problem lies not only in the amount of digital training, but also in its internal logic. If professional development is organized around integrating communication, collaborative product creation, and project-based activity, even a relatively short format can be meaningful. At the same time, our results do not contradict the position of Hodges et al. (2026), but rather reinforce it: a short-term positive effect should be treated as an argument for systematically embedding such practices into teacher education programs, not as proof that isolated interventions are sufficient.

It is important that our study's results align with contemporary approaches to understanding teachers' digital competence as a multidimensional professional construct. In particular, Tzafilkou et al. (2023) argue that digital competence should be assessed not only through technical actions but also through pedagogical, professional, and innovative elements. In our study, we further developed this logic: we effectively isolated the teamwork dimension of teachers' digital professional activity and showed that it cannot be adequately captured when assessment is limited to a general evaluation of digital readiness. The positive dynamics across the three components confirm the value of such a specification. In other words, the pilot experiment's results indicate that digital teamwork warrants consideration as a separate structural dimension of teachers' professional competence.

A similar line of reasoning is supported by the conclusions of García-Delgado et al. (2023), who, based on a study of teachers at different educational levels in Spain, identified a predominantly intermediate level of digital competence and emphasized the need to strengthen it from initial preparation through continuing professional development. Our results add an important nuance to this argument: even when the overall level of digital readiness appears acceptable, the teamwork dimension of the activity often remains underdeveloped, especially in organizing the shared process. It is precisely for this reason that, in our study, the organizational-projective component showed the greatest increase. Such dynamics suggest that, in ordinary educational preparation, this particular dimension of digital interaction remains insufficiently articulated and rarely becomes the object of purposeful development.

The conclusion about the importance of institutional and cultural factors in teachers' professional digital development is also supported by our study. Masoumi and Noroozi (2023), in their analysis of the development of professional digital competence among teachers in the early stages of their careers, show that it is substantially influenced by institutional culture, resource availability, managerial support, mentoring, and workload. In our pilot study, these factors were not themselves the direct subject of measurement. However, the results indirectly confirm their

significance. In particular, the positive dynamics among participants became possible because the training sessions were organized in a functionally structured digital environment, with clear task structure, time frames, accessible tools, and reflective support. This means that teachers' digital teamwork develops not only as an individual capacity, but also as the result of an interaction between personal effort and institutionally organized conditions.

The results obtained are also consistent with the conclusions of Lin et al. (2022), who demonstrate that digital pedagogical competence is an important mediator between ICT skills, data literacy, and learners' actual empowerment. In our study, this logic appears in a different but related form: the technical affordances of digital platforms alone do not ensure effective team interaction unless embedded in pedagogically meaningful activity. The training series was effective not because participants simply worked in Zoom or Miro, but because these tools were integrated into the logic of a shared professional task requiring communication, alignment, collaborative editing, and project coordination. Thus, our study provides additional support for the thesis that digital competence acquires real value only when combined with pedagogical functionality.

Particular attention should also be given to comparing our results with studies on collaborative and team-based learning. Brannan et al. (2019) show that team-based learning creates systematic conditions for engaging participants in solving meaningful problems in small groups and contributes to the development of critical thinking. Although their study does not directly concern teachers' digital teamwork, it is important for interpreting our results because it confirms the fundamental productivity of the small-team format. In our experiment, it was precisely the micro-group organization that proved most suitable for making each participant's contribution visible, for shaping the character of the role distribution, and for the modes of communication and coordination. This makes it possible to argue that small teams are not only a convenient organizational format, but also an important condition for the development of digital teamwork as a professional capacity.

In a similar way, the results of our study resonate with the conclusions of Kuznetsova et al. (2023), who showed that virtual team building has a positive effect on communication, motivation, a sense of cohesion, and interest in shared work, although it does not entirely eliminate the advantages of the face-to-face format. Our experiment was also conducted entirely online, and the results confirm that the digital environment can be sufficiently productive for developing teamwork, provided that the activity is specially organized. At the same time, our data somewhat extend this position, as they show not only the communicative or motivational effects of online interaction, but also the development of the ability to collaboratively create a product and to organize a team process in project form. This makes it possible to speak of virtual teamwork not merely as a compensatory format in conditions of distance, but as a distinct, professionally valuable practice.

Results from team analytics studies are also important for interpreting our findings. Echeverría et al. (2024a), analyzing TeamSlides as a multimodal dashboard for supporting teacher-guided reflection, showed that digital analytics can substantially enhance discussion and reflective practice, although it also creates risks of interpretive difficulty. In our study, we did not use complex analytical dashboards, but our approach to analyzing digital artifacts, revision histories, comments, and board structures aligned with theirs. This allows an important conclusion to be drawn: digital traces of team activity have not only diagnostic, but also educational value. Their use for reflection may be a promising direction for further development of the methodology, especially in later stages of research.

The findings of Abildinova et al. (2024) also have interpretive value, as they emphasize that active teaching methods and digital integration are more effective when they foster genuine participation rather than passive absorption of material. Our experiment, in essence, confirmed this thesis in the context of preparing future teachers. The positive dynamics across all three components were driven not by expanding the amount of information about teamwork, but by participants acting as a team in the digital environment while carrying out professionally relevant tasks. This once again demonstrates that, in preparation

for digital teamwork, the decisive factor is the activity-based format itself.

At the same time, the results of the pilot study should be interpreted in light of its limitations. First, it should be noted that this was a small, purposeful sample consisting of 26 future master's students in secondary education from one higher education institution. Such a sample is sufficient for pilot testing the methodology, but it does not provide grounds for broad generalizations about all categories of teachers or learners. For this reason, the results should be viewed as evidence of the proposed approach's promise rather than as final proof of its universal effectiveness under any conditions.

