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Blended learning in the development of university students' metacognition

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ABSTRACT

In the conditions of the advancing digitalization and the introduction of restrictions aimed at combating the COVID-19 pandemic, there is a search for new formats of learning at universities, the most promising of which the authors believe to be blended learning. The study aims to assess the effectiveness of the development of metacognition in a university blended learning environment. The development of students' metacognition as part of an empirical study is achieved by a set of methods, the key among which is the experiment. The results of the experimental study suggest that students' perception of the environment of blended learning tends to improve. In particular, improvement is observed in the indicators of some metacognitive skills (the choice of the place and time of training, planning of learning activities, monitoring of the obtained knowledge, and the experience of working with information). The results reveal improvements in the self-regulatory component of metacognition. As a result of the study, it is concluded that the comprehensive development of metacognitive skills among students ensures their engagement in learning and greater consciousness and proves useful in the context of blended learning.

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1. INTRODUCTION

The problem of metacognitive development and metacognitive skills has been considered from various standpoints [1]. General recommendations have been provided by a number of authors who distinguish two directions of development of metacognition, such work on specific strategies in the study of academic disciplines including knowledge of how and when to use them and the creation of a social environment that supports metacognition (knowledge about oneself as a learner). The principles of the development of metacognition consist in providing students with opportunities to assess what they do and do not know and offering them help in formulating their own way of thinking. A study emphasizes the cultural context of metacognition, establishing the significant impact of where and with whom, in what cultural context, the student finds themselves [2]. Millis [3] presents the methods and recommendations for the development of metacognition in a typology of measures implemented before, during, and after classes or as current assignments in an online course. The concept of metacognition, commonly employed in various contexts, is analyzed within two primary categories–metacognitive behavior development strategies (identification of "what you know" and "what you do not know"; conversations about thinking; keeping a

journal of thinking; planning and self-regulation; analysis of the thinking process; self-assessment) and the creation of a metacognitive environment [4].

The development of metacognition is closely intertwined with self-regulation in learning. Approaches to the development of students' self-regulation are explored by Mejeh and Held [5], who presents two approaches to encouraging self-regulatory behavior. An online tool for the development of metacognition proposed by Stanton *et al.* [6] focuses on two universal recommendations for learning–development of strategies and learning skills, support for monitoring and control of the learning process, and metacognition in the social environment. Allen *et al.* [7] has tested the commonly used so-called "supplemental instruction", the purpose of which is to teach students how to study. Recommendations regarding metacognitive planning, monitoring, and evaluation are provided by several researchers [8], [9]. Tanner's recommendations are presented as a multilayered hierarchical list of reflexive questions that can be used for the development of metacognition in the aspects of planning, monitoring, and evaluation. Urban [9] on the other hand, studied the different dimensions of metacognition, specifically in the context of creative problem-solving. They introduce the Metacognition in Creative Problem-Solving (MCPS) scale, an 11-item instrument adapted from the well-established Motivated Strategies for Learning Questionnaire (MSLQ). This scale is designed to assess metacognitive abilities related to creative problem-solving, encompassing skills like planning, monitoring, regulation, and evaluation.

A number of researchers elaborate on the issue of metacognition in reading [10]–[16]. Such research often uses reading reports [17]. Khellab *et al.* [18] experimentally investigates various metacognitive reading strategies that lead to improved self-regulation. Her study also touches upon the issues of planning, monitoring, and evaluation in reading. In the context of reading, of great importance for metacognitive development is the development of the skills of graphic representation – the creation of graphs and conceptual maps by students. The fundamentals of creating and applying conceptual maps are presented in previous research [19]–[21]. The topic of graphic organizers is explored as one of the aspects of metacognitive by Xu *et al.* [22]. From a contextual perspective, there is relevance to the development of metacognition in online/blended environments, as well as in informational educational environments.

