

Investigation of the Blended Programming Learning Community of Teachers Öğretmenlerin Harmanlanmış Programlama Öğrenme Topluluğunun İncelenmesi

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Makale Bilgileri

Geliş Tarihi (Received)

03.11.2025

Kabul Tarihi (Accepted)

03.03.2026

Yayınlanma Tarihi (Published)

21.04.2026

*Sorumlu Yazar

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Abstract: With the development of technologies, learning programming has become increasingly critical in every aspect of our lives. Every teacher needs to learn programming to use it in their lessons. For this reason, researchers established a community of inquiry consisting of teachers, and teachers were enabled to learn programming using blended learning environments. A qualitative case study design was adopted in this research. The study group consisted of 18 teachers. Data was collected through multiple sources, including interview forms, reflective reports, lecture video recordings, instant messaging exchanges, and forum discussion records. The collected data were analyzed using content analysis, a widely employed method in qualitative research. Results revealed that indicators of cognitive presence, including defining the problem, exchanging information, creating solutions, and making applications, were identified. It was concluded that teachers' self-disclosure behaviors and their continued discussion and addressing of the group are the leading indicators of social presence. Indicators related to the categories of teaching presence, such as utilizing the environment effectively, facilitating discussion, and consolidating learning through evaluation and explanatory feedback, have been identified. The indicators revealed within the scope of the research were discussed based on the literature, and suggestions were made for programming education, blended learning, and the community of inquiry. The social, cognitive, and teaching presence indicators revealed within the scope of this study will guide future research on programming education and contribute to theoretical and applied studies based on the community of inquiry in blended learning environments.

Keywords: Community of inquiry, programming education, blended learning, teacher education

Öz: Teknolojinin gelişmesiyle birlikte programlama öğrenmek hayatımızın her alanında giderek daha önemli hale gelmiştir. Her öğretmenin derslerinde kullanılabilmesi için programlama öğrenmesi gerekmektedir. Bu nedenle öğretmenlerden oluşan bir araştırma topluluğu kurulmuş ve öğretmenlerin harmanlanmış öğrenme ortamlarını kullanarak programlama öğrenmeleri sağlanmıştır. Bu çalışmada nitel araştırma modellerinden biri olan durum çalışması deseni tercih edilmiştir. Araştırma grubu 18 öğretmenden oluşmaktadır. Çalışmanın verileri görüşme formu, yansıtıcı raporlar, ders video kayıtları, anlık mesajlaşma ve forum mesajlaşma kayıtları aracılığıyla toplanmıştır. Katılımcılardan elde edilen veriler nitel veri analiz yöntemlerinden biri olan içerik analizi yöntemi kullanılarak analiz edilmiştir. Veri analizi sonucunda problemi tanımlama, bilgi alışverişinde bulunma, çözüm üretme ve uygulama yapma gibi bilişsel bulunuşluğun göstergeleri belirlenmiştir. Öğretmenlerin kendini açma davranışları ve grupla sürekli tartışma ve hitap etmelerinin sosyal bulunuşluğun önde gelen göstergeleri olduğu sonucuna varılmıştır. Ortamı etkili bir şekilde kullanma, tartışmayı kolaylaştırma, değerlendirme ve açıklayıcı geri bildirim yoluyla öğrenmeyi pekiştirme gibi öğretimsel bulunuşluk kategorileriyle ilgili göstergeler belirlenmiştir. Araştırma kapsamında ortaya konulan göstergeler ilgili alanyazına dayalı olarak tartışılmış, programlama eğitimi, karma öğrenme ve araştırma topluluğu için önerilerde bulunulmuştur. Bu çalışma kapsamında ortaya konulan sosyal, bilişsel ve öğretimsel bulunuşluk göstergelerinin, programlama eğitimi üzerine yapılacak gelecekteki araştırmalara rehberlik edeceği ve harmanlanmış öğrenme ortamlarında araştırma topluluğuna dayalı teorik ve uygulamalı çalışmalara katkı sağlayacağı düşünülmektedir.