The second limitation is the short duration of the formative intervention. The series of three training sessions enabled the identification of positive dynamics, but it does not allow conclusions about the stability of the acquired changes in the medium- or long-term. The question remains open as to the extent to which the developed skills will be retained after completion of the program, whether they will transfer to new professional situations without special support, and whether they require further reinforcement in longer learning formats. For this reason, a promising direction for future research is delayed measurement or the development of a longer professional development program.

The third limitation concerns the research design. Measurements were conducted after the first and third training sessions, so there was no separate pre-experimental assessment before any formative activity began. This approach was methodologically justified in the pilot format because the first training session performed a diagnostic and activation function. Nevertheless, it limits the possibility of a more rigorous comparison with a fully pre-formative state. In a broader study, it would be advisable to combine initial, intermediate, final, and, if possible, delayed assessment points to provide a more detailed picture of the dynamics of development.

The fourth limitation is the absence of a control group. Within the pilot study, the main task was to test the methodology and document initial changes, rather than to provide strict

experimental proof of causal relationships. However, to further deepen the study, it would be advisable to include a control group working in a traditional format or in another digital learning model. This would make it possible to show more convincingly the specific contribution of the proposed methodology itself to the development of digital teamwork skills.

The fifth limitation concerns the context-dependent nature of the results. All training sessions were conducted online using specific digital tools such as Zoom, messengers, shared Miro-type boards, and other services. On the one hand, this strengthens the ecological validity of the study, since the work did indeed take place in a digital environment. On the other hand, the results may partly depend on how convenient, understandable, or appealing these specific tools proved to be for this particular group of participants. In further research, it would be advisable to test the extent to which the methodology's effect is maintained when other platforms are used or under blended interaction conditions.

Despite these limitations, the pilot study fulfilled its main function. It confirmed that digital teamwork skills can be the object of purposeful development, that the developed system of criteria, indicators, and levels is workable, and that the combination of digital communication, collaborative product creation, and project-based organization of activity is methodologically productive for developing the corresponding professional skills. In addition, the study enabled refining the methodology's most sensitive points, observing differences in the dynamics of individual components, and outlining directions for further improvement.

Thus, the results of the pilot study make it possible to consider the proposed methodology a promising means of developing digital teamwork skills among future teachers, while at the same time maintaining research caution regarding the scale of generalizations. The positive dynamics observed across all three components confirm the effectiveness of an integrated approach to developing digital team interaction, while the identified limitations indicate directions for further, more extensive research. On this basis, one may move to practical recommendations for developing teachers' teamwork in a digital educational environment. More generally, the results of our pilot

study not only align with the available scientific evidence but also refine it in several respects. First, they make it possible to specify teachers' digital teamwork as a separate object of research and professional development. Second, they show that the most productive methodology is an integrated one that combines meaningful digital communication, collaborative product creation, and project-based organization of activity. Third, they confirm that even a short series of training sessions can produce a statistically significant developmental effect when based on professionally relevant tasks and a structured digital environment. Fourth, they point to the promise of further studies involving a larger sample, the inclusion of a control group, the use of delayed assessments, and the expansion of the analytical potential of digital artifacts.

## **6. Practical recommendations for fostering teamwork among teachers in a digital educational environment**

The theoretical substantiation of the structure of teachers' digital teamwork skills, the results of the pilot experiment, and the analysis of the dynamics of change provide grounds for moving to the practical level of generalization. Whereas the previous sections focused on the essence of the phenomenon under study, its components, the assessment system, and the possibilities for its purposeful development, this section shifts the emphasis to the practical implementation of the findings in educational activity. What is meant here are those recommendations that may be used to support and develop teachers' teamwork in a digital educational environment at the level of the educational institution, the system of professional development, and individual pedagogical practice.

The need for such recommendations stems from the fact that digital teamwork does not arise automatically from access to platforms, messengers, cloud services, or digital boards. Its development requires not only technical possibilities, but also an appropriate organizational culture, specially created conditions for professional collaboration, methodological support, time for shared planning, and an understanding that the digital environment is a space not only for individual, but also for collective pedagogical activity. For this reason, practical recommendations should not concern only one separate level, but

should encompass the entire complex of conditions within which teachers' teamwork is formed and implemented.

The results of the pilot experiment showed that the most significant positive changes occur when digital teamwork is organized around professionally meaningful tasks, when functionally appropriate tools are used for communication, collaborative product creation, and project coordination, and when participants have the opportunity to work in small groups, pass through the stages of planning, mutual alignment, editing, and reflection. This means that practical recommendations should be based not on general calls for digitalization or cooperation, but on concrete mechanisms for organizing shared activity.

Within this section, the recommendations are presented in three interrelated directions. The first concerns educational institutions and their managerial level, since it is at this level that organizational conditions, institutional rules, digital infrastructure, and a culture of professional interaction are created. The second direction concerns the system of in-service training and professional development, where special learning formats oriented toward the formation of digital teamwork as a distinct professional capacity may be embedded. The third direction concerns the teacher and their own professional practice, because even with institutional support and appropriate development programs, the decisive importance still lies in the teacher's personal readiness for teamwork, self-analysis, and the transfer of acquired modes of action into the real educational process.

Thus, the practical recommendations presented below are intended not merely to summarize the study's results, but to transform them into a set of guidelines for effectively improving teachers' digital teamwork. For this reason, it is first advisable to turn to recommendations for educational institutions and their leaders, since without institutional support, the individual and group efforts of teachers often remain fragmentary and unstable.

