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The impact of peer feedback on collaborative problem-solving skills in the online environment

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Abstract: The aim of this study is to investigate the impact of online peer feedback in the Information Technologies and Software course on the improvement of collaborative problem-solving skills (CPS), which are considered essential skills for the 21st century. The impact of peer feedback on CPS was designed using a mixed-methods approach that combines quantitative and qualitative data in the research. The study employed a set of CPS tasks that were specifically designed to measure the target behaviors outlined in the 6th-grade Information Technologies and Software course curriculum. Additionally, the study made use of various instruments, including a peer feedback survey, a longitudinal rating scale for tracking the development of CPS, and a peer feedback interview protocol. As a result, a statistically significant difference was found between the CPS of the experimental and control groups. According to the results of the study, it can be expressed that the CPS and peer feedback skills of the students in the experimental group have improved and that they have a more positive attitude toward giving peer feedback and solving collaborative problems based on the results of the interview form.

1. INTRODUCTION

The increasing dependency on information technologies, changing societal trends, and the creation of knowledge by using technology have made it how to manipulate these technologies, and almost essential to focus on this question: how will we teach individuals to navigate available communication channels?" (Csapo & Funke, 2017). The situation has made the definition of 21st-century skills an intriguing subject on a global scale. National organizations, international consortia, teacher forums, and government initiatives have conducted several studies on workforce requirements, e-learning environments, digital technologies, and their applications in conventional classrooms. Additionally, they have explored topics like resolving significant global issues, among others. Some of the institutions that have conducted these studies include the Partnership for 21st Century Skills, the Collective Intelligence Center, and the National Academy's National Research Journal. (Csapo & Funke, 2017). Because of technological, economic, political, and societal changes in the 21st century, 21st-century skills have become almost a necessity in defining qualified individuals. These changes have not only

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led to changes in the qualifications sought in the workplace but also made it almost essential to make significant changes in the information, skills, and competencies that personal requirements to acquire through education (Cansoy, 2018; Fiore et al., 2017). The new tasks assigned to the education system have also brought about changes in the organizational structure of education and the roles played by those working in these structures. The change in the expected qualifications has made it almost essential to leave routine and repetitive tasks to technology and impart complicated skill sets like solving complicated problems and collaboration to individuals. The New Vision for Education Report by the World Economic Forum, published in March 2015, emphasizes the significance of 21st-century skills like collaboration and problem-solving based on an analysis of research conducted in approximately 100 countries. The report states that "there are clear signs that in the 21st century, many students could not be getting the education they should succeed, and countries are not finding the skilled workers they should compete with other countries and meet the demands of the times" (World Economic Forum, 2015).

The report "The Future of Jobs" (2018) by the World Economic Forum highlights that complicated problem-solving, collaboration, and emotional intelligence, critical thinking, creativity, and people management skills were prominent in 2020 (Tusiad, 2019). The same report also indicates that complicated problem-solving skills, leadership, and social skills were among the demanded skills in the commercial world in 2022 (World Economic Forum, 2018). In the 21st century, team-based projects are becoming more prominent and require individuals to work in groups, which in turn help develop their communication skills (Barron, 2000). Collaborative problem-solving (CPS) has become more and more significant in our education system due to both the expectations of the era and skills it provides individuals. According to Nelson's (1998) CPS theory, learning environments that require solving everyday problems help students develop critical thinking, questioning, creativity, decision-making, and complicated problem-solving skills, while also assisting in their socialization.

Buder et al. (2015) describe CPS as an intricate system that requires participants to coordinate their own problem solutions into a consistent sequence of events. Jennings and Wooldridge (1999) define CPS as the process in which individuals work collaboratively toward a common goal. On the other hand, Clewley at al. (2017) define it as the process in which two or more people share their knowledge, skills, readiness, and efforts to solve a problem. Cuevas et al. (2017) describe CPS as a communication process that requires individuals to share their resources and strategies with other teammates to achieve a common goal. Considering these definitions, CPS is an approach in which multiple individuals pool their resources and strategies to solve complicated problems, using both mental and interpersonal abilities.

