Co-Learning as a New Model of Learning in a Digital Environment: Learning Effectiveness and Collaboration

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Abstract—During the last decade, co-learning techniques have been widely used for the formation of an effective open society. Co-learning allows increasing the skills of social adaptation and joint work of representatives of inhomogeneous groups. The purpose of this study was to determine educational effectiveness, as well as danger, the effectiveness of the digital environment in developing social skills and achieving learning quality in a new generation. The study was conducted in the form of a survey among 60 students from Gulin Tourism University and Moscow State Pedagogical University; they were divided into two groups, the methods of cooperative and collaborative co-education with immersion in a digital environment were used. A control group consisted of at least 30 students. The real effectiveness of training was tested both by the solution of task and by independent testing that was obtained in the process of solving. A separate survey was conducted to establish a subjective assessment by students of the social skills and interaction. The survey was conducted according to the methods that have been developed over the past 6 years by different groups of researchers. Consequently, it was found out that co-learning technologies do not influence the quality of training and the assimilation, and students immersed in a digital environment showed even better results. The number of students with most correct answers for the test was 46.67% and 23.33% in study groups, and only 10% – in control group. Generally, the results of a subjective assessment of social skills coincides with similar data obtained by other researchers and shows an improvement of collaboration in inhomogeneous groups, slighter leadership in common problems solving, and very low conflict indicators. Generally, the results of a subjective assessment of social skills coincides with similar data obtained by other researchers and shows an improvement of collaboration in inhomogeneous groups, slighter leadership in common problems solving, and very low conflict indicators.

Keywords—Collaborative learning; digital environment; emerging technologies; cooperative learning.

1 Introduction

Co-learning methods are becoming more widespread both in higher school, as well as secondary and elementary, and have also become very popular in the process of exchanging information in private companies [1-3]. The essence of co-education is defined as the use of group interaction in class, and the goal of not only achieving the necessary skills, but also developing of social communication between students [4]. Nowadays, more and more often, any community, among schoolchildren, students, and also workers, has an inhomogeneous nature [3-6]. They come across representatives of different races, religious groups, nationalities and mentalities. Thus, a number of works emphasize that traditional teaching practices, established in the Anglo-Saxon pedagogical tradition and widely spread all around the world, can be completely unacceptable for people for which traditional values of cooperation between members of the community exist (for example, American Indians, African Americans, representatives of many peoples of Southeast Asia) [3,5,7,8]. The dominance of the teacher and the principle of transmitting information from him to students as passive receivers is also ineffective in the modern world, in which the significance of individual sources of information is leveled in the digital environment. An important feature of the digital universe is the peer-to-peer information sources from the point of view of the perceiver, who, based on his experience and world model, builds a ranking of these sources [9]. Thus, there is a need to create a learning environment where participants of different social, religious, ethnic groups have the opportunity to interact with each other for common goals and for the common good. On the other hand students should be as free as possible from the "dictate" of the teacher and perceive the material as their own discovery and research, rather than passively supplied knowledge. Therefore, in the process of co-learning, the material studied, or rather, in this case, "extracted" by students or schoolchildren, receives much higher value [10,11].

Today, there are lot of widely used and often studied, separate teaching techniques and methods [12-14]. Two main variants of co-learning techniques are distinguished: collaborative and cooperative. The difference is that in the case of collaborative interaction, group members do not have a clear division of functions and take part in the task all at the same time, while in the case of cooperative interaction, each group member receives a well-defined part of the work or function, the performance of which is his/her responsibility [4,6,15,16].

The main goal of co-education is the adjustment of social interconnection and a high quality of interaction between members of inhomogeneous social groups. These teaching methods are primarily aimed at training adequate members of a modern, open, democratic society and instilling the cooperation and understanding skills that are necessary for the existence of this society [3,5]. However, there are no studies that would be devoted directly to assessing the effectiveness of training and knowledge acquisition by such methods. Studies show the undeniable value of cooperative and collaborative co-education for the social development of students, but the question remains as to how these methods affect the quality of information assimilation itself.

Our study is based on the hypothesis that the quality of knowledge acquisition in groups with collaborative and cooperative co-education with immersion in a digital

environment [9], will be no lower than in the control group due to improved interaction skills and a more active exchange of knowledge in the group.