Anahtar Kelimeler: Araştırma topluluğu, programlama eğitimi, harmanlanmış öğrenme, öğretmen eğitimi

Dikmen, C. H. & Ocak, M. A., (2026). Investigation of the blended programming learning community of teachers. *Erzincan Üniversitesi Eğitim Fakültesi Dergisi*, 28(2026), 1-11. <https://doi.org/10.17556/erziefd.1816285>

Introduction

Nowadays, anything has become programmable due to technological advances and programming knowledge directed to production instead of consumption is now seen as a necessity. Teachers play an essential role in providing students with programming skills. For this reason, programming training is also offered to teachers. In the programming training, participants are expected to develop a product to solve any problem. In this context, it is thought that it will be essential to structure information in a social environment and to realize inquiry-based learning in programming training. Different tools can also be used in face-to-face and online environments to ensure collaborative learning activities in the community of inquiry (COI). Blended learning environments (BLEs) allow these tools to be used in harmony. For this reason, designing and evaluating a programming education for teachers in a blended learning environment (BLE) by a research-based learning strategy will be beneficial for disseminating programming education.

Many studies, such as Scratch, AppInventor, code.org, and hourofcode.com, are carried out to popularize programming education worldwide. Likewise, it is observed that most European countries have integrated programming education into their curricula to provide students with logical thinking, problem-solving, programming, and other vital skills (Balanskat & Engelhardt, 2015; Sampson, Kamylyis, Moreno-Leon, & Bocconi, 2025).

In Turkey, the Ministry of National Education also organizes training on block-based programming tools through the Educational Informatics Network to provide programming skills to every student. Access to Scratch, Alice, and Blockly Games training can be supplied from the coding section on the website. These trainings provide essential skills for block-based programming.

It is seen that programming skills are generally acquired at the level of knowledge, comprehension, and application in programming training. However, these skills can only be acquired at the analysis, synthesis, and evaluation level if the

learning environment is designed according to the constructivist approach. Developing students' digital literacy, spatial thinking, problem-solving, and analytical thinking skills as carrying out projects and collaborative studies is possible if teachers' programming teaching processes are well structured (Kalelioğlu, 2018). Duffy and Cunningham (1996) state that knowledge occurs in the individual's social interactions, that learning processes include acculturation in the community of practice, and that learning occurs through psychosocial and cultural processes. To achieve learning this way, micro world and hypermedia designs, collaborative learning, goal-based scenarios, problem-based learning, software, and course management tools are used as teaching methods (Driscoll, 2005).

BLEs enable learning management systems and collaborative teaching methods to be used effectively and harmoniously. According to Graham (2006), BLEs are formed using face-to-face learning and computer-supported learning environments simultaneously or asynchronously. Face-to-face learning environments and distance learning environments have various advantages and disadvantages. Although online education has its benefits, it leads to a decrease in physical interaction and social communication among students and between students and teachers (Adigun, Mpofu, & Maphalala, 2025). BLEs are used to benefit from the good aspects of face-to-face and distance learning environments.

BLEs enable individuals in the research community to learn collaboratively. For this reason, it is thought that the COI model (Figure 1) (Garrison, Anderson, & Archer, 1999), based on constructivist theory and collaborative learning method, will help explain the extent to which blended learning occurs.

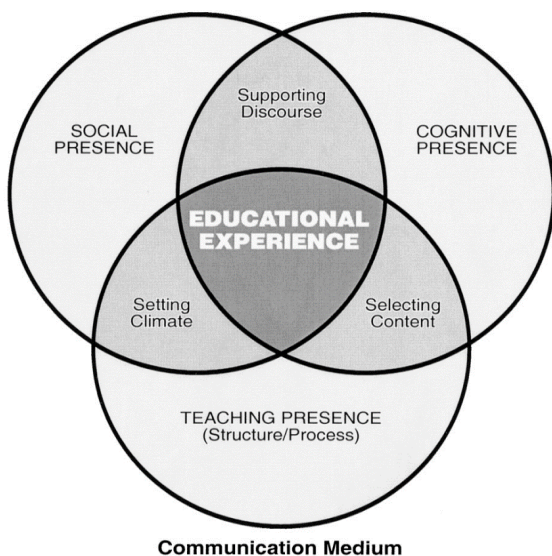


Figure 1. COI model (Garrison, Anderson, & Archer, 1999)

The COI model consists of components of social presence, cognitive presence, and teaching presence (Garrison et al., 1999). The educational experience at the core of these components supports connection and collaboration among learners. A COI creates a learning environment that integrates social, cognitive, and instructional components and accelerates and sustains critical thinking and discussions. BLEs allow creating and maintaining a COI beyond the classroom (Garrison & Vaughan, 2008, p.8). However, despite the existence of previous studies on online learning communities, it is difficult to find applicable research on the dynamics of learning communities in BLEs (Hanson & Clem, 2006). In the COI studies conducted in BLEs, only social, cognitive, and teaching presence indicators in online learning environments

are examined (Akyol & Garrison, 2011; Akyol, Garrison, & Özden, 2009; Öztürk, 2015; So & Brush, 2008; Wicks, Craft, Mason, Gritter, & Bolding, 2015). For this reason, it is thought that the COI studies conducted in BLEs ignore the fact that there may be different indicators in the face-to-face learning process.