### *6.1. Recommendations for Educational Institutions*

The development of teachers' teamwork in a digital educational environment depends to a large extent on the degree

to which the educational institution creates organizational, technical, and methodological conditions for this. It is precisely the institutional level that determines whether teachers' digital interaction will remain random and situational or acquire the character of a stable professional practice. For this reason, recommendations for educational institutions and their leaders should encompass not only issues of technical provision, but also a wider circle of aspects: organization of shared activity, regulation of digital interaction, support of pedagogical teams, creation of a culture of collaboration, and recognition of teamwork as a meaningful component of the teacher's professional activity.

First of all, educational institutions should regard teachers' digital teamwork not as a secondary supplement to individual activity, but as a norm of contemporary professional interaction. This means that managerial decisions, internal regulations, methodological work, and the organization of the educational process should all embody an understanding of shared planning, the collective creation of materials, the coordination of digital interaction, and the exchange of professional resources as ordinary and expected forms of activity. If, however, an individualized model of professional work dominates, even the presence of digital platforms will not ensure the real development of teamwork. For this reason, the first practical step should be to institutionalize the value of pedagogical collaboration in a digital environment.

The second important direction is the creation of a functionally organized digital environment. Educational institutions should avoid situations in which teachers are forced to use a large number of uncoordinated platforms, messengers, and services in parallel, without a clear application logic. Such digital fragmentation does not support teamwork and, on the contrary, often makes it more difficult. Instead, it is advisable to define an agreed set of tools for the main types of activity: one for synchronous interaction, one for collaborative editing, and one for planning and project support. This does not mean excessive standardization, but it does require a clean digital environment in which pedagogical teams can work without constantly losing time to technical switching or to clarifying which tool to use for which purpose.

The third recommendation concerns the organization of time for team interaction. One of the main obstacles to the development of teachers' teamwork is not only a lack of tools but also a lack of time specifically allocated for shared planning, alignment, and refinement of materials. If teamwork takes place only "in passing," in the intervals between main duties, it usually remains superficial. Therefore, school leaders should provide organizational formats that give teachers' shared work temporal legitimacy: methodological sessions, digital workshops, team consultations, brief coordination meetings, and shared blocks for developing materials or reflectively discussing common decisions. Without such managerial recognition of time, digital teamwork risks remaining fragmentary.

The fourth direction is support for small pedagogical teams as the most productive format of digital collaboration. The pilot experiment showed that the micro-group format creates the best conditions for the visibility of each participant's contribution, a clear role distribution, collaborative product creation, and the organization of the team process. For this reason, educational institutions should develop not only general forms of collective work, but also small pedagogical teams organized around a common course, a subject module, an interdisciplinary theme, an educational direction, a digital resource, or an educational project. Such teams are best suited to the development of stable digital teamwork skills.

The fifth important step is the stimulation of collaborative creation of digital products. In educational institutions, teachers' digital interactions are often limited to messages, files, and brief coordination actions. Yet teamwork develops most intensively when teachers have a shared professional result for which they are jointly responsible. Leaders should support precisely such formats: collaborative creation of methodological materials, assessment templates, digital collections of resources, integrated tasks, scenarios for educational events, interdisciplinary modules, visual schemes, or instructional presentations. In this case, the digital environment begins to function not only as a channel of communication but as a space of collective pedagogical authorship.

The sixth recommendation is the introduction of simple mechanisms for organizing team activity in a project-based manner. What is meant here is not formal overloading of teachers with management elements, but the use of accessible digital tools to document stages, tasks, roles, and deadlines. Even an elementary digital board with designated responsible persons and status indicators can substantially increase transparency in teamwork. Therefore, educational institutions should support the use of such tools in pedagogical teams' activities while avoiding their bureaucratization. The value of digital boards and trackers lies not in reporting, but in helping the team see the structure of its own work and respond in a timely way to difficulties.

The seventh recommendation is tied to the need to foster a culture of digital communication and feedback. High-quality teamwork depends not only on the task content but also on how teachers communicate in the digital environment: whether they can formulate messages clearly, provide constructive feedback, respond appropriately to revisions, and maintain a productive atmosphere without excessive tension. For this reason, leaders should encourage such forms of methodological work in which not only results are discussed, but also the modes of digital interaction themselves. This may include analyzing a shared project, examining examples of digital communication, discussing typical difficulties in teamwork, and developing common rules for using comments, messages, and shared documents.

The eighth direction concerns methodological support and mentoring. Not all teachers enter digital teamwork with the same level of readiness. Some may use platforms quite confidently, but experience difficulties with facilitating group interaction or with project planning. Others, on the contrary, may have good organizational skills but feel uncertain in working with shared documents or digital boards. For this reason, it is advisable to create mechanisms of internal mentoring, in which more experienced participants can help colleagues not only technically, but also methodologically, showing how a digital tool is embedded in the logic of real team activity.

The ninth recommendation is the use of a developmental assessment of digital team activity. Educational institutions should avoid an approach that assesses digital teamwork solely by the

presence of a final product or by the mere fact of participation. Instead, attention should also be paid to process-oriented features: the character of communication, coherence of actions, transparency of role distribution, the ability to collaboratively refine the result, and the use of digital traces for reflection. Such an assessment allows us not to punish imperfection but to support the team's development, highlighting strengths and areas for improvement.

The tenth recommendation is to create an atmosphere of professional safety and trust. Digital teamwork develops effectively only when teachers are not afraid to express proposals, ask questions, acknowledge difficulties, revise previously proposed decisions, and collectively refine the result. If the digital environment within the institution is used primarily as an instrument of control or criticism, teachers begin to avoid open interaction, limit their contributions to the minimum, and gravitate toward individual autonomy. Therefore, leaders should support a culture of professional partnership in which digital tools strengthen collaboration rather than create tension.

Thus, the development of teachers' teamwork in a digital educational environment requires not so much individual technical solutions as a coherent organizational policy at the educational institution level. It is at the institutional level that conditions should be created under which teachers' digital interaction acquires a systemic character, rests on a functionally organized environment, is supported in terms of time and methodology, and becomes part of professional culture. The next logical step is to consider recommendations for the in-service training system, since it is precisely this system that can ensure the purposeful development of the corresponding skills on a broader professional scale.