2   Materials and Methods

The study was conducted in three separate groups consisting of Gulin Tourism University and at Moscow State Pedagogical University students. One of the three groups acted as a control. The control group training was carried out according to the same training material and according to the same program as in the study groups. The control group students were not immersed in a digital environment, but also worked in collaboration or in a cooperative interaction. Two study groups were trained in a digital environment using co-learning techniques.

The optimal group for co-education or joint implementation of projects for adults is five people as the majority is a practical work on organizing co-education. Each of the study groups was divided into 6 subgroups of five people [16-19]. Thus, the COO and COL groups contained 30 respondents each. Each of the subgroups performed the same practical task for the purity of the experiment, but all the subgroups did not know about each other and had no communication.

The digital environment purposes:

— Full access of participants to all means of communication and the Internet through smartphones, tablet computers, laptops and PC
— The availability of digital television fully available with a wide selection of television channels both in the classroom and home
— A free use of all social networks available to students for group communication and communication with teachers (restrictions on the use of certain networks were not introduced) [20]
— On restrictions for the use of any information from any information channels, subject to the protocol of the educational process and the absence of distractions from the fulfillment of the educational task in the school time. At the same time, distractions occurred constantly, because of social networks use for communications outside the group working on assignment. However, the study of such distractions is beyond the scope of this work and is therefore ignored. The amount of time spent on distraction was taken into account only when studying the time of delays when performing part of the training task (Figs. 1, 2, and Table 1) [13,21]
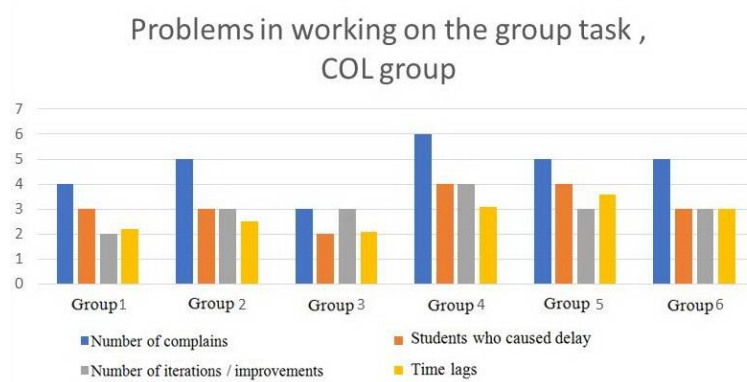
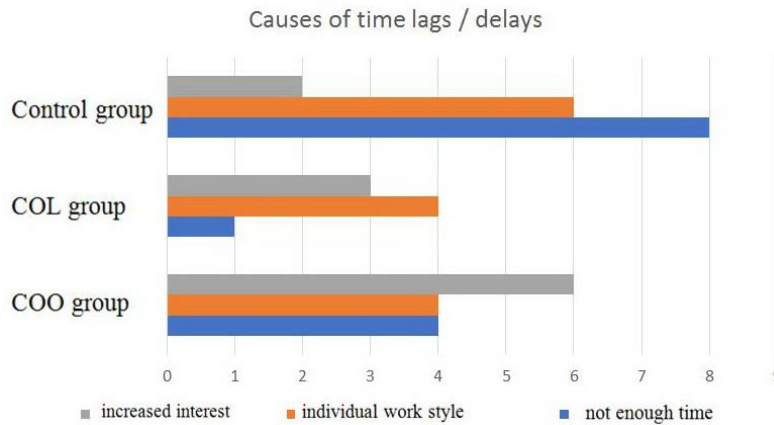**Fig. 1.** Problems in working on the group task in the COL group

Fig. 2. Causes of time lags/delays

Table 1. The number of participants who have delayed their part of the overall group assignment.

	Total	Caused delays
COO group	30	14
COL group	30	8
The control group	30	16

One study group (hereinafter "COL group") was trained in a collaborative environment, when a common educational task was set for the entire group, requiring independent research, independent search and determination of suitable sources, analytical processing of data and conclusions. The members of the group completely and independently determined both the deconstruction of the task and the order of work, intermediate stages, the distribution of the volume of work between individual members of

the group. Leaders did not stand out specifically in this group, all members of the group had an equal rank, communications were carried out "horizontally" [1].