If the aim is to solve complicated problems, focus on group work processes, and develop collaborative working habits in individuals, CPS is a useful educational and teaching tool (Csapo & Funke, 2017). CPS is defined as an uninterrupted problem-solving process with a common goal and team spirit in which teammates support each other and aim to improve individual relationships and communication (Flood & Lapp, 1989). Solving a problem requires individuals with different perspectives to evaluate their views within the context of the problem at hand. Students' ideas being appreciated and accepted by other teammates develop a sense of belonging and acceptance in the group (Ashman & Gillies, 2013). In a CPS environment, teammates are constantly exposed to different ideas, which allows each member to listen to others' solutions and reflect on those ideas. These solution proposals allow individuals to interpret and reconstruct them based on their own thought processes (Gardunio, 2001). Additionally, motivation loss is less of a problem in little clusters, and coordination increases during activities (Huber & Huber, 2008). One of the primary elements of CPS is for teammates to continuously communicate with each other and provide feedback to one another.

CPS involves constant communication and feedback among teammates, which is one of the vital elements of the process. Feedback, in general, includes information on the current learning state and performance of individuals engaged in a learning activity in relation to the desired learning outcomes and performance levels (Çevik, 2014). With increasing class sizes, the practicality of teacher-centered feedback is limited, leading to a problem of inadequate teacher feedback. Peer feedback can be a pragmatic solution to overcome this problem (Macfarlane-Dick & Nicol, 2006). Also, peer feedback enhances student learning because it allows for social sharing and interaction to construct information (Bijami et al., 2013). Peer feedback is a feedback type that can be considered the equivalent of teacher feedback, which has a shaping effect on learning, and involves students using each other as a source of information (Anwar et al., 2019). Peer feedback highly the attracts the attention of students due to its social dimension. According to Falchikov (2005), this is because receiving feedback from peers is less anxiety-provoking than from teachers. Peer feedback also contributes to transforming learning environments where the assessment process is limited to the teacher in a participatory learning culture (Çevik, 2014).

It can be quite difficult for students to monitor and track peer feedback in the classroom. However, diverse open source platforms and online learning environments like "Synergy" facilitate the online presentation of collaborative peer feedback (Er et al., 2020). In an online environment, students tend to be more open and constructive in their feedback (Carless & Liu, 2006). Compared to traditional peer feedback, online platforms allow students to contribute to their peers' work in a more structured manner without limitations (Bayat et al., 2020). Online peer feedback applications provide opportunities for enriching the environment by implementing various scripts and structuring the peer feedback process. Additionally, they offer students flexibility in changing feedback that may not be possible in face-to-face or paper-based feedback (Bayat et al., 2020).

In accordance with the literature , it was found that studies on CPS are generally focused on mathematics classes (Aydın, 2020; Hogan et al., 1996; Kittur & Tausczik, 2014) and aimed to understanding and improving the conceptual structure of CPS (Arıcı, 2019; Karakuş, 2020; Uzunosmanoğlu, 2013; Roschelle & Teasley, 1995; Barron, 2000; Rummel & Spada, 2005; Andrews-Todd et al., 2018; Molnár et al., 2021) as well as examining the influence of CPS on academic achievement (James & Johnston, 1996). No studies have been found on the development of measurement and evaluation approaches that are compatible with the structure of high-level abilities like collaboration, problem-solving, information, media, and technology literacy, which are among the 21st-century skills.

In studies related to peer feedback, it has been observed that peer feedback is focused on language education and writing abilities and a restricted number of studies have been conducted in this area (Temizkan, 2009; Özşavli, 2017; Patri, 2002; Nilson, 2003; O'Dowd & Ware, 2008; Dochy et al., 2010). Various studies have been conducted to develop collaboration and problem-solving skills, which are among the 21st-century skills (Genç, 2007; Gök, 2006; Uysal, 2010); however, no studies have been found that investigate the function of peer feedback in online CPS environments. Given the importance of this ability in both day-to-day life and the workplace, and the insufficient amount of research, and the inadequacy of teacher feedback in CPS practices carried out in crowded classes, it is thought that peer feedback will reduce the workload of teachers. This study was deemed essential to address the uncertainty about how CPS abilities, which have a significant role in the Information Technologies and Software course aimed at developing mathematical thinking, problem-solving, algorithmic thinking, and creativity skills, will change based on peer feedback in an online learning environment.

Research questions:

1. Do the online discussions among the students in the experimental group make a significant difference in the achievement scores obtained from the Problems Developed for Collaborative Problem Solving Skills (IPCPS)?
2. Has there been an improvement in collaborative problem-solving skills assessed based on the Collaborative Problem-Solving Skills Grading Key (CPSSGK) in the experimental group because of the experimental study?
3. Are the students in the experimental group competent in giving feedback before the training? How is the peer feedback practice from the perspective of the students in the experimental group after the training?