## *6.2. Recommendations for the System of In-Service Training*

The system of in-service teacher training should regard the development of digital teamwork skills not as a side effect of digitalization, but as a separate direction of professional development. Such a need is subject to the fact that traditional forms of in-service training often focus either on subject content,

on mastery of particular digital tools, or on general issues of teaching methodology. At the same time, the teacher's ability to work in a digital environment as a team member, facilitator, co-author of a shared product, and co-organizer of a team process often remains outside focused attention. For this reason, the professional development system should move from episodic inclusion of digital collaboration elements to the purposeful development of the corresponding skills.

First of all, it is advisable to recommend inclusion of the topic of digital teamwork in the content of professional development programs as a separate substantive module. What is meant here is not merely training in the use of videoconferencing platforms, shared documents, or digital boards, but understanding how these tools function within the logic of team interaction. Professional development programs should specifically address digital communication, facilitation, collaborative editing, role distribution, coordination across work stages, project-based organization of activities, and reflective analysis of digital artifacts. Without such substantive specification, digital teamwork will remain a diffuse notion and will not acquire the status of a clearly defined professional capacity.

The second important direction is the reorientation of professional development formats from predominantly lecture- and information-based to activity-based. The experience of the pilot study shows that digital teamwork skills develop not through explanation of their importance, but through involving teachers in specially organized shared activity. For this reason, professional development programs should include training, micro-projects, practical sessions on collaborative creation of digital products, and short cycles of team tasks in which participants do not merely listen about digital collaboration, but actually practice it. Such an approach is much more productive for the formation of stable modes of action than demonstration of individual services without immersion in shared professional work.

The third recommendation is to construct professional development programs according to a logic of gradual increases in complexity. Professional growth in this area should not begin immediately with complex project formats if participants do not yet have sufficient confidence in digital team communication. It is

advisable to first develop the ability to sustain meaningful interaction, provide constructive feedback, and make simple decisions, then move to collaborative creation of a digital product, and only then to full organization of the team process through the use of boards, trackers, roles, and temporal coordination. Such staging ensures not only a clear learning trajectory but also reduces the risk of overloading teachers with varying prior digital interaction experiences.

The fourth direction concerns reliance on professionally relevant tasks. In-service training programs should offer teachers not artificial exercises, but such forms of work that directly reproduce situations typical of their own practice. These may include collaborative development of a learning module, creation of an integrated task, design of assessment criteria, preparation of a digital collection of resources, development of a plan for an educational event, or alignment of a team-based model of learner support. It is precisely through such tasks that digital teamwork acquires professional meaning for the teacher. It ceases to be perceived as a formal training activity and is understood as a way to solve real pedagogical problems.

The fifth recommendation is the mandatory inclusion of various digital interaction formats in professional development programs, above all, synchronous and asynchronous ones. Teachers should learn to act in conditions of live online discussion, where rapid alignment and facilitation are needed, as well as in asynchronous mode, where particular importance lies in the precision of messages, written coordination, work with comments, adherence to deadlines, and documentation of changes. If a professional development program is oriented only toward synchronous webinars, it does not form a full experience of digital teamwork. By contrast, the combination of different interaction modes makes learning more closely aligned with real pedagogical practice.

The sixth important step is the use of professional development not only for communication tools but also for collaborative editing and project management services. Many digital literacy programs focus mainly on meeting platforms or on separate electronic resources. Yet for the development of teamwork as such, this is not enough. Teachers should, in

practice, work with shared documents, Miro-type boards, planning services, role-distribution tables, and team-project templates. This is needed not for the sake of technical variety, but because different tools correspond to different types of team action. The professional development system should help teachers see this correspondence and consciously choose a tool for a particular professional task.

The seventh recommendation is to introduce a reflective component as a mandatory part of programs. Professional development in the area of digital teamwork cannot be effective if participants merely complete tasks without reflecting on how they actually acted. After shared work, teachers should analyze which communication practices were productive, where difficulties arose, how roles were distributed, whether the team managed to preserve the integrity of the product, and what helped or hindered progress. Such reflection transfers experience from the level of a one-time activity to that of a conscious professional skill. For this reason, it is advisable to include short analytical sessions, self-assessment, peer assessment, analysis of digital artifacts, and shared discussion of the course of team activity in professional development programs.

The eighth direction concerns the need for a differentiated approach. Participants in professional development programs may differ substantially in experience of digital interaction, confidence in working with tools, readiness for facilitation, project thinking, or collaborative editing. For this reason, it is desirable to avoid identical requirements and identical pace for everyone without exception. It is advisable to provide variable trajectories for task completion, different levels of complexity, the option to choose a role in the team, supportive materials for those who need greater guidance, and, at the same time, more complex tasks for those who already have sufficient experience. Such an approach not only increases the effectiveness of learning but also reduces the risk of merely formal inclusion of some participants in team activity.

The ninth recommendation is the use of developmental assessment in professional development programs. The system of professional growth should not be limited to certifying participation or assigning a final score. It is also advisable to assess the process of team interaction itself: the quality of digital

communication, the nature of feedback, coherence of contributions, the ability to organize project-based work, and the use of digital boards and shared documents. Such an assessment should be supportive rather than punitive. Its function is to help the teacher see which aspects of digital teamwork have already become a professional strength and which still require further growth.

The tenth recommendation concerns the professional development of trainers and instructors. It is impossible to teach teachers digital teamwork in a format in which the organizers themselves work mainly individually, without facilitation, collaborative editing, or project logic. For this reason, trainers should not only know about these skills but also demonstrate them in their own practice. The very organization of the program should be a model of the digital team interaction that it seeks to develop. This means that participants should see examples of meaningful digital communication, carefully organized environments, structured tasks, transparent roles, and a reflective summary of results.