Another study group with a cooperative type of training ("COO group") got assignment similar to the COL group, but each member of the group took responsibility for a certain part of the work, a separate function or the volume of tasks that he alone performed. At the same time, participants were a constantly exchanging the results and the information learned. Thus, the knowledge and skills gained were evenly distributed as a result of the overall task. Participants were free to contact each other for support or information, but could not shift part of their task to another member of the group.

The time delays were measured using the Toggl network resource for time tracking (https://toggl.com/). The delay time was reflected in hours, using decimal fractions, rather than minutes, for proper presenting.

When the task was completed, we held a test containing 20 questions with four possibility answers where only one was correct (Fig. 3). Testing is designed to verify the quality of acquired knowledge by each of the group members individually.
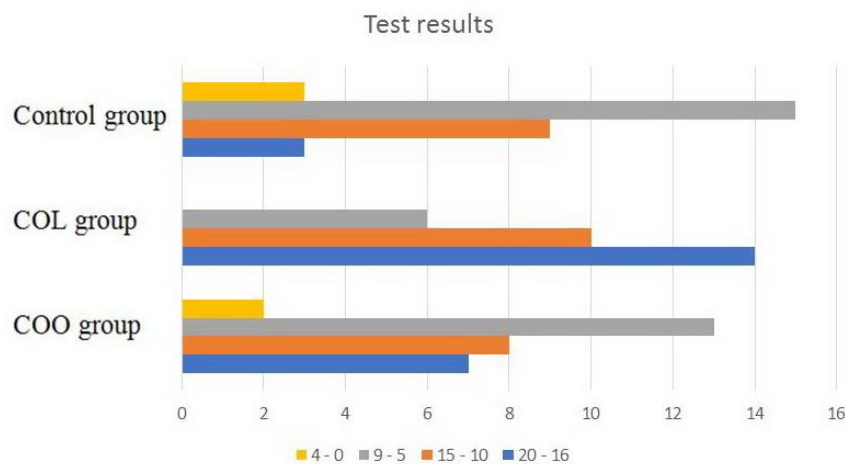

Fig. 3. The results of objective testing.

Further, the mutual subjective assessment of the quality of interaction in both studied groups was conducted (Fig. 4, Tables 2 and 3). A joint training and a survey of all study participants was used to assess the students' social interaction skills. Thus, students gave a subjective assessment to all other participants in their subgroup according to six selected parameters with a 10-point scale. Next, the arithmetic mean values for each of the parameters for all 30 participants of the tested groups were calculated. This study was not conducted for the control group as students were not immersed in a digital environment.
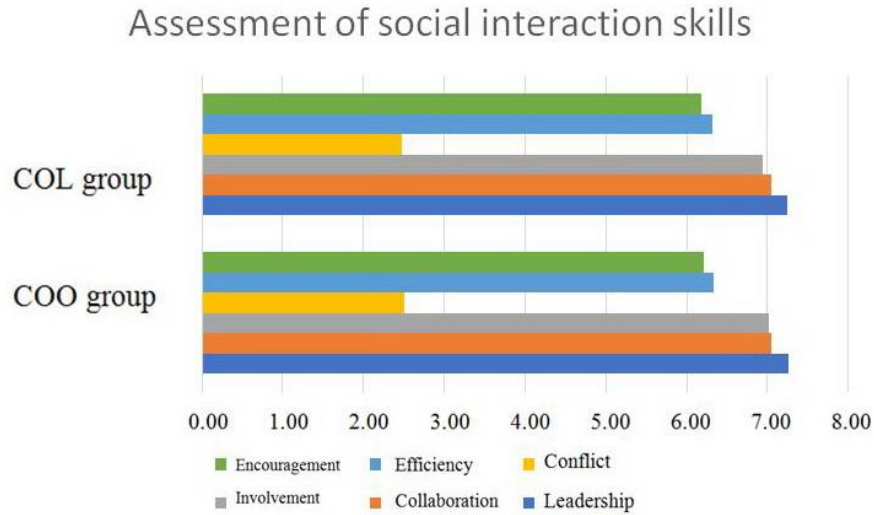
Fig. 4. Mutual subjective assessment of social interaction skills.

Table 2. The results of a mutual subjective assessment of social interaction skills on a 10-point scale in the COO group.