In this context, considering the differences between face-to-face and online learning environments, examining the social, cognitive, and teaching presences of individuals participating in programming education designed using the COI framework in BLE will make a significant contribution to the field. Therefore, this study aims to conduct an in-depth examination of the social, cognitive, and instructional aspects of teachers participating in BLE programming education.

The primary purpose of this study is to examine the social, cognitive, and teaching presence of teachers who participate in programming training in a BLE. For this purpose, the study sought answers to the following research questions:

- What are the indicators of the cognitive presence levels of programming training participants in the BLE?
- What are the indicators of the social presence levels of programming training participants in the BLE?
- What are the indicators of the teaching presence levels of programming training participants in the BLE?

Method

In this study, designed, implemented, and evaluated a programming training for teachers with the blended learning method based on the COI framework, the case study design, was employed. It is stated that those who use qualitative research methods interpret the events in their natural environments according to the meanings people give to the events (Denzin & Lincoln, 2011). The case study design is a qualitative research approach in which researchers use multiple data sources to collect detailed and in-depth information about real life, a specific situation, or situations in a certain period, describe the situation, or reveal themes related to the situation (Creswell, 2013). Since this study aims to examine the social, cognitive, and teaching presence of teachers participating in programming training in the BLE to understand them better, the case study design is thought to be the most appropriate research design.

After determining the theoretical framework during the research process, the most appropriate design was decided according to the research problem, and the study group was determined. Within the scope of the study, programming instruction carried out in a BLE was designed. Morrison, Ross, and Kemp's (2007) model was used in designing the teaching system. This model was preferred as it is suitable for the constructivist approach with its flexible structure and for designing a learning environment for programming education.

After developing data collection tools, necessary permissions were obtained to conduct the application and collect data. Within the scope of the research, data were collected during the programming training process and at the end of the process. The analysis of the collected data was carried out based on the theoretical framework. In order to ensure the objectivity, reliability, and validity of the research, the steps specified by Miles and Huberman (1994) regarding drawing and verifying conclusions were followed. To ensure the reliability of the research, the opinions of four experts in the field of computer education and instructional technologies were consulted, the role of the researcher was clearly defined, and the quality of the data and coding was checked. In order to

ensure the validity of the research, the meaningfulness and consistency of the findings were examined, and different data sources and data collection methods were used. It has been confirmed that the research findings are consistent, connected, and compatible with the theoretical framework. After the reliability and validity studies were completed, the research findings were interpreted, and the research process was concluded by discussing the related theoretical frameworks.

Role Of the Researcher

In this case study, the researcher who designs the learning environment and carries out the programming training has a participatory role. The researcher, as an instructional designer and educator, did not intervene in the data during the data collection process. To ensure reliability and validity, the researcher analyzed the data solely based on the collected information, presented their findings, and then added their own interpretations.

Participants

The teachers who will participate in the research study group were determined using the convenience sampling method. The convenience sampling method allows the researcher to choose a situation that is close and easy to access (Patton, 1987, p. 58). In this research, the convenience sampling method was preferred because the situation was close and easy to access. In order to determine the study group of the research, an announcement was made about the programming training offered within the scope of the research to primary, secondary, and high schools in the Dinar district of Afyonkarahisar province. Fifty teachers applied for the training, and 39 teachers attended the information meeting about the training. At the information meeting, teachers were given detailed information about the content of the training and how it would be carried out. After the information meeting, the working group comprised 18 teachers who voluntarily wanted to participate in programming training. Information about the study group is given in Table 1.