Separately, it is worth recommending that the professional development system orient itself not toward one-time short events, but toward cyclical or modular formats of professional learning. Such formats make it possible to combine initial immersion, practice, application in real conditions, and renewed reflection on experience. A short webinar may raise awareness, but it rarely forms stable digital teamwork skills. By contrast, a modular course or a series of interconnected sessions creates the possibility for gradual growth, repetition of actions in new situations, and documentation of the dynamics of change. In this respect, the pilot study results confirm the effectiveness of a serial training format.

Thus, the system of in-service teacher training should regard digital teamwork as a separate and methodologically significant object of professional development. For this purpose, it is necessary to integrate the corresponding topic into educational programs, orient them toward activity-based formats, use professionally relevant tasks, combine synchronous and asynchronous interaction, apply tools for collaborative editing and project management, provide reflective support, differentiated

assistance, and developmental assessment. Only under such conditions can in-service training become not a source of isolated technical knowledge, but a space for the real formation of the teacher's ability to engage in meaningful, organized, and effective teamwork in a digital educational environment.

### *6.3. Recommendations for Teachers' Self-Development*

Despite the significance of institutional support and the in-service training system, the development of digital teamwork skills depends to a large extent on the teacher's professional stance. It is precisely the individual readiness for collaboration, openness to shared creation of a product, ability to reflect on one's own role in the team, and desire to improve ways of digital interaction that determine whether the digital environment becomes for the teacher a space of real professional cooperation. For this reason, practical recommendations for teachers' self-development should aim not only at mastering specific skills, but also at forming a stable orientation toward teamwork as an integral component of contemporary pedagogical activity.

First of all, teachers should purposefully develop in themselves an understanding that digital teamwork is a distinct professional capacity rather than a secondary consequence of technological proficiency. This means it is worthwhile to consciously distinguish between situations in which digital tools are used only for individual work and those in which they genuinely support shared planning, coordination, the creation of materials, mutual editing, and project interaction. Such understanding is important in itself because it helps the teacher move from a technical attitude toward digital platforms to a professional-pedagogical understanding of their possibilities.

The second important direction of self-development is the formation of a habit of reflective analysis of one's own digital interaction. Teachers should regularly ask themselves not only whether the shared task was completed, but also how exactly the teamwork unfolded. Was the communication genuinely meaningful? Was it possible to provide constructive feedback? Were the roles clear? Did the shared work amount only to a mechanical combination of separate parts? Were the digital tools

used in a functionally appropriate way? Such reflection gradually forms a more conscious attitude toward one's own teamwork behavior and enables one to see not only obvious successes but also hidden problematic areas.

The third recommendation is that teachers should not limit their own digital development to individual mastery of services. A much more productive approach is one in which a digital tool is mastered immediately within team logic. If a teacher is learning to use a shared document, it is advisable not simply to create an individual file, but to work with a colleague on a shared text using comments, revision mode, and version alignment. If a digital board is being explored, it is worthwhile to use it at once for planning a micro-project, distributing roles, or collaboratively structuring ideas. Such practice gives much more for the development of digital teamwork than individual testing of a platform's functions outside the context of shared activity.

The fourth direction of self-development is the conscious improvement of digital communicative culture. Teachers should pay attention to the clarity of their own messages, the appropriateness and meaningfulness of their comments, the way they formulate disagreement, the quality of their feedback, and their ability to summarize and document decisions. In the digital environment, communication often determines the success or failure of shared work. For this reason, it is worth working not only on the technical speed of reaction but also on the ability to make communication functional, appropriate, productive, and oriented toward a shared result. Particularly important is the habit of not leaving shared activity at the level of "we will agree later," but of moving discussion toward documented decisions, deadlines, and clear next steps.

The fifth recommendation concerns developing readiness for shared authorship. For many teachers, an individual logic of material creation, in which one's own product is perceived as completely autonomous, is more natural. However, the digital educational environment increasingly requires readiness to work in an open, collaborative mode of creation and editing. For this reason, teachers should gradually develop the ability to work with colleagues' comments, agree on changes, adapt their own fragments to a shared structure, return to previously created

material, and improve it in line with the logic of a collective result. This not only expands digital professional possibilities but also fosters a culture of partnership, which is important for contemporary pedagogical activity.

The sixth recommendation is the conscious mastering of elementary project logic in the digital environment. Teachers should learn to see a team task not only as a topic for discussion, but also as a process with stages, roles, time boundaries, interim results, and a need for coordination. For this purpose, even in small shared tasks, it is useful to employ simple planning tools: digital boards, lists of actions, labels of responsibility, documentation of deadlines, and updates of completion status. Such practice gradually forms the organizational-projective component of digital teamwork and reduces dependence on external coordination.

The seventh direction concerns the teacher's participation in professional digital communities. Self-development in the sphere of digital teamwork is significantly strengthened when the teacher has experience of regular participation in professional groups, networks, communities of practice, or temporary teams working toward a concrete result. Such communities may be subject-specific, interdisciplinary, methodological, or project-based. Their value lies in creating a natural environment for shared planning, idea discussion, resource exchange, mutual editing, and collective decision-making. For this reason, professional communities should be regarded not only as a channel of information exchange but also as an environment for the development of digital teamwork skills. Such discussions help communities not only produce results but also become spaces of professional learning for one another. This is precisely their special value for the development of digital teamwork.