COO group	Leadership	Collaboration	Involvement	Conflict	Efficiency	Encouragement
1	2.28	3.19	6.76	2.15	6.60	6.15
2	3.15	5.57	7.71	2.18	7.12	6.19
3	6.38	6.18	7.98	2.02	8.17	7.24
4	5.58	8.16	7.92	2.03	9.19	8.16
5	7.80	8.34	8.81	2.17	8.84	8.38
6	7.21	6.24	6.92	2.99	6.77	7.56
7	7.45	7.24	9.02	3.16	6.57	7.14
8	9.12	7.14	8.02	3.03	8.36	5.13
9	9.00	3.15	7.63	3.17	3.12	2.11
10	7.54	7.29	7.56	3.10	4.78	3.98
11	8.10	8.28	4.65	2.98	5.64	8.60
12	9.54	7.56	7.17	2.01	3.98	8.98
13	7.16	7.45	8.18	2.50	4.76	6.97
14	8.33	6.98	6.49	2.18	6.13	6.88
15	6.15	8.88	6.19	5.70	7.34	9.14
16	7.91	8.49	8.07	4.18	7.12	7.44
17	7.54	7.79	7.77	2.00	8.03	6.22
18	6.82	7.84	7.59	1.15	5.14	8.26
19	7.65	4.98	7.91	0.79	4.94	5.94
20	5.98	4.18	9.85	1.50	6.16	3.99
21	9.18	5.12	8.81	1.17	8.09	9.14
22	7.40	5.19	6.38	2.36	7.43	7.16
23	6.98	6.79	5.24	2.04	6.82	7.08
24	6.92	8.28	6.37	2.09	8.15	7.12
25	6.50	8.23	6.46	1.68	7.00	7.06

26	7.41	9.13	6.11	1.91	8.21	3.22
27	4.29	8.36	5.99	3.70	9.98	2.12
28	5.19	8.41	7.98	5.10	7.44	8.28
29	7.14	8.05	6.11	2.92	6.19	6.61
30	8.16	8.01	6.19	1.98	5.76	6.24
Arithmetic means	7.00	7.02	7.26	2.53	6.79	6.62
Mean error	4.16	3.41	3.41	0.12	0.59	0.06

Table 3. The results of a mutual subjective assessment of social interaction skills on a 10-point scale in the COL group.

COL group	Leadership	Collaboration	Involvement	Conflict	Efficiency	Encouragement
1	4.01	4.17	9.02	2.02	7.15	6.89
2	3.37	4.58	9.20	2.14	7.88	6.28
3	2.98	4.55	9.70	2.78	7.28	6.19
4	3.02	3.78	8.76	2.15	8.26	5.14
5	1.98	3.98	8.05	3.02	7.56	3.17
6	3.03	3.47	7.14	3.07	7.23	3.58
7	6.01	6.83	9.20	2.12	8.09	4.49
8	3.02	4.39	8.14	2.93	8.22	7.03
9	4.16	4.15	8.17	3.01	7.12	6.24
10	2.38	4.98	8.49	3.87	6.78	3.03
11	2.17	3.99	7.29	2.12	8.70	7.12
12	4.11	4.12	7.18	4.18	3.48	7.06
13	2.01	2.98	6.63	4.05	8.16	4.48
14	4.09	4.18	7.36	3.00	7.99	3.02
15	3.78	4.87	8.12	2.92	9.82	8.14
16	3.08	5.01	8.00	2.17	8.03	8.07
17	3.11	3.51	8.16	1.98	7.56	3.12
18	1.01	4.12	7.44	4.16	7.12	7.14
19	1.94	3.28	8.38	2.37	7.03	7.98
20	3.17	4.22	6.15	3.19	4.82	4.16
21	2.98	4.17	6.99	2.87	5.02	4.28
22	4.01	6.33	6.18	4.15	7.12	5.86
23	2.01	5.12	6.23	3.73	8.01	8.12
24	2.74	6.18	7.98	3.12	7.06	8.38
25	3.08	6.04	6.79	4.88	7.69	9.02
26	3.84	3.12	7.17	5.19	8.29	6.54
27	3.14	3.94	7.99	1.18	7.61	5.79
28	7.08	3.77	8.18	3.03	6.73	6.09
29	3.77	4.01	7.16	3.08	6.12	4.37
30	2.19	4.08	6.32	2.12	7.08	6.26
Arithmetic means	3.24	4.40	7.72	3.02	7.30	5.90
Mean error	1.29	0.06	1.91	0.07	0.05	0.45

Evaluation parameters for the study were selected based on an analysis of a number of studies. Particularly, different researchers used the following parameters: "quality of discussion in a group", "level of use of educational media", "quality of work in a group", "fulfillment of obligations when working in a group";

"Intergroup participation", "fulfillment of one's professional role", "training outside the standard stream"; "Collaboration", "friendliness", "conflict" [8,15,22-24].