2. METHOD

2.1. Study Design

The research examining the effect of peer feedback given online on CPS skills was designed in a mixed model in which quantitative and qualitative data were handled together. The mixed model is a type of research in which qualitative elements and quantitative research approaches are combined to provide answers to the research question that will increase the depth of understanding and accuracy (Clark & Creswell, 2017). Experimental method with pretest-posttest control group was used to obtain quantitative data. Experimental designs are research designs that aim to discover cause and effect relationships between variables. In the pre-test-post-test control group studies, there are two groups, one control group and the other experimental group, which were created by unbiased assignment in order to keep extraneous variables under control. In both groups, the effect of the independent variable on the dependent variable is investigated by making measurements before and after the experiment (Karasar, 2018). With these measurements, in-group and between-group differences were analyzed. In order to obtain qualitative data, a questionnaire and interview form were applied to the students in the experimental group. The dependent variable of this study is CPS skills and success. The independent variable of the research is peer feedback in the four-week online CPS study applied to the experimental group.

2.2. Study Group

The study group consists of 32 randomly selected 6th-grade students who attended Şehit Onbaşı Ahmet Şükrü Karataş Boarding Middle School, Mehmet Akif Ersoy Middle School, and Bayraktar Middle School located in Karayazı district of Erzurum province during the 2021-2022 academic years. The purpose of focusing on 6th grade students as the study group in the research is that it is easier to acquire collaborative problem solving skills at an early age and that this skill to be acquired at an early age can be used in later years and in academic life. In addition, considering that the sample group in PISA 2015, in which collaborative problem solving skills were measured, was 15-year-old students, it is considered important to determine whether this skill is acquired at an earlier age (Karakuş, 2020; Türkeş Yazıcı, 2022). The students in the investigation group have been randomly assigned to 16 experimental and 16 control groups. Of the 16 students in the experimental group, nine were girls and seven were boys; eight were boarding students and eight were regular students. Of the 16 students in the control group, seven were girls and nine were boys; eight were boarding students and eight were receiving formal education. The students in the experimental and control groups were randomly divided into paired study groups, and the invariance of the groups was ensured throughout the implementation process. The interview form for collecting qualitative data was obtained by conducting one-on-one interviews with 16 volunteers who were part of the experimental group and willing to participate in the investigation.

2.3. Data Collection Tools

2.3.1. *Peer feedback survey*

The peer feedback survey was developed by the researcher to define students' ideas about what peer feedback is and their preferences and approaches to giving feedback. In the survey development process, a literature review was conducted first. Considering the information obtained because of the literature review, an item pool was created, and a draft survey was created by selecting items from the item pool. The draft of the prepared survey was presented to an expert in Turkish Language Teaching and an expert in Measurement and Evaluation in Education to ensure the content validity. The current version of the survey draft was prepared after it was reorganized by taking into account the feedback provided by the experts. The current version of the survey was administered to 12 students studying at the same grade level (6th grade) who could represent the study group. As a result of the pre-application, the survey was finalized by making the essential corrections on statements like self-confidence and being objective, which the students had difficulty in understanding. In the preliminary application, it was deemed appropriate to keep the questionnaire as a five-point scale by taking into account the students' ability to distinguish the difference between the scale scores, their academic levels and age groups (Büyüköztürk, 2005). In the light of the information obtained as a result of the pre-application, the questionnaire was developed as a five-point scale consisting of 14 items.

2.3.2. *CPS skill-based analytical rating scale (CPS-ARS)*

CPS-ARS was developed by Aydın (2020). Aydın (2020) used 19 sub-skill areas specific to intellectual and interpersonal skills as criteria in the rubric, adhering to the theoretical framework established in the ATC21S project. The social skills included in the scoring key were action, interaction, accomplishing a task /perseverance, response skills, audience awareness, compromise, self-assessment, shared memory, and responsibility initiative. Cognitive skills were organizing, goal-setting, resource allocation, uncertainty tolerance, open-mindedness, collecting pieces of information, regularity, regularity, rules, and hypotheses. In the behavioral indicators of these sub-skill areas, there were descriptions of behavioral indicators as 1-3 (low), 4-6 (medium), and 7-9 (high). In accordance with the problem situations and scope used in the investigation, the authors adapted the rubric to the study by taking expert beliefs from the 19 criteria developed by Aydın (2020) and using nine criteria specific to this study. In the adapted version of the grading rubric, under the social skills category, the skills of action, interaction, accomplishing a task/perseverance, responsiveness, audience awareness, compromise, and responsibility initiative were scored. Under the cognitive skills category, the students' CPS skills were scored using sub-skills of uncertainty tolerance and hypothesis.