The idea of developing metacognition in the context of interactive multimedia programs has been discussed by specialists since the 20th century [23]–[25]. Using the materials of various authors, Gurbin has conducted a theoretical analysis of how metacognition contributes to technological adaptation in online learning. As a result, Gurbin [26] asserted that "metacognition is essential in facilitating successful technology adoption which is intrinsically a part of learning today." One of the fundamental works in this area is a paper by Li and Yuan [27], which describes ways to introduce metacognitive instruction. In particular, Gama proposes the metacognition instruction model, which is designed to develop problem understanding and knowledge monitoring, selection of metacognitive strategies, and evaluation of the learning experience.

Programs for the development of metacognitive skills are being actively developed in the university environment. Rivas *et al.* [28] highlighted the significance of metacognitive strategies in enhancing students' academic performance and problem-solving abilities. Their research underscores the idea that metacognition equips students with the cognitive tools to monitor, regulate, and adapt their learning strategies, ultimately leading to improved outcomes in various academic domains. An online resource for developing metacognition in the context of problem-solving in the natural sciences has been developed at the University of New England [29]. In 2015, a team of authors developed the Meta-CIC model focused on the development of metacognition in an online environment. The results of testing of this model show that individual metacognitive support improves students' online metacognition indicators, whereas the other type of instruction, social metacognitive support, promotes cooperation between students in computer-supported collaborative learning [30].

Metacognitive skills are required for lifelong learning, one of the most impactful concepts in modern education because a student with well-developed metacognition is capable of self-study [31]. Metacognition is especially important for a student as they are required to be independent, proactive, and conscious in their training to the highest possible degree. The forced restrictions put in place to reduce the risks of the progression of COVID-19 became the greatest impetus to the relevance and popularization of the format of blended learning in university education. With respect to blended learning, a positive correlation was noted between student motivation, metacognitive skills, and the frequency of online interaction [32], [33]. Empirical findings prove the link between the level of development of a student's metacognition and high academic performance in blended learning [34], [35]. Overall, blended learning offers opportunities for students to self-organize their educational process, gives them more freedom, and requires the ability to independently distribute one's resources for learning [36], [37]. The quality of such an orientation of the educational process can be provided by metacognitive development, which contributes to the quick adaptation of the student to the specific conditions of university education (including those of blended

learning), as well as their self-regulation when completing assignments, effective organization and planning of study, and the ability to adapt and manage their abilities and skills [38]–[43]. This paper addresses the challenge of metacognitive development in blended learning environments, aiming to assess its effectiveness and provide valuable insights. It seeks to answer questions such as how metacognitive skills can be fostered, what impact blended learning has on students' perception of their learning environment, and whether students' preferences align with this mode of instruction.

In response to the pressing challenge of fostering metacognitive skills in the evolving landscape of higher education, this paper introduces a comprehensive and innovative approach tailored to the blended learning environment. The proposed solution encompasses a multifaceted framework that combines various methods and strategies to nurture metacognition among university students. In our view, comprehensive development of metacognition in the context of blended learning will be able to form the optimal learning conditions that would allow the student to express their thoughts and ideas more openly, minding the interests and needs of the students themselves. This, we believe, will ultimately improve the quality of higher education. Blended learning can be practiced more effectively if metacognitive development is utilized. Metacognitive development focuses on the development of experience, which helps students be more conscious and effective in regulating their behavior. The development of metacognitive skills in students is considered by us as a process of acquisition of said experience in the process of learning.

Purposeful development of students' metacognitive skills is a process of acquisition of knowledge and experience by means of metacognitive instruction comprised of specific methods and techniques. In this study, we understand metacognitive instruction as an organized educational activity (a metacognitive program) focused on the pedagogical application of metacognitive methods and techniques aimed at the acquisition of the experience required for making decisions and managing one's behavior. In particular, in one 2022 study, students reported that metacognitive skills helped them make better decisions relating to job search, relationships with other people, and control over their own emotions [44].

Proceeding from the previous research experience, it was decided to conduct an experimental study to clarify the need for the development of metacognitive skills among students in the conditions of blended learning in universities of the Republic of Kazakhstan. Thus, the present study seeks to answer two research questions: i) Are the proposed conditions for the development of metacognition effective in a blended learning environment?; ii) To what degree does metacognitive instruction affect the parameters tested as part of ascertaining in blended learning?