3 Results

Figure 5 shows the ratio of learning disruptions common to all groups. Among these factors are complaints about individual members of the group who did not enough for the overall result (according to other group members). Such complaints are noted by many researchers who studied of co-learning mechanisms [8,17,18].
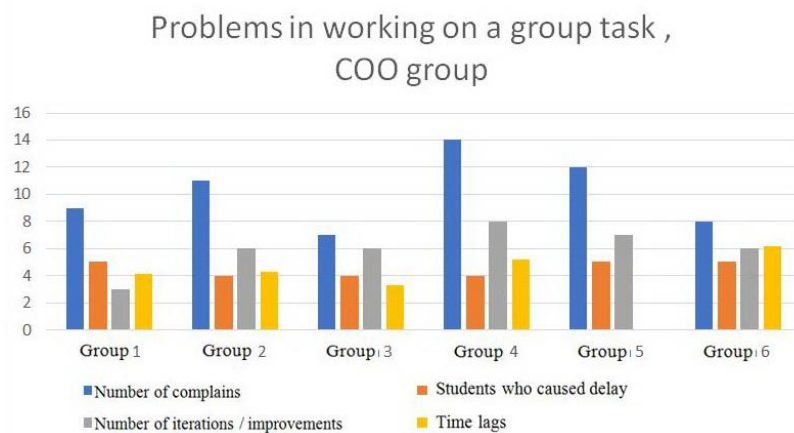

Fig. 5. Problems in working on a group task in a COO group.

The study indicates the total number of such complaints that participants made during the project, and separately, the number of participants in each small group to whom such complaints were received. Two more interfering factors. The first one is the number of repeated iterations during the training project that occurred due to a shortage of some important points or as a result of mistakes made by the participants. The second is delays in performing different segments of a common group task due to the fault of participants who did not complete their part of the group task on time. Such problems occur in the COO group, when the participants did not complete their task segment by a certain time group, or when one part of the participants had already completed their part and the others had not yet, but without compete result, further progress was impossible. For the COL group, such a situation could occur when some of the participants had already finished their task, while others were still working on it, and further progress was impossible without complete result.

According to Fig. 5 it is noticeable that most of the problems were complaints against other participants in cooperative interaction. The parameter that changed to the greatest for all working groups was the number of iterations / improvements of the training material prepared by the group members. It can be assumed that this parameter is more dependent on the personal characteristics of the group members and their personal learning style. According to Fig. 1, in the COL group, claims to the downtime of other

participants were also the main subjectively identified problem, but they do not prevail that much over compared to the COO group. It can be assumed that the problems of delays by individual members of the group were solved more effectively in the COL group.

The process of solving the problem in groups was continuously monitored in both study groups during the available class time. According to several interim polls, regularly conducted, it was revealed that one of the critical factors was the delay in completing the next stage of the assignment when students waited for the results of other group members. The cloud-based tools for time tracking helped to record the time spent on waiting the results of individual participants. The delay was tracked for each of participants who caused it; for the group as a whole and for individual members who were forced to wait for the result The beginning of the delay was determined from the moment the previous segment of task was completed and ends when the delayed segment of the workflow was completed, after which other members of the group can already use it.

Survey helped participants of each group to pointed out members who caused delays. The results were compared to data obtained using cloud-based tools for time tracking. Thus, there was objectively determined the number of participants who caused delays, as well as the average time of the delays (measured in hours with decimal place accuracy). The arithmetic means of those indicators were calculated for each study group. In Table 1 shows the number of participants who have delayed the task in each of study groups.