Thus, teachers' self-development in the sphere of digital teamwork requires a conscious orientation toward collaboration, reflection on one's own digital behavior, readiness for shared authorship, gradual mastery of project logic, and involvement in professional digital communities. At the same time, these professional communities themselves should become not merely environments for exchanging opinions, but spaces for the real joint production of professionally meaningful digital results. Only

such a combination of individual self-development and collective practice can ensure the stable growth of teachers' digital teamwork skills as a component of contemporary educational leadership.

## **Conclusions**

The study provides grounds for considering teachers' digital teamwork skills as a distinct, integrated professional construct that cannot be reduced to either general digital competence or to isolated skills in using platforms, messengers, or shared documents. It has been substantiated that, under conditions of social uncertainty, the digital educational environment becomes not only a technical resource for supporting the educational process, but also a space of collective pedagogical activity in which the teacher is required to demonstrate the ability to engage in meaningful communication, collaboratively create a digital product, coordinate stages of work, facilitate interaction, distribute responsibility, and sustain a shared professional result. For this reason, teachers' teamwork in a digital environment should be understood as a component of contemporary educational leadership, manifested in everyday professional interaction rather than confined to the boundaries of formal managerial roles.

In the course of the study, the author's understanding of teachers' digital teamwork skills was clarified as an integrated set of practiced professional actions that ensure the effective interaction of the teacher with other participants in the educational process in a digital environment in order to achieve a common goal through communication, coordination, role distribution, collaborative product creation, facilitation of the group process, and reflective adjustment of shared activity. On this basis, three interrelated structural components were identified. The communication-facilitation component reflects the ability to initiate and sustain meaningful digital interaction, provide constructive feedback, and promote the group's progress toward a shared decision. The cooperative-productive component encompasses participation in the collaborative creation of a digital product, coordination of editing, alignment of contributions, and

refinement of the result. The organizational-projective component is connected to planning, role distribution, coordination of stages, time management of activities, and process adjustment in a digital environment. It has been demonstrated that the interaction among these three components is precisely what ensures the integrity of teachers' digital teamwork.

An important result of the study was the substantiation of an assessment system for teachers' digital teamwork skills. It is built on the principles of the competence-activity approach, structurality, multiplicity of data sources, the combination of process and outcome dimensions, criterion-based clarity, and level-based interpretation of results. Three assessment criteria corresponding to the structure of the phenomenon under study were identified: communication-facilitation, cooperative-productive, and organizational-projective. For each criterion, a system of indicators was outlined to document the actual manifestations of digital team interaction. A four-level model for interpreting results was proposed: initial, basic, advanced, and expert levels. This model enables not only the determination of the presence or absence of particular skills, but also the description of their degree of development, the stability of their manifestation, and the qualitative character of the teacher's professional behavior in a digital environment.

Based on theoretical generalizations, a methodology for developing teachers' teamwork skills in a digital educational environment was designed. It was constructed as a purposeful system of training activity based on professionally relevant tasks, integrated use of digital tools, micro-group interaction, the combination of synchronous and asynchronous formats, reflective support, and developmental assessment. The methodology's logic was implemented through a series of three weekly training sessions, in which the emphasis was successively placed on digital communication and coordination of interaction, collaborative content creation and version management, and the use of digital boards for project-based organization of teamwork. It was established that such staging is methodologically productive because it enables movement from initial engagement in team interaction to more complex, integrated, and professionally mature forms of it.

The pilot experiment conducted in 2025 with master's-level learners in Secondary Education at Makarenko Sumy State Pedagogical University confirmed the workability of the proposed methodology. The study involved 26 participants, and assessment was conducted after the first and third training sessions using self-assessment, structured observation, and analysis of digital artifacts. A comparative analysis of the two assessment points demonstrated statistically significant positive dynamics across all three components of digital teamwork skills. The mean score for the communication and facilitation component increased from 2.04 to 3.12, for the collaborative creation of digital content component from 1.77 to 2.85, and for the team project management component from 1.77 to 3.04. The overall mean indicator increased from 5.58 to 9.00 points. The most substantial changes occurred in the organizational-projective component, which provides grounds for regarding it as especially sensitive to a specifically organized training intervention. At the same time, the results confirmed that this component develops only in interaction with the communication-facilitation and cooperative-productive dimensions.

Interpretation of the pilot study results enabled identification not only of positive dynamics but also of several significant methodological conclusions. Within a short-term program, the communication-facilitation component activates most quickly, though its transition to a stable, mature level requires systematic inclusion of participants in meaningful digital interaction. The cooperative-productive component develops best when participants work on a real shared digital product rather than merely on a discussion task. The organizational-projective component is especially strengthened when teamwork has an explicit structure, visualized stages, roles, deadlines, and mechanisms for ongoing adjustment. At the same time, the study has certain limitations connected with the small sample, the short duration of the formative intervention, the absence of a control group, and the local context of online interaction. This does not diminish the significance of the obtained results, but it does define the limits of their generalization and indicates prospects for further extended research.

Based on the analysis, practical recommendations were formulated for three levels of educational practice. For educational institutions and school leaders, the need was substantiated for institutional recognition of digital teamwork as an important component of the teacher's professional activity, for the creation of a functionally organized digital environment, for the allocation of time for team interaction, for support of small pedagogical teams, and for developmental assessment of the process of shared activity. For the system of in-service teacher education, it was recommended to include digital teamwork in the content of professional development programs, to use activity-based formats, to incorporate professionally relevant tasks, to use modular learning logic, to combine synchronous and asynchronous formats, and to provide reflective support. For teachers' self-development and professional communities, the importance of reflective analysis of one's own digital behavior, gradual mastery of shared authorship, project logic, participation in digital professional communities, and orientation not only toward information exchange, but toward the collaborative production of professionally meaningful digital results was emphasized.