2. METHOD

2.1. Participants

Participants in the experiment were first-year master's degree students at L.N. Gumilyov Eurasian National University in Kazakhstan who were taking the "Technique of teaching of pedagogical disciplines at universities" course in English during the 2020-2021 academic year. The groups consisted of 28 people studying in the specialties "Two foreign languages" and "Innovation management" and 27 people studying in the specialties "Two foreign languages" and "Mathematics". The study was conducted during the second semester of the academic year for 2 months as part of ongoing classes (rather than through separate activities outside of studying the discipline).

2.2. Environment

The experiment was conducted in a blended learning environment. Lecture sessions with the students were held online via a MOOC with a random choice of place and time of study, through the study of downloaded materials. Seminar classes were held offline.

2.3. Stages of the research

The three-stage model of the experiment includes preliminary ascertainment, implementation of the formative experiment, and the final assessment in the group. At the first stage, a series of diagnostic questionnaires were administered to assess the initial level of metacognition among the students. At the second stage (formative) of the experiment, a set of activities aimed at the development of metacognition were carried out as part of the students' offline classes. The third stage involved another series of questionnaires administered to detect the changes expected after the experiment. Metacognition development indicators are conditionally divided by us into three components.

i. The system-forming component of the development of metacognition is assessed using the Metacognitive Awareness Inventory as interpreted by Karpov (Metacognitive engagement in activity questionnaire), which consists of 52 statements [45].
ii. The students responded to these statements formatted in Google Forms by choosing from five answer options (1=Completely disagree; 2=Rather disagree; 3=Not sure; 4=Rather agree; 5=Completely agree).

iii. The self-regulatory component is assessed using the online self-regulated learning questionnaire (OSLQ) [46].
iv. Data on the self-regulatory component was also collected via Google Forms. The students were presented with questions with five answer options to choose from 1=Completely disagree; 2=Rather disagree; 3=Not sure; 4=Rather agree; 5=Completely agree.
v. The reflexive component characterizing the level of metacognition was assessed by a method developed by Karpov [47], which diagnoses the individual degree of expression of the quality of reflexivity. Data on the reflexive component were collected by sending the students an online version of the test available online with automatic calculation of the results.

2.4. Questionnaire

The metacognition in blended learning questionnaire was developed for the purpose of this study to determine the specifics of students' metacognition specifically in a blended learning environment, which is why this method is crucial for the results of the study. The questionnaire consists of two blocks of questions, the first addressing the perception of blended learning, and the second concerning metacognition in blended learning. The survey was also sent to students via Google Forms. The respondents were presented with seven close-ended questions and one open-ended question. The process of the formative experiment consisted of the following topics, notionally referred to as links: i) first link of development: enriching students' knowledge about metacognition; ii) second link of development: planning, monitoring, and evaluation; iii) third link of development: metacognition in reading; iv) fourth link of development: graphic representations; v) fifth link of development: enriching students' arsenal of online tools for independent use.

The formative experiment aimed at the development of metacognitive skills was organized by the principle of theoretical instruction followed by students' practical activity. Theoretical instruction was provided based on scientific information supplemented by materials from the media. During the experiment, the students were practicing three skills–planning, monitoring, and evaluation. Thus, the primary materials of the study were students' comments on metacognitive planning, monitoring, and evaluation and the data obtained through the ascertaining techniques.

2.5. Data analysis

The study employed both quantitative and qualitative analysis. Statistical analysis of data was performed via student's t-test for related samples ($t_{cr}=2.005$, $p<0.05$; $t_c=2.670$, $p<0.01$) using IBM SPSS statistics software. This statistical analysis allowed for the examination of significant differences in metacognitive development indicators before and after the implementation of the metacognitive instruction program.