Table 1. Demographic variables

		Frequency (f)
Branch	Primary school teachers (PRI)	7
	Computer education and instructional technology teachers (COM)	3
	Mathematics teachers (MAT)	2
	Science teachers (SCI)	2
	Technology and design teachers (TEC)	2
	Electricity teacher (ELC)	1
	Physics teacher (PHY)	1
Gender	Female	5
	Male	13
Educational Status	Undergraduate	16
	Graduate	2
School	Primary	7
	Secondary	8
	High School	3
Age Groups	25-30	5
	31-35	8
	36 years and above	5
	Total	18

Data Collection Instruments

Within the scope of the research, more than one data collection tool was used to ensure the validity of the data and the accuracy of the results obtained. According to Creswell (2013), in a good case study, it is necessary to provide an in-depth

understanding of the situation using various data sources. It is thought that more reliable results regarding the situation or situations will emerge based on the findings obtained by analyzing the data obtained using various data collection tools. In order to ensure diversity in this context, interviews, observations, and document reviews were used as data collection methods. Interview forms, reflective reports, lecture video recordings, instant messaging, and forum messaging records were determined as data collection tools.

The Interview Form

The interview form (Appendix 1) used as a data collection tool within the scope of the research was created by using the inquiry communities model interview form (Reisoğlu, 2014) in order to determine the opinions of the teachers who participated in the programming training regarding their social, cognitive and teaching presence in the BLE. In order to ensure the reliability and validity of the interview form, the opinions of four experts in computer and instructional technologies education were consulted. Experts stated that the interview form was suitable after making the necessary arrangements. The interview form was prepared in line with the opinions of field experts. While the interview form was being administered to the participants, a voice recording was made with the participants' permission. All programming training participants (f = 18) participated in the interviews. Interview times are approximately 20 minutes. After the interviews were completed, the researcher transcribed the audio recordings. While the interview form was being administered to the participants, a voice recording was made with the participants' permission. All programming training participants (f = 18) participated in the interviews. Interview times are approximately 20 minutes. After the interviews were completed, the researcher transcribed the audio recordings. To ensure reliability and validity, transcripts were confirmed with participants.

Reflecting Thinking Reports

The participants wrote a reflective thinking report at the end of each unit and uploaded it to the system to determine the participant's experiences in the programming education process. A total of 33 reflective reports have been uploaded to the system. Participants benefited from the reflection cycle (Gibbs, 1988), which involved writing reflective reports and expressing their thoughts about programming education. According to the reflection cycle, the reflective report should include a description, emotions, evaluation, analysis, conclusion, and action plan. During the reflection process, participants are expected to indicate:

- Definition: A definition should be made that explains precisely what the event is.
- Emotions: It should be explained exactly what was felt during the incident.
- Evaluation: The experiences gained should be evaluated with their good and bad aspects.
- Analysis: The current situation should be analyzed by separating it into its components.
- Conclusion: A synthesis of what has been learned during the experience should be made, and what else can be done should be stated.
- Action Plan: Information should be given about what to do if the incident occurs again.

In-Laboratory Camera

During face-to-face lessons, a camera was used as a data collection tool. A total of 11 hours and 29 minutes of lesson video recordings obtained with the camera were transcribed by the researcher. As some situations due to the angle of view cannot be observed clearly and the sound cannot be heard in the lecture video recordings, the reliability of the lecture video recordings was ensured by having the participants confirm it.

Synchronous And Asynchronous Message Recordings

Data on participants' synchronous and asynchronous conversations were collected through instant messaging software and the learning management system's forum. A guide on using the forum has been prepared and presented under the title of using the sharing forum on the course main screen in the learning management system. Instant messaging records were transcribed through the program, and forum messaging records were copied through the system. Instant messaging and forum messaging records, face-to-face lecture video recordings, interview recordings, and reflective reports were prepared for data analysis using RQDA software.

Instructional Design Process

Within the scope of this study, in which the social, cognitive, and teaching presence of teachers were examined, a programming teaching method was designed in a BLE. Morrison, Ross, and Kemp's (2007) model was used in designing the teaching system. This model was preferred because it is suitable for the constructivist approach with its flexible structure and for designing a learning environment for programming education.

The instructional design process determined teachers' in-service teaching needs, and learner and context analysis was conducted. After task analysis, teaching objectives were determined. After the course contents were sorted, teaching strategies were determined by considering Posner and Strike's (1976) ranking schemes for learning and concepts.

While designing the learning environment, attention was paid to participants' cognitive load, visual hierarchy, balance, integrity, and color harmony. While designing the message, the learning hierarchy, learner characteristics, and participants' prior knowledge were also considered.

In the message design of presentations made in the classroom and course contents in the online environment, it has been ensured that the texts and visuals are suitable for learning. The information is concretized and logically organized, and visuals and videos support the information given through texts. Care has been taken to ensure that the messages in the video course content are short and clear and have information related to the subject's essence through the demonstration technique.