Thus, the study confirmed that the development of teachers' teamwork skills in a digital educational environment is a pedagogically grounded, methodologically feasible, and practically significant direction of professional preparation and development. Conditions of social uncertainty, digitalization, and the growing role of distributed educational leadership make these skills not auxiliary, but necessary for contemporary pedagogical activity. For this reason, their further study, methodological improvement, and inclusion in the system of professional teacher education constitute a promising and socially justified direction for the development of contemporary education.

## References

- Abildinova, G. M., Ormankulova, R. S., Tursyn, A. T., Tastanbekkyzy, A. A., Makhambetova, A. K., Rakhmetova, M. M., ... & Shapalakova, M. T. (2024). Professional training of future teachers for implementing active learning methods and integrating digital technologies. *Contemporary Educational Technology*, 16(2), ep501. <https://doi.org/10.30935/cedtech/14574>

- Abildinova, G., Abdykerimova, E., Assainova, A., Mukhtarkyzy, K., & Abykenova, D. (2024). Preparing educators for the digital age: Teacher perceptions of active teaching methods and digital integration. *Frontiers in Education*, 9, Article 1473766. <https://doi.org/10.3389/feduc.2024.1473766>
- Alom, M. M., & Ramalingappa, V. (2025). Development and validation of a digital literacy scale and the evaluation of post-graduate teacher educators' digital literacy. *International Journal of Information and Education Technology*, 15(10). <https://doi.org/10.18178/ijiet.2025.15.10.2421>
- Amayou, G. A., Herrera-Pavo, M. Á., Reyes de Cózar, S., & Velázquez-Iturbide, J. Á. (2025). Collaborative learning and teamwork strategies in the future teachers' initial training. *Education Sciences*, 15(1), 86. <https://doi.org/10.3390/educsci15010086>
- Amelia, S., Riyandi, A., Solehudin, A., & Hidayat, W. (2024). Improving teachers' competence in digital age adaptation through digital pedagogy workshops. *Jurnal Penelitian Pendidikan IPA*, 10(5), 3049–3056. <https://doi.org/10.29303/jppipa.v10i5.8163>
- Amemasor, J., Opoku, M. P., Agormedah, E. K., Baffour-Koduah, D., Asare-Nuamah, P., Nketsia, W., & Ofori, M. A. (2025). Professional development of teachers in using digital technologies and active learning strategies: Evidence from Ghana. *Cogent Education*, 12(1), 2486693. <https://doi.org/10.1080/2331186X.2025.2486693>
- Amemasor, S. K., Oppong, S. O., Ghansah, B., Benuwa, B.-B., & Essel, D. (2025). A systematic review on the impact of teacher professional development on digital instructional integration and teaching practices. *Frontiers in Education*, 10, Article 1541031. <https://doi.org/10.3389/feduc.2025.1541031>
- Balova-Tzvetkova, S., & Panayotova, M. (2023). Educational practices in teaching humanities and EU studies in a digital environment. *Pedagogika-Pedagogy*, 95(4), 483–499. <https://doi.org/10.53656/ped2023-4.05>
- Bohoslavskyi, S. V., Semenikhina, O. V., & Yurchenko, A. O. (2025). Porivnialnyi analiz ukrainskykh ta yevropeiskykh praktyk orhanizatsii tsyfrovoho osvithnoho seredovyshcha [Comparative analysis of Ukrainian and European practices of organizing the digital educational environment]. *Naukovyi visnyk Pivdennoukraiynskoho natsionalnoho pedahohichnoho universytetu imeni K. D. Ushynskoho*, 2(151), 38–42. <https://doi.org/10.24195/2617-6688-2025-2-6>
- Brannan, L., Parrish, C. W., & Szatkowski, H. D. (2019). Team-based learning. In *Handbook of research on critical thinking strategies in pre-service learning environments* (pp. 89–108). IGI Global. <https://doi.org/10.4018/978-1-5225-7823-9.CH005>

- Echeverría, V., Maldonado-Mahauad, J., Baars, M., Timms, M. J., Schnaubert, L., & Buckingham Shum, S. (2024a). Teacher-led team reflection with multimodal team dashboards. *Journal of Learning Analytics*, 11(1), 184–202. <https://doi.org/10.18608/jla.2024.8195>
- Echeverría, V., Yan, L., Zhao, L., Abel, S., Alfredo, R., Dix, S., Jaggard, H., Wotherspoon, R., Osborne, A., Buckingham Shum, S., Gašević, D., & Martínez-Maldonado, R. (2024b). TeamSlides: A multimodal teamwork analytics dashboard for teacher-guided reflection in a physical learning space. In *Proceedings of the 14th International Learning Analytics and Knowledge Conference*. ACM. <https://doi.org/10.1145/3636555.3636857>
- Espejo, R., Tena, A. R., & Martínez, J. R. (2023). Teamwork as a competence in virtual learning environments: Proposal of activities in the university context. *Pixel-Bit. Revista de Medios y Educación*, 66, 199–224. <https://doi.org/10.12795/pixelbit.97311>
- García-Delgado, M. Á., Rodríguez-Cano, S., Delgado-Benito, V., & di Giusto-Valle, C. (2023). Digital teaching competence among teachers of different educational stages in Spain. *Education Sciences*, 13(6), Article 581. <https://doi.org/10.3390/educsci13060581>
- Hodges, C. D., Barbour, M., & Pratt, K. (2026). The persistent deficit: Historical gaps in the preparation of K-12 educators for digital teaching. *Journal of Online Learning Research*. <https://doi.org/10.70725/361467zxvzis>
- Holovnia, Y., Lisnychenko, A., Dovhaliuk, T., Falshtynska, Y., & Samoilenko, I. (2024). The role of digital competencies in creating an inclusive educational environment. *Synesis*, 16(1). <https://seer.ucp.br/seer/index.php/synesis/article/download/2955/3748/11423>
- Hrechanyk, N., Eganov, A., Bandura, V., Aramyan, A., & He, S. (2024). Digital educational environments: Strategies and tools for training competent professionals. *Amazonia Investiga*, 13(76), 202–216. <https://doi.org/10.34069/AI/2024.76.04.16>
- Kuznetsova, M., Gura, D., & Vorona-Slivinskaya, L. (2023). Virtual team building in an intelligent collaborative learning environment. *Journal of Information Technology Education: Research*, 22, 495–517. <https://doi.org/10.28945/5089>
- Lin, R., Yang, J., Jiang, F., & Li, J. (2022). Does teacher's data literacy and digital teaching competence influence empowering students in the classroom? Evidence from China. *Education and Information Technologies*, 27, 10537–10557. <https://doi.org/10.1007/s10639-022-11274-3>
- Majdi, H. S., Kzir, M. H., & Ghazi, M. A. (2024). The impact of digital transformation on the educational environment of private universities. *Revista Iberoamericana de Psicología del Ejercicio y el Deporte*, 19(2), 238–241. <https://dialnet.unirioja.es/descarga/articulo/9622563.pdf>