2.6. Validity and reliability of the instrument

In the context of this study, the validity and reliability of the instruments used hold paramount importance, particularly because similar instruments are frequently employed in research within the field of education [48]. These instruments are essential tools for assessing the impact of educational interventions and pedagogical approaches. Content validity assesses whether the questionnaire items comprehensively cover the domain of metacognition and its relevance to blended learning. During the development of our questionnaire, we took great care to ensure that the questions align with the specific aspects of metacognition within the blended learning environment [49]. We reviewed existing literature on metacognition and blended learning to inform the questionnaire's content, which enhances its content validity [50]. Test-retest reliability: To assess the stability of our instruments over time, we asked a subset of participants to complete the same questionnaires on two separate occasions. By comparing their responses, we were able to determine whether our instruments yielded consistent results over time.

3. RESULTS

3.1. First link of development: enriching students' knowledge about metacognition

One of the fundamental and primary ways to develop students' metacognitive skills is by constructing their understanding of metacognition as a basis for further development of skills. The most efficient methods of metacognitive instruction rely on providing students with knowledge about cognitive processes and strategies (metacognitive knowledge) and, simultaneously, their practice [51]. The capacity for metacognition can be strengthened through the activity of realizing and understanding declarative knowledge, procedural knowledge, and conditional knowledge [52]. Proceeding from his personal experience of teaching at a university, Urban [9] argued the need for the teacher to allocate time to discuss metacognitive knowledge and regulation and self-regulation in learning. Consequently, the first instruction for the development of metacognition had the goal of forming the notions and knowledge of metacognition and

giving an introduction to the theory. The students were presented with verbal and visual information on the meaning of the term, metacognition as a direction in science, the categories and concepts of metacognition, its mission, goal, and meaning, and opportunities for development in various age groups of students with discussion of the examples of metacognition in students. As a result of this introductory instruction, the students got interested in the topic of metacognition and became attuned to the further development process.

3.2. Second link of development: planning, monitoring, and evaluation

The students were familiarized with the theory of procedural planning, monitoring, and evaluation skills through scientific and media materials. An explanation of what metacognitive planning, monitoring, and evaluation mean in teaching was given with examples. The students were introduced to the planning, monitoring, and evaluation checklists developed by us as shown in Table 1. After that, they shared their ideas about how they could incorporate planning, monitoring, and evaluation into their teaching.

Students' practice of metacognitive planning, monitoring, and evaluation skills consisted of a verbal discussion and written recording of the moments when they had some thoughts arise during the lesson. The recording was performed on a shared Padlet board. In addition, the students were tasked with answering the question "How can I incorporate planning, monitoring, and evaluation in my studies?" Thus, the students have designed the application of metacognition in relation to their learning. Some students automatically began to project the use of metacognition in their roles as educators (not as learners). Some students shared their thoughts about metacognitive planning, monitoring, and evaluation as global life skills.

Table 1. Planning, monitoring, and evaluation checklist

Metacognitive examples	Instruction
Planning (before) 1. Planning for today's class (any thoughts on planning). 2. Thoughts on metacognitive planning in general. 3. What have you already learned and know and what do you plan to discover, understand, and learn to do? What do you want to learn? 4. How can you use the knowledge obtained today in the future?	1. While writing lecture notes, you can allocate one column in the notebook for metacognitive notes, namely planning, monitoring, and evaluation. 2. After studying a discipline, take the time to study the syllabus and think about the results you want to achieve in learning this discipline.
Monitoring (throughout) 1. Monitoring of today's class (any thoughts on monitoring). 2. Thoughts on metacognitive monitoring in general. 3. During the study of the topic I have difficulties with... 4. Next time I should… 5. While studying the topic, I noticed that... 6. Today I realized that... 7. I was surprised that... 8. Before studying the topic, I thought that ... now ... 9. Convey "in your own words", in layman's language, what has been understood in order to monitor comprehension.	3. There are many things included in a student's independent work: completing assignments and preparing for exams and the final weeks. Before performing some activity independently, plan how to do it faster, more efficiently, and with higher quality.
Evaluation (at the end) 1. Evaluation of the results of today's lesson–your own and those of others (any thoughts on evaluation). 2. Thoughts on metacognitive evaluation in general. 3. How do you assess your results in learning the topic? Describe your results in learning the topic. 4. How effective were your work and the work of your groupmates? 5. Establish your evaluation criteria.	