2.3.3. *CPS skills enhanced problems (CPSEP)*

Semi-structured open-ended problems for collaborative problem solving skills were developed for the Information Technologies and Software course to be used in the research. The reason for developing semi-structured problems in the context of Information Technologies and Software course is that the course outcome is suitable for measuring collaborative problem solving skills and the researcher has the knowledge and skills that will be needed in the study process since he is an Information Technologies and Software teacher. Semi-structured open-ended problems require a limited number of solutions, rules and solutions to categorize the answers into scales. Due to the nature of the study, the semi-structured open-ended problems "Information and Technology Week Classroom Board" and "Creating Awareness of Fighting the Epidemic" were developed by the researcher and two Information Technologies and Software teachers, while Gülse's Story was inspired by the National Education 6th grade Information Technologies and Software book and made suitable for the study. In order to determine the appropriateness of the developed and adapted problems that make up the study,

the beliefs of an Information Technologies and Software expert, a Turkish language expert, and a Measurement and Evaluation expert were taken and the problems were finalized thanks to the formal and content improvement feedback. In the first and fourth weeks of the study, the same problems were used in both the experimental and control groups, while in the second and third weeks, two different problem situations were addressed in the experimental group. The answers given by the experimental and control group students to the problems were evaluated by the researcher and the measurement and evaluation specialist using a scoring key on a 15-point scale.

2.3.4. *Peer feedback interview form*

To obtain the qualitative data of the study, a semi-structured interview form developed by Özşavli (2017) was used. The peer feedback interview form developed by Özşavli (2017) consisted of 11 items. In the interview form developed by Özşavli, essential arrangements were made with the opinions of the Turkish teacher, the Information Technologies and Software teacher, and the Measurement and Evaluation expert, and at draft of the form was created. Based on expert opinions, the expressions in the items that made up the form were adapted to the age of the students. The current version of the draft interview form was applied to five students studying at the same grade level (6^{th} grade) who could represent the study group, and the comprehensibility of the statements was tested and the form was finalized after receiving expert opinion. The interview form, which was adapted for the study, was applied by interviewing 16 students in the experimental group one-on-one.

2.4. Data Collection

In the 21^{st} century, there are technological tools and environments for measuring complicated skill like CPS and analyzing feedback, one of its most important elements. However, the study was conducted out using technological tools and software in the classroom environment in order to increase the continuity of the study, to minimize the possibility of missing data, to include teacher observations in the process, to enable students to conduct pair group work in a healthier way and to record the data. As mentioned in Heller and Heller's (2010) study, teams of two people each were formed in the experimental and control groups due to the process would proceed more efficiently if computerized, audio and video recordings could be analyzed, and the increase in the number of people in the group would complicate the cooperation, interaction and communication structure. The research process covered a period of four weeks. The weekly sessions were conducted in two class hours, with 20 minutes allocated for the solution generation phase and 60 minutes for students to participate in online discussions and provide feedback to their peers. In the research process, Ethics Committee Approval, Application Permission Certificate from the Provincial Directorate of National Education, and essential permissions with the Parental Informed Consent Form were obtained due to the participants of the research being under the age of 18.

2.5. Data Analysis

With the GPower program, the sample size required for non-parametric tests at 80% power with a margin of error of .05 was calculated as at least 14 people in both groups. The minimum sample size required for parametric tests was 21 people in each group. The sample size reached in the investigation was 16 people for both groups. In this context, it has been evaluated that the sample is sufficient for non-parametric tests. Moreover, based on the available sample sizes and the mean and standard deviation values for the dependent variable, the power value calculated for different non-parametric statistical tests ranges between 91% and 100%. This points to the accuracy and reliability of the decisions to be taken based on the data obtained. The data obtained qualitatively by analyzing the audio recordings and videos; audio recordings, video recordings and written documents obtained with the Peer Feedback Survey, CPS-ARS,