Fig. 1 shows that the performance of the control group and COO group practically have no difference, while COL group has half as many participants who caused delays. That's because all members of the group shared tasks among themselves, and when one participant did not manage to complete part of the task, his neighbors were aware of other parts of the material being studied and intercepted the missing fragments. Naturally, due to limited resources, it is impossible to completely eradicate delays or mistakes within the team. We called this phenomenon the metafunctionality of the group work. Its essence lies in the fact that all participants perform at the same time all or most of the functions that the group as a whole distributes among themselves.

Those can be such functions as information search; authentication of information (verification); clarification of sources or getting access to sources; assessment of information; quantitative analysis of information; comparing and combining information to obtain new knowledge; experimental verification of new knowledge; reconciliation of new knowledge gained with trusted sources available for research.

There was a separate survey was conducted among participants who caused delays. All participants were asked about the reasons for the delay, which they could freely express, providing one main or determining reason that explains all or most of the delays. All free formulations naturally came down to three main reasons:

1. Lack of time to complete the task (by various reasons that had external or internal nature of interruptions, and were not due to the characteristics of thinking, working skills or training methods that are individual for every person). It is labeled "not enough time" on the Fig. 2.

2. Student's individual work style, which did not allow completing his part of the task on time. In It is designated as "individual work style" on the Fig. 2.
3. An increased interest in the task content. This, participant spent more time and effort for subject than was detrimental causing delays. It is referred to as "increased interest" on the Fig. 2.

Figs 2, 5 indicate that most of the delays were recorded in the control group, which did not use the digital environment. At the same time, the COL group recorded the most delays associated with an increased interest in the topic. Among those who delayed due to increased interest, COO and COL groups were more than three times greater than in the control (12.5% and 42.85% in COO or 37.5% in COL).

Unexpectedly, a larger number of those who did not have enough time to solve their tasks in the COO group (28.57%) compared with the COL group – 12.5%. The increase in academic performance is associated with the metafunctionality of group work, mentioned above.

Fig. 3 presents the results of objective testing of knowledge on the subject, which were obtained as a result of the group task. Testing was carried out using a questionnaire containing 20 questions with four possible answers where one is correct. The participants are divided into 4 groups: 1) who answered correctly for more than 15 questions, 2) more than 10, 3) more than 5, and 4) who answered for at least 5 questions.:

The distribution of the number of respondents in the control group can be considered as average distribution observed in most educational groups. It can be considered as normal and standard. Both study groups showed a relevant decrease in the number of those who gave the minimum correct answers and a significant increase of those who gave more than half of the correct answers. Only 20% of the participants answered correctly for less than half of questions, and not a single one less than the correct 5 answers in the COL group (in the COO group – 50% and in the control group – 60%, respectively). The most significant differences in the effectiveness of training for the COL group, was in the largest number of correct answers 46.67%, while in the COO group – 23.33%, that is, almost a half. The difference between these groups lies in the fact that twice as many were precisely those who most fully learned all the information. Moreover, the indicators for those with average grades in the COO and COL group are very close (COL – 33.33% and COO – 26.67%).

Mutual assessment of social interaction skills in groups was carried out using six parameters, the value of which was previously explained to the survey participants and accepted by them.

"**Leadership**" – the ability to take responsibility not only for one's actions but also for the actions of others; distribution of tasks and their sequence; distribution of roles in the group. Those members of the group who were more likely to propose and insist on than to accept other people's decisions or the general decision of the group should have got the highest score.

"**Collaboration**" – subjectively perceived ability to work harmoniously with other people in the distribution of roles, take on additional functions, and easily transfer their functions to others,

"**Involvement**" – subjectively perceived group activity and the ability to concentrate for a long time only on the training task. The group members additionally invested in this parameter the ability to calmly perceive the behavior and personal habits of other members of the group during work.

"**Conflict**" – subjectively perceived frequency of conflict caused by one group member. It doesn't matter if s/he was considered the cause of the conflict himself or if he was only drawn into it by the behavior of other participants.

"**Efficiency**" – subjectively perceived ability to quickly and efficiently receive the result of work or the performance of one's function.

"**Encouragement**" – subjectively perceived frequency of emotional support, motivation, and creation of a positive emotional background. Students who did not take expressed actions, but simply maintained a constantly positive mood and emotional background that supported other participants, for example, often smiled in conflict situations and behaved calmly and judiciously should have got the highest score.