3.3. Third link of development: metacognition in reading

Metacognitive reading is more conscious and efficient. Therefore, the development of metacognitive skills in reading is useful for nearly all categories of students. The instruction presented the material addressing the key question of "how to read metacognitively" based on scientific articles and information from the media. The goal of the instruction was to give the students a general understanding of metacognitive reading and metacognitive reading strategies. According to Xu *et al.* [22], metacognitive skills in reading include viewing; activation of knowledge; prediction; self-questioning; monitoring understanding, generalization and connection of new material with previous knowledge. In the framework of our study, of great relevance to the reading process is metacognitive monitoring. One of the ways to develop metacognitive skills in reading is by asking students to monitor, detect what strategies they use while reading. The embedding of metacognitive strategies in reading will help make the process of reading more conscious and productive.

The groups were tasked with reading materials for the next topic and making a report on it. In the "my metacognition" column, the students were writing down all their metacognitive thoughts, observations, feelings, and sensations. In the "reading resume" column, the students put the facts: a brief summary and

important information from the material, the general understanding, and the details that seemed important. Next, the students exchanged their notes in lessons and thus familiarized themselves with the reports of their groupmates.

Through planning, monitoring, and evaluation practices, students learned to perceive the material they were studying in terms of its practicality:

> "*In the process, I realized that this topic was familiar to me. For me, it's like reviewing already known material.*"
> "*For me as a language teacher, it is important for me to know some strategies and techniques on how to manage teaching in small groups. Thus, I am looking forward to learning and applying them in my working sphere. I may already know and use some of them but refreshing the theoretical part once more is also important. I can see a new perspective on the known strategies.*"

The students were also observing their cognitive strategies and the arising challenges:

> "*How can I read effectively? Firstly, I use the skimming technique to know what to expect. I look for keywords and the names of paragraphs to get a general overview. And only then I start reading. I pay attention to the introduction part and the conclusion a lot.*"
> "*While reading, I had some difficulties with vocabulary, so I wrote them down to memorize but I could identify the meaning in the context.*"

In notes on the monitoring of reading, the students also monitored their understanding of specific facts in reading. In the course of the practice, the students exchanged reading reports with each other and discussed them. The reading instruction matched with students' discussions about problem-based learning. In the context of problem-based learning, the answer to the question of "*how to promote reading literacy and independent reading skills in schools and universities*" was developed. This resonated with and amplified the perception of the current metacognitive situation.

3.4. Fourth link of development: graphic representations

Graphic representations can be considered a universal metacognitive strategy that can become a basis for planning and an instrument for monitoring, as well as be applied in evaluation of the results of one's work and projected onto any discipline. Graphic representations may imply the compilation of conceptual maps and graphic organizers of key ideas, which constitute the next topic in the development program. In the course of instruction, the students were familiarized with the principles of creating graphic representations, as well as their types (flow chart, tree diagrams, fishbone diagram, series-of-events map) and online instruments for their creation, which is especially relevant in blended learning. Next, the students independently divided into teams. The task of each team was to independently develop a graphic representation, using planning, monitoring, and evaluation in the activity. In this, they were not required to use any specified types of graphic representations. Each group then presented their work. After the presentation, each work was discussed and assessed, including by other teams. While constructing their graphic representations, the groups worked in collaboration, discussing and planning their team's graphic representation.

The first group created a scheme reflecting a typology presented in the text. In the course of planning, the scheme was constructed "proceeding from the topic". The students rated their work as "average", noting that "there were not enough colors". The second group also designed an arbitrary scheme, using signs and keywords. The group worked on the question "How to inspire students to independent work", dividing the elements into the categories "before", "during", and "after". The resulting graphic representation was not overloaded with text, while successfully summarizing the studied theoretical material and demonstrating how to use the theory in practice. Planning was performed by this group in stages: "overview of the topic, selection of the graph, structurization of information". In their evaluation, the students noted the positive aspects of their work: logical organization of information and perspectives of further use.