Peer Feedback Interview Form and Pre-test Post-test were quantitatively analyzed quantitatively by using various descriptive statistics with the SPSS 25 package program. In the analyses, .05 was accepted as the significance level. Cohen's effect size was calculated for statistically significant results. In the interpretation of this value, a d value of less than 0.2 means a weak effect size, 0.5 means a medium effect size, and greater than 0.8 means a large effect size (Kılıç, 2014). To answer the first sub-objective of the study, "whether online discussions among students in the experimental group create a significant difference in achievement scores obtained from the CPSEP," the descriptive statistics results of the achievement scores obtained from the problem-solving tasks developed for CPS for the experimental and control group students are presented in Table 1. To answer the second sub-objective of the study, "whether there is an improvement in CPS skills evaluated based on the CPS-ARS in the experimental group after the experimental study," the descriptive statistics results of the CPS skill scores obtained from the CPS-ARS for the experimental and control group students are also presented in Table 1.

Table 1. *CPSEP and CPS-ARS descriptive statistics results of achievement scores.*

			N	x̄	Median	Mode	Kurtosis	Skewness
CPSEP Achievement Scores	Experimental Group	Pre-test	16	5.87	6.00	5.00	-1.10	-0.15
		Post-test	16	12.87	12.50	12.00	-0.24	0.99
	Control Group	Pre-test	16	6.87	7.00	5.00	-1.23	-0.85
		Post-test	16	5.37	5.00	3.00	-0.95	0.43
CPS-ARS Achievement Scores	Experimental Group	Pre-test	16	27.37	27.50	30.00	1.23	0.70
		Post-test	16	44.69	45.00	40.00	-0.94	-0.57
	Control Group	Pre-test	16	24.81	25.00	28.00	0.59	-0.13
		Post-test	16	23.25	23.50	17.00	-1.17	-0.01

When Table 1 is examined, owing to the fact that the arithmetic means and median values of the scores obtained are quite close to each other indicates that the data are normally distributed. When the kurtosis and skewness values of the obtained scores are analyzed, it is seen that the values are generally between -1 and +1. However, since the kurtosis values of the experimental group pretest scores and the control group pretest scores were greater than 1 and the group size was less than 21 (the number required for the minimum power calculated according to the Gpower program), they were analyzed using the Wilcoxon Signed Ranks Test. In addition, to determine whether there was a difference between the pre-test mean scores of the students in the experimental and control groups and whether there was a difference between the post-test mean scores of the students in the experimental and control groups, the Mann Whitney U Test was used since the parametric test assumptions were not met and the groups were independent of each other.

To examine the third sub-objective of the study, "Are the students in the experimental group competent in giving feedback before the training?", the responses to the peer feedback survey were analyzed by descriptive analysis. Furthermore, data obtained from the peer feedback interview form were analyzed using a descriptive analysis method to obtain the opinions of the students in the experimental group on peer feedback application after education, and the opinions of the students are included in the analysis.

3. RESULTS

3.1. The Effect of Online Discussions among the Students in the Experimental Group on Achievement Scores Obtained from the CPSEP

The results that the students in the experimental and control groups obtained from the problems developed for CPS skills before and after the application are given in Table 2.

Table 2. *Results of pretest - posttest scores by group.*

	Group	N	Rank Mean	Rank Total	U	*p*
Pre-test	Experimental	16	15.00	240.00	104	.36
	Control	16	18.00	288.00		
Post-test	Experimental	16	24.50	392.00	000	.00
	Control	16	8.50	136.00		

As seen in Table 2, the results of the analysis show that there is no significant difference between the mean ranks of the pretest scores of the experimental and control group students (U=104, $p>.05$). When the rank averages are taken into consideration, it is seen that there is no significant difference between the achievement scores of the students who will and will not participate in the program in which the effect of peer feedback on CPS is examined.

The results of the analysis in Table 2 show that there is a statistically significant difference in the mean ranks of the posttest scores of the experimental and control group students (U=000, $p<.05$). Considering the mean ranks, it was found that the students who participated in the program in which the effect of peer feedback on CPS was examined had higher mean ranks than the students who did not participate. The detected effect size was r=0.86, indicating a large effect and explaining 73% of the total variance (Cohen, 1992). This finding demonstrates the effectiveness of peer feedback in CPS as the experimental procedure applied. The results of the students in the experimental and control groups from the problems developed for CPS skills before and after the application are given in Table 3.