- Masoumi, D., & Noroozi, O. (2023). Developing early career teachers' professional digital competence: A systematic literature review. *Journal of Education for Teaching*, 49(6), 1057-1072. <https://doi.org/10.1080/02607476.2023.2229006>
- Navio-Marco, J., Ruiz-Gómez, L. M., & Sevilla-Sevilla, C. (2025). Perceptions of teamwork among education students in online and hybrid universities. *Education Sciences*, 15(6), 644. <https://doi.org/10.3390/educsci15060644>
- Nychkalo, N., Muranova, N., Voliarska, O., & Matulcikova, M. (2024). Integration of Ukrainian children and youth using digital tools in the educational environment of Slovakia. *Information Technologies and Learning Tools*, 101(3), 150–163. <https://doi.org/10.33407/itlt.v101i3.5657>
- Popovych, I. S., Blynova, O. Y., Artemieva, H. R., Kovalova, O. O., Halian, I. M., & Piletska, L. S. (2024). Research on the types of future teachers' self-realisation under conditions of a digital educational environment. *Revista de Cercetare si Interventie Sociala*, 84, 55–70.
- Rudenko, Y., Ahadzhanov-Honsales, K., Ahadzhanova, S., Batalova, A., Diemientiev, Y., & Semenikhina, O. (2024). Interactive boards as digital tools in the modern educational process. In *2024 47th MIPRO ICT and Electronics Convention (MIPRO)* (pp. 329-333). IEEE. <https://doi.org/10.1109/MIPRO60963.2024.10569393>
- Rudenko, Y., Zhurba, K., Bekh, I., Petrenko, S., Bobokalo, A., & Semenikhina, O. (2025). Using dashboards in the development of students' analytical thinking. In *2025 48th MIPRO ICT and Electronics Convention (MIPRO)* (pp. 406-411). IEEE. <https://doi.org/10.1109/MIPRO65660.2025.11131997>
- Semenog, O., Hrona, N., Khomych, T., Stasiuk, T., Yurchenko, A., & Semenikhina, O. (2024). Communicative tasks as a means of developing the emotional intelligence of students. *International Journal of Modern Education and Computer Science*, 16(4), 46-57. <https://doi.org/10.5815/ijmeecs.2024.04.04>
- Shuppe, L., Koval, V., Sotska, H., Trynus, O., & Melnyk, A. (2024). Communicative competence of future specialists in the information and digital educational environment. *Amazonia Investiga*, 13(77), 188–200. <https://doi.org/10.34069/AI/2024.77.05.14>
- Soroko, N., & Shymon, O. (2025). Teachers' readiness to use digital tools in a STEAM-oriented educational environment. *Educational Analytics of Ukraine*, 2025(1), 28-42. <https://doi.org/10.32987/2617-8532-2025-1-28-42>
- Tzafilkou, K., Perifanou, M. A., & Economides, A. A. (2023). Assessing teachers' digital competence in primary and secondary education: Applying a new instrument to integrate pedagogical and professional elements for digital education. *Education and Information Technologies*, 28, 10551-10583. <https://doi.org/10.1007/s10639-023-11848-9>

- Xu, J., Yuan, C., Gu, X., Zhang, X., & Van de Vliert, E. (2026). Fostering teachers' teamwork behavior: The roles of organizational justice and knowledge sharing. *Current Psychology*, 45, 17453–17463. <https://doi.org/10.1007/s12144-024-06275-x>
- Yurchenko, A., Drushlyak, M., Khvorostina, Y., Ostroha, M., Ponomarenko, V., & Semenikhina, O. (2024a). The impact of team competitions on the development of soft skills in youth. In *2024 47th MIPRO ICT and Electronics Convention (MIPRO)* (pp. 323-328). IEEE. <https://doi.org/10.1109/MIPRO60963.2024.10569574>
- Yurchenko A., Momot P., & Semenikhina O. (2024b). On the development of teachers' information and digital culture using computer visualization. *Education. Innovation. Practice*, 12(6), 93–99. <https://doi.org/10.31110/2616-650X-vol12i6-014>
- Yurchenko, A., Momot, R., Ostroha, M., & Semenikhina, O. (2025c). Visualization of knowledge by web technology in the formation of pre-service computer science teachers' critical thinking. *Physical and Mathematical Education*, 40(5), 80-88. <https://doi.org/10.31110/fmo2025.v40i5-11>
- Yurchenko, A., Riznyk, V., Shamonina, V., & Semenikhina, O. (2025b). Mutual synergistic effects of visual approach and SMART education. *Educological Discourse*, 49(2), 6-14. <https://doi.org/10.28925/2312-5829/2025.2.1>