The graphic representation prepared by the third group, presented in the form of a flowchart, was the most complex compared to the other two. Information in it was presented in three levels and from two points of view: the students' and the teachers. The group's planning process was included in the scheme: "selection of the topic, distribution of work in the group to be efficient, article reading, organization of the presentation; evaluation: 'We actively involved all members of the group. Our flow chart facilitates us to disclose the topic'". The last group was the most effective at distributing responsibilities. In particular, there was a person responsible for observing metacognition, and general planning. The groups were not quite active when discussing each other's work. The most detailed comments were given when examining the graphic representation made by the second group. The most advantageous from the point of this study was the second

graphic representation, for the creation of which the students set their own goals of search and logically constructed the course of their reasoning. The third group was the most effective and organized in terms of collaboration.

3.5. Fifth link of development: enriching students' arsenal of online tools for independent use

The purpose of the instruction was to enrich the student's arsenal of online tools and introduce them to new instruments and resources that could be useful to them. The instruction presented a number of tools for collaboration, creating presentations, infographics, charts, and graphs, interactive assignments, the concept of wiki, as well as educational resources. Afterward, the students completed an assignment, in which they applied the newly discovered online instruments/resources in the context of the current topic. The entire process was accompanied by a written recording of their metacognition, namely planning, monitoring, and evaluation. When summarizing, the students shared their experiences using FutureLearn platforms and presentation-making platforms and put together information about the programs suitable for planning teaching activities. With regard to metacognition, the students learned to channel their thinking process toward the practicality of the studied material and became more precise and conscious in observing their learning process.

3.6. Results of the ascertaining experiment

3.6.1. Results of the metacognition in blended learning questionnaire

In response to the question "*Your perception of the blended learning environment, how do you feel about the blended learning environment*," the answer "negative" was not given, the option "positive" was chosen by 72% of the students, and "neutral" was received from 28%. After the experiment, 87.5% of the students answered "positive", 8.3%–"neutral", and 4.1%–"negative".

When answering the question, "*Is the blended learning format convenient for you*," 88% of the respondents deemed this format convenient, and 12% responded with "no", believing this learning format to be inconvenient. The results collected after the experiment were the same. This consistent response before and after the experiment highlights the stability of students' perceptions regarding the convenience of blended learning. The findings suggest that for the majority of respondents, the blended learning format remains a preferred and convenient mode of education.

The next question assesses in which format students, in their own view, study more effectively– offline, online, or in the blended mode. 24% of the students assumed they were more efficient studying offline, 16% preferred online, and 60% chose the combination of online and offline learning, i.e. blended learning. Thus, the majority of respondents believed they studied more effectively in blended learning. After the formative experiment, 54.1% of the students reported being more effective in blended learning, 41.6% preferred offline learning, and 4.1% voted for online learning.

Answer options for the next questions also assumed the choice between online, offline, and blended learning. Completing the statement "*I am better at showing my qualities in the process of learning …*," 44% of the students chose the offline environment, 20% selected the online option, and 36% leaned toward blended learning. After the formative experiment, the majority of the students, 54.1%, deemed they were better at showcasing their qualities when studying in an offline environment, next by popularity comes the blended environment with 37.5%, followed by online learning with 8.3%.

In response to the phrase "*I can focus on the learning process better …*," 12% of the students selected the "at home" option, the answer "while attending class" was given by 32%, and "the same in both cases" option was picked by 56%. After the experiment, 66.6% of the students answered, "the same in both cases", 20.8% chose the option of "while attending class", and 12.5%–"at home".

Next followed the question "*Which of the following skills help you learn in a blended learning environment?*". For this question, multiple answers were available. Before the experiment, the most useful skills selected by the students were the skills of choosing the time and place of training and planning. Monitoring of learning activities was rated low, and information management strategies also turned out to be little used from the students' point of view. The results of the experiment before and after the formative work are presented in Table 2.