Table 3. *Results of experimental and control group pretest - posttest scores.*

	Pre-test- Post-test	N	Rank Mean	Rank Total	z	*p*
Experimental	Negative Rank	16	8.50	136.00	3.53*	.00
	Positive Rank	0	.00	.00		
	Equal	0				
Control	Negative Rank	2	2.50	5.00	1.848*	.066
	Positive Rank	6	5.17	31.00		
	Equal	8				

* *Based on negative ranks*

The findings presented in Table 3 reveal a significant difference in pretest and posttest scores for the students in the experimental group who took part in the intervention. (z=3.53, $p<.05$). When results are taken into consideration, it is seen that this observed difference is in favor of the negative ranks, that is, the posttest. The magnitude of this difference is r=0.89, the difference has a large effect and explains 79% of the total variance (Cohen, 1992). Based on these findings, it can be said that the program in which the effect of peer feedback on CPS was examined had a significant effect on improving the achievement scores of the experimental group students.

The analysis results in Table 3 indicate that there is no significant difference between the pretest and posttest scores of the control group students who participated in the investigation (z=1.85,

p>.05). Based on these findings, it is seen that there is no significant difference between the achievement test scores of the control group students who did not participate in the program in which the effect of peer feedback on CPS was examined.

3.2. Improvement in Cooperative Problem Solving Skills Based on CPS-ARS in the Experimental Group

The results of the scores they received from the longitudinal rubric developed for CPS skills in the first and last applications of the study are given in Table 4.

Table 4. *Test results of pretest - posttest scores by group.*

	Group	N	Rank Mean	Row Total	U	*p*
Pre-test	Experimental	16	18.09	289.50	102.50	.34
	Control	16	14.91	238.50		
Post-test	Experimental	16	24.2	387.50	4.50	.00
	Control	16	8.78	140.50		

As seen in Table 4, the results of the analysis show that there is no significant difference between the mean ranks of the pretest scores of the experimental and control group students (U=102.50, *p*>.05). When the rank averages are taken into account, it is seen that there is no significant difference between the level of development of CPS skills of the students who participated in the program in which the effect of peer feedback on CPS was examined and those who did not.

According to Table 4, the results of the analysis show that there is a significant difference between the mean ranks of the posttest scores of the experimental and control group students (U=000, *p*<.05). Considering the mean ranks, it was determined that the students who participated in the program in which the effect of peer feedback on CPS was examined (387.50) had a higher mean rank than the students who did not participate (140.50). The magnitude of this difference was r=0.82, the difference had a large effect and explained 67% of the total variance (Cohen, 1992). According to the results of the longitudinal rubric based on CPS skills, the program contributed to the development of the CPS skills of the students in the experimental group. The results of the students in the experimental and control groups on the longitudinal rubric developed for CPS skills before and after the application are given in Table 5.

Table 5. *Test results of experimental and control group pretest - posttest scores.*

	Pretest – Posttest	N	Rank Mean	Rank Total	z	*p*
Experimental	Negative Rank	16	8.50	136.00	3.517*	.00
	Positive Rank	0	.00	.00		
	Equal	0				
Control	Negative Rank	6	8.17	49.00	-.785	.43
	Positive Rank	6	4.87	29.00		
	Equal	4				

** Based on negative ranks*

The analysis results in Table 5 show that the experimental group students who participated in the application there was a significant difference between the pretest and posttest scores (z=3.52, *p*<.05). When the results are considered, it is seen that this difference is in favor of the posttest, that is, the negative ranks. It is seen that the magnitude of this difference is r=0.88, the difference has a large effect and explains 77% of the total variance (Cohen, 1992). Based on these findings, it can be said that the program in which the effect of peer feedback on CPS was

examined had a significant effect on the development of CPS skills of the experimental group students.

The analysis results in Table 5 show that there is no significant difference between the pretest and posttest scores of the control group students who participated in the intervention (z= -.79, p>.05). Based on these findings, it is seen that there is no significant difference in the CPS skills of the control group students who did not participate in the program in which the effect of peer feedback on CPS was examined.

3.3. Experimental Group Students' Efficiency in Giving Feedback and Their Opinions on Post-Training Peer Feedback Practice

Table 6 presents the descriptive results of the answers given by the students participating in the investigation to the survey questions about peer feedback before the experimental study.