In fact, all indicators for both study groups should be considered identical as their values are within mean error. Thus, we cannot make conclusions about the significant difference between study groups with a cooperative or collaborative type interactions. Not only quantitative, but qualitative differences in parameters should be considered. Therefore, a very low "Conflict" values were observed in both group comparing to other parameters – despite the fact that more or less all the participants in subgroups took part in the conflicts (Fig. 5). "Leadership" was the highest indicator in both groups, which indicates the possibility of a more vivid manifestation of personality in the absence of dictatorship on the part of the teacher, when all communications pass "horizontally" [25].

Fig. 4 shows that students highly evaluated the effectiveness of their partners in the group, which also indicate the achievement of psychological compatibility and a higher level of tolerance, willingness to recognize the achievements of other participants.

4   Discussion

One of the additional goals of the study was to test the hypothesis that during collaborative and cooperative learning, there might be identified factors that not only contribute to the development of new social forms of behavior, but also problems that reduce the effectiveness of teaching. The study examined two groups of students, one of which was looking for a problem solution with the collaboration mode, and another with cooperative interaction. Both groups used a digital environment. Direct interaction between the participants through social networks increases the time of real work on the educational project due to discussion on the network after the end of class time [26]. Also, constant access to information via mobile services and the availability of information processing in a digital environment at any time makes it possible to distribute efforts in a way that is more natural for each person [27].

Groups were identified in which the simplest methods of joint training were used, with a clearly defined interaction algorithm between the participants in the groups. In COL group, a freer protocol of communication between group members was used, in

accordance with the described features of the application of this method. At the same time, the more complex varieties of these methods were not used, as it may clearly limit the study [1,24,28]. An accurate study of the effectiveness of individual methodologies precisely in terms of the effectiveness of knowledge acquisition by participants in joint training should serve as a topic for new research.

The control group wasn't subdivided into COL and COO as the main task of the study was to obtain differences in the behavior of groups based on work in and without a digital environment. Based on multiple researches, we can maintain that the digital environment contributes to a better and more complete assimilation of knowledge, as well as an increase an interest in learning process under "generations Y and Z" [27]. Moreover, people who were born during the existence of the Internet (native digital) and almost never know the state without interacting with information anywhere in their individual space require other teaching methods [29]. These methods should be characterized by the independence of the student, an independent choice of the direction and intensity of the learning process, considering individual learning style of each student. Adapting training to the personal needs of individuals is possible only with the help of cloud services technologies, big data, the use of a wide digital environment [30,31].

Only representatives of generations that are transitional to the "native digital" took part in our study. The impact of the digital environment on the quality of education in the study was generally verified by the data obtained over the past decade by other researchers. The importance of the digital environment for the formation of socially acceptable interactions of heterogeneous groups is as high as for the formation of basic skills of effective thinking [32]. The data in Tables 2 and 3, Fig. 5 compering to similar data obtained by other researchers [1,5,7,12,17,22,27] shows common results – increased learning efficiency, reduced conflict, increased leadership chances in the group and the possibility of high collaboration between group members. Group members also highly evaluate each other's effectiveness. However, in this case we cannot determine how much this subjective assessment of effectiveness coincides with the real contribution of each individual group member to the achievement of the group result. The proximity of performance indicators both in teaching technical and humanitarian specialties, and in the field of physical activity is of particular interest [20,30].

5 Conclusion

The study confirmed the hypothesis that the quality of knowledge acquisition in groups with collaborative and cooperative co-training is higher than in the control group. The main difference with the control group was the use of the digital environment. Therefore, we can conclude that the use of both cooperative and collaborative types of co-education leads to the expected positive results of deeper social integration and interaction in non-homogeneous social groups of students. At the same time, the quality of education, verified by independent testing, does not decrease (more than half of the correct answers to questions were given by 80% and 50% of students in the study groups, and only 40% in the control group). The quality of teaching will be higher if

students taught by co-learning are immersed in a digital environment since childhood (the number of students with most correct answers was 46.67% and 23.33% in the study groups, and only 10% – in the control group) – due to an increase in social interaction skills and a more active exchange of knowledge in the group. The study can be of practical use to improve the quality of work in classes where co-learning technologies are used by expanding their capabilities with digital environment.

6   Acknowledgement

7   References

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