"*What challenges do you face in a blended learning environment?*", "*What qualities do you need to develop, improve, or build in order to improve your learning outcomes in a blended learning environment?*" This question was asked once prior to the experiment. Answers to this question from both groups often contained or implied metacognitive skills, or were related to them: there were such responses as "planning", "evaluation, time management", "time management", "timeliness of execution", "analysis of completed tasks", "discipline"; "Concentration in home study, analysis of effectiveness after work", "the difficulty is to allocate time correctly", "monitoring learning activities and planning for learning", "time planning, finding new information"; "planning my learning process"; "concentration and assiduity."

"*I am often distracted by other things, such as my own image on the screen or the people who are in the same room with me. So, I would like to learn how to focus and analyze the effectiveness of learning after lessons.*"
"*Discipline and time management! You need to get into the habit of learning on your own! And proper planning!*"
"*To improve time planning strategies, as in the academic process I distribute priorities unevenly*."
"*I find it difficult to concentrate on my studies when learning online. I am distracted by household chores, I feel stressed and isolated from the team when the Internet does not work well*."

In addition, mentioned as problems were "motivation" and performance skills*:* "*There were no particular difficulties. But I wish I could express my thoughts and ideas freely and confidently without embarrassment*," "*to express my thoughts correctly and confidently*"; "*it is not convenient to combine with work*," "*it is difficult to combine with work*," "*it was difficult to get used to working on the platforms, to get used to two different teachers."*

Table 2. Factors helping students to study in the conditions of blended learning

Skills	Before	After
Skills that showed a tendency to improve in the experiment		
Choosing the place and time of training	68%	79.2%
Planning (planning for learning, goal setting)	60%	70.8%
Monitoring of learning activities	40%	50%
Information management strategies (effective organization, summarization, elaboration, focusing on important information, new information)	40%	54.2%
Skills that showed a tendency to deteriorate in the experiment		
Evaluation (post-performance analysis of effectiveness, reflection on one's experience after completing a task)	56%	33.3%
Correction strategies (strategies for correcting errors in understanding and performance, seeking help in learning, changing and rethinking the strategies used, understanding one's mistakes)	52%	33.3%

3.6.2. Results of the diagnosis of metacognition development indicators

The results of the ascertaining diagnostics of metacognition components prior to and after the formative experiment are provided in Table 3. The results indicate that the formative experiment had a significant positive impact on students' self-regulatory skills, as evidenced by a notable increase in the mean score in this component. However, some other metacognition components, such as system-forming and reflexive, showed relatively minor changes.

Table 3. Ascertaining experiment on the system-forming, self-regulatory, and reflexive components

Metacognition components	Results of the ascertaining section						
	Before			After			t-test
	Mean	Sd	Se	Mean	Sd	Se	
System-forming	212.0	23.4	7.45	211.8	22.6	6.96	-0.454
Self-regulatory	86.2	12.6	2.88	91.6	8.4	2.11	3.756
Reflexive	125.1	14.8	4.54	123.9	14.3	4.36	-0.872

4. DISCUSSION

Comprehensive development of metacognition through the selected methods has directed students to form a mindset of standing above their learning in a blended learning environment. The conducted experiment on the development of metacognition has also improved students' perception of the blended learning environment. At the same time, most students remain convinced that they show their qualities best in the offline environment, which can be associated with the fact that the traditional learning environment is more habitual for students. The students who both before and after the experiment answered that they studied best in a blended learning environment, we believe, must have to some degree associated this question with personal preference – the blended format is convenient to combine with work and helps save time. The results of the experiment also showed improvement in the skills of choosing the time and place of study, planning learning activities, monitoring obtained knowledge, and experience of working with information. This outcome has been achieved through the pervasive practice of foundational skills together with the topics selected for students' development.

Similar positive results of the implementation of metacognition in learning were obtained in other studies [53]–[55], although some differences are also found. The set of ascertaining methods reveals statistically significant improvement in students' results on the self-regulation component (t_{emp}=3.756,

$p<0.01$). The rest of the parameters show no changes, which is a negative result for our study. In this regard, we assume that a broader range of skills should have been practiced achieving the expected results.