Table 6. *Peer feedback survey descriptive analysis results.*

Item	Mean	Mode	Median	Standard Deviation
1	3.33	5	4	1.68
2	3.87	5	5	1.10
3	2.67	1	2	1.63
4	3.40	3	3	1.24
5	3.80	5	5	1.82
6	3.33	3	3	1.05
7	3.53	2	4	1.25
8	3.93	4	4	0.96
9	3.07	2	3	1.39
10	2.33	1	1	1.80
11	2.87	2	2	1.46
12	3.60	5	4	1.45
13	2.47	3	3	1.06
14	2.93	3	3	1.34

According to the results of the descriptive analysis in Table 6, the item with the highest mean score is item 2 (I feel nervous if I receive especially negative comments from my teachers), while the item with the lowest mean score is item 10 (I do not take my classmates' feedback seriously). According to the second item, it is understood that teachers' comments are very effective on students. In item 10, it is understood that they care about their classmates' feedback. However, they also stated that their friends' feedback was superficial (I8: My classmates' feedback is superficial). The mean of item 8 was found to be 3.93. It is also the item to which the students gave the most homogeneous response among all statements (sd: 0.961).

In the investigation, the Peer Feedback Interview Form (PFIF) was applied to learn the opinions of the students participating in the investigation about the peer feedback activity they carried out during the process. The Peer Feedback Interview Form was created by making some changes in the semi-structured interview form consisting of 11 open-ended items developed by Özşavli (2017). The four categories that stand out from the student opinions obtained through the semi-structured interview form are presented below.

a) Benefits of Peer Feedback: The opinions of the student coded E2, who thinks that it contributed to helping and solution-oriented thinking, are presented below:
E2: *"Yes, it was useful, and I experienced the feeling of helping them. Yes, it made me work solution-oriented."*

b) Contribution of Peer Feedback to the Development of Various Skills: The opinions of the student coded I, who thinks that it improves communication skills, are presented below:
I: *"Seeing my own mistakes affected my success positively. I did not have much contact with my friends, now I started to have more contact, I talked and communicated more with my groupmate, and I did not have much communication with my other friends, now I am better."*
c) The Contribution of Peer Feedback to IPC Skills: The opinions of the student coded H, who thought that it contributed to taking responsibility, are presented below:
H: *"While we were avoiding our responsibilities before the study, now we are trying to take responsibility with my groupmate. I think I have improved socially."*
d) Problems Experienced During Peer Feedback: The opinions of the student coded G, who stated that he had difficulty in going beyond his own perspective and not being open to other ideas, are presented below:
G: *"Yes, while evaluating my friends' work, I had difficulty both in going beyond my own viewpoint of view and in understanding my friends' points of view."*

In order to learn the opinions of the experimental group students participating in the investigation on peer feedback, the data obtained from the peer feedback survey before the application and the peer feedback interview form after the application were analyzed. According to the data obtained from the survey used before the implementation, students generally stated that receiving feedback increased their self-confidence, while according to the comments obtained from the post-implementation interview form, all students agreed that peer feedback increased their self-confidence. According to the peer feedback survey data, while there were students who thought that receiving peer feedback was superficial before the intervention, and after the intervention, all students stated that they took their peers' feedback into consideration and that the feedback contributed to them in many ways. According to the peer feedback survey data before the intervention, very few students thought that feedback from their peers would facilitate their learning and contribute to better learning, while after the intervention, all students stated that peer feedback was useful for their learning and improved their CPS skills in various ways.

4. DISCUSSION and CONCLUSION

In this study, two different data collection tools were used to examine the effect of peer feedback on CPS skills. When the data obtained because of the longitudinal rubric to gauge CPS skills and the answers given to the problems to gauge CPS skills were analyzed, it was seen that peer feedback had a significant effect on CPSs.