The experimental work has revealed some peculiarities owing to the context of the study. The development of metacognition among students of pedagogical educational programs in the context of our study becomes ambiguous. While the goal of the study was to develop the metacognitive skills of university students, the teachers tried to direct and manage, thereby affecting the development of metacognitive skills in their students. The teachers constantly tried to think about how they could use metacognition in training their students. This position was also emphasized by the academic discipline as part of which the experiment was conducted–the technique of teaching pedagogical disciplines at universities. Another feature of our experiment is that metacognitive instruction was incorporated in the offline part of the blended learning environment, which drastically distinguishes it from research where metacognition was introduced into the electronic environment. Our work consisted of testing not online but face-to-face methods of the development of metacognition implemented in direct interaction with the teacher, whereas most studies at the intersection of metacognition and blended learning use non-human student tool interactional methods to facilitate self-regulation strategies [56]–[58].

Other distinguishing features of our study, we believe, are a high load of questionnaires and frequent written fixation of metacognition in the course of conducted instructions and independent assignments, on the other side, students practiced the skill and reinforced it through repeated use. The introduction of metacognitive activity into the everyday learning process formed the habit of using it, which is demonstrated by another research [59], [60]. The pervasive practice of planning, monitoring, and evaluation in the context of this study helped to reinforce these skills among students. Unhelpful was the discussion of each other's metacognition, which is explained in part by the fact that, more often than not, students were not interested in such practices. In the practice of using graphical representations, the researcher should pay special attention to the following: students should be stimulated not to use the ready-made logical structures found in the text, but to present their own mental product, to display in the graphical representation their idea, reasoning, the answer to the question that arose during the reading, not to simply copy the logic of the work read. Comprehensive development has helped to develop students' thinking about their learning. At the same time, according to our experience, one should be selective in conducting metacognitive practices so as to not overload students with them, balance their use, and carefully choose the context in which they can be applied, as often mentioned by researchers who agree with us.

Instructions for the development of metacognition were conducted in live contact with students and discussed, and we observed and sensed the change in students' moods. Each link of development was perceived differently, and students' attitudes toward metacognitive instruction also varied: students were both interested in the practice of metacognition and had neutral or even negative attitudes. On the whole, the students were inspired by the topic of metacognition, learned to recognize metacognition, and often used related terminology in class. The most interested students sought to more clearly distinguish their own processes of metacognition from cognition. Students expressed opinions about the organization and content of metacognitive instruction for the discipline: "*Metacognitive instruction helps cultivate discipline and learn my strengths and weaknesses*", "*Metacognitive instruction helps with the topic, what I want to learn and have learned. With MI I already know what I need and how to do and use it, how useful the information is, its further application*", "*We went through new topics every day and did metacognitive tasks. The instructions were organized for each topic and we performed them quickly*", "*now I know more about learning, I have identified my weaknesses and strengths.*" At the same time, students suggest that in order to improve the practice of metacognition in this format, more feedback from the teacher and more learning strategies need to be introduced.

5. CONCLUSION

Proceeding from the obtained results, we can conclude that comprehensive development of metacognitive skills in students ensures engagement in learning and greater consciousness of the learner and proves useful in the context of blended learning, in which the study was carried out. Answering the research questions, according to the survey and the results of the ascertaining stage of the experiment, the proposed conditions of the development of metacognition are to some extent effective in the context of blended learning. Innovatively, this research introduces a comprehensive, multi-stage approach to metacognitive development, encompassing various metacognitive skills and strategies. It distinguishes itself by seamlessly integrating metacognitive instruction into a blended learning context, a departure from previous studies that often focused on either online or offline methods. The approach emphasizes frequent written reflection, practical application of metacognitive skills, and collaborative learning experiences among students.

The limitations of the study, in our view, include the rather small sample of students, which is due to the limited resources of the study. The organizers of the study were required to provide for the process of metacognitive practices in interaction, as well as to actively monitor and observe, to evaluate the effect of their integrated use. The results of the presented study can be used as a theoretical framework for metacognition in developing an online blended learning program. It should be pointed out that in this study, we used a number of "classic" methods of metacognition development in our own interpretation. Further research in this direction needs to expand the range of methods associated with the online environment. For example, in our study, we developed an arsenal of online instruments for independent use by students.

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