In the pretest results applied to the experimental and control groups, it was observed that there was no difference among the achievement scores of the students, but the achievement scores of the experimental group students who had online discussions for four weeks increased significantly, whereas there was no significant change in the achievement scores of the control group. This result may be evidence that students' feedback to each other in a study environment where there is no teacher feedback is effective in increasing achievement scores. This finding is consistent with the findings of Gu et al. (2015). Gu et al. (2015) stated that students tend to conduct research for reasons like seeking new information, clarifying their ideas, and justifying themselves in CPS studies, which enables students to realize new learning in the investigation process and increase their academic achievement. Schwartz (1995) stated that different problem-solving tasks improved problem-solving skills in collaborative groups. Additionally, many findings have been found that cooperative learning, which forms the basis of cooperative problem-solving, increases success (Açıkgöz, 1990; Baykara, 2000; Bonner et al., 2002; Genç, 2007; Kneivel et al., 2003). When the longitudinal rubric data on CPS skills based on the scoring of the communication of the experimental and control groups while working in pairs were analyzed, it was observed that while there was no difference among the scores of the two

groups in the pretest study, a notable rise was observed in the achievement scores obtained from the rubric of the experimental group students who received feedback from both their groupmates and their peers who participated in the online discussion for four weeks during the CPS process. According to this result, online discussions and feedback improved students' social and cognitive CPS skills.

When the findings were evaluated in general, there was no significant difference among the CPS skills of the students in the experimental and control groups before the implementation. According to the posttest results conducted after the implementation process, there was a positive development in the CPS skills of the experimental group students who received peer feedback and participated in online discussions. In addition, there was no improvement in the CPS skills of the students in the control group. Some studies in the literature (Bulu & Pedersan, 2012; Ge & Land, 2003; Karakuş, 2020; Wegerif, 2006) also support this finding. According to these studies, as students face complicated cognitive, metacognitive, and strategic challenges during the solution of a collaborative problem, students stated that their CPS skills like organizing and retrieving information, modeling, and monitoring solutions, presenting persuasive ideas, evaluating and reflecting improved (Bulu & Pedersan, 2012; Ge & Land, 2003; Karakuş, 2020; Wegerif, 2006). In their study, Atar and Yavuz (2020) stated that Turkish students' CPS competencies can be improved through various applications. Accordingly, the OECD (2013) states that students' problem-solving competence can be improved through a high-quality education process. In this context, it is thought that it is important to design the educational environments and processes for developing these skills. According to the findings obtained from the post-intervention interview form, all students stated that peer feedback increased their self-confidence, was useful for their learning, and improved their CPS skills in various aspects. It was concluded that there was a positive change in the students' views on peer feedback before and after the application and that the feedback they received from their peers was critical in CPS skills.

According to the peer feedback survey data before the implementation, very few students thought that feedback from their peers would facilitate their learning and contribute to better learning, while after the implementation, all students stated that peer feedback was useful for their learning and improved their CPS skills in various ways. It was determined that the findings obtained from the interviews with the students were generally consistent with the findings obtained because of the studies conducted in the literature. Carnell's (2000) interviews with students showed that they liked receiving peer feedback. They stated that talking to friends was easier than talking to a teacher, that they felt freer when talking to their friends, and that they could say what they wanted. Ur (1996) found that students appreciated being consulted and often made a serious effort to give feedback. Smith and Tillema (2000) and Gijbels et al. (2008) found that students had positive attitudes toward receiving feedback and found it effective for their learning. In a study conducted in Hong Kong, those who reviewed their peers' texts reported that this inspired them to write their own essays (Berggren, 2015). In this context, it can be stated that student views on peer feedback overlap with the views in the related literature.

Based on the results obtained, some suggestions for researchers and practice are presented: i) Peer feedback can be integrated into the entire learning process as it improves students' affective skills like criticism, respecting different perspectives, defending their ideas in front of the community, and self-expression; ii) since it was found that students' CPS competencies can be improved through various practices, it is recommended that the educational environments and the process offered to students should be designed for developing these skills; iii) students can be trained in giving advanced feedback as it was shown that students were not at a sufficient level in giving advanced feedback, and feedback was effective in increasing achievement scores. In addition, other researchers can i) examine the differences among the achievement

scores, CPS skills, and feedback-giving skills of students working with virtual and peer collaborators, ii) study the differences among students' achievement scores when solving problems individually and when solving problems collaboratively, iii) examine the relationship among CPS skills and the time students spend solving the problem, iv) the effect of peer feedback on collaborative problem solving skills can be examined in larger samples, in different courses, with students from different age groups and educational levels.

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Declaration of Conflicting Interests and Ethics

The authors declare no conflict of interest. This research study complies with research publishing ethics. The scientific and legal responsibility for manuscripts published in IJATE belongs to the authors. **Ethics Committee Number**: Ankara University, 31.05.2021, 10/221.

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