A computer laboratory was used to carry out classroom applications of the BLE, and the Moodle learning management system was used to carry out online applications and ensure communication.

One week before the training started, the participants were informed in the laboratory environment about the training and its achievements through the learning management system, and their opinions were received before the training. In the first week of the training, the installation of the necessary software and drivers, the circuit elements of the microcontroller development board to be used, and fundamental electronics issues were discussed online. After studying programming language topics face to face and online for two weeks, the

participants conducted microcontroller applications in a laboratory environment for three weeks. After completing the microcontroller applications topic, the participants developed the project online within seven weeks and made their project presentations in the laboratory environment last week. Thus, the participants completed 13 weeks of theoretical and practical programming training in a BLE.

During the evaluation process, participants were asked to participate in forum discussions about the project they developed and to report and present their projects. For this reason, the participants presented their projects in a face-to-face classroom environment and discussed them with other participants. In addition, the participants shared their project reports with other participants online and contributed to creating discussion environments about the projects in the online forum.

In this context, an evaluation was made during the process with the feedback given by the educator about the projects, and the final evaluation was carried out by providing a discussion environment regarding the results of the projects.

Data Analysis

Since the qualitative data obtained within the scope of the research needed to be examined in depth, the content analysis method was used. Berelson (1952, p. 18) defines content analysis as an objective, systematic, and quantitative explanation of the explicit content of the communication. Merriam (2009) stated the advantages of content analysis as follows:

- It provides an in-depth look at a situation not limited by existing perspectives or methods. Thus, it allows the discovery of new theories on the subject.
- Content analysis is highly effective when applicable models are not available as a basis for quantitative research projects.
- The observational approach allows the participants' opinions to be considered. This is noted to be impossible in the generalized view provided by quantitative research.

In this study, content analysis of the data collected with data collection tools was carried out by two coders who are experts in computer education and instructional technologies, with the help of RQDA software. Data were analyzed, and indicators were determined, considering the components and categories specified regarding the research community in BLEs within the theoretical framework. The analyses aim to identify the indicators and related codes for the cognitive presence, social presence, and teaching presence components within the COI framework, using a deductive approach. In order to ensure the reliability of the data analysis, a reliability study was conducted between the coders regarding the codes revealed by the coders and the themes determined based on the literature. To ensure reliability, the formula "reliability = number of consensus / (total consensus + total disagreement)" (Miles & Huberman, 1994, p.64) was used. As a result of the reliability study between the coders, the reliability rate was determined to be 84.04%. After the reliability study was carried out, control coding was done. Miles and Huberman (1994, p. 64) state that when performing control coding, researchers code the same data, examine each resulting result, and discuss them, providing more clarity to the definitions. In the study results, participants were named according to their branches.

Results

Cognitive Presence in Programming Education

As a result of the analysis of the data, codes related to cognitive presence in programming education given in the BLE were revealed. Indicators of cognitive presence in programming education: The activity was identified as triggering the event, discovery, integration, and analysis. Indicators related to cognitive presence are given in Table 2.

Table 2. Cognitive presence

Categories	Indicators
Triggering the event	Defining the problem, prior knowledge, curiosity, and enthusiasm for research.
Exploration	Information exchange, making recommendations, researching, investigating, divergent ideas, brainstorming.
Integration	Convergence of ideas, making connections between ideas, creating solutions
Resolution	Make applications, share application results, test solutions, and defend solutions.

Triggering The Event

In general, it is thought that the most motivating indicator for the participants in the programming training is that they encounter a problem and define the problem to initiate the cognitive activity. In the laboratory, COM3 said, *"The colors did not light up in the order written in the codes."* SC11 wrote on the forum, *"The codes in the application in the link did not work properly at first."* PHY1 in the instant messaging group: *"I tried to change the brightness of the three LEDs using a potentiometer, but there is no brightness decrease."* Thus, the participants identified their problems and took the first step to start learning in face-to-face and online learning environments.

Along with the observations made in the BLE, the participants expressed their opinions about the definition of the problem in the interviews and reflective reports they submitted, revealing the role of problem definition in initiating cognitive activity in programming education. In our interview, SC11 said, *"I first learned to learn where there was a problem. In other words, I tried to see where I made mistakes. Then, I tried not to repeat these mistakes."* Additionally, COM1's statements in the reflective reports summarize very well how the problem situation triggers learning. *"When I have a problem while doing a job, the uneasiness I experience will continue as long as I do not solve that problem."*

When participants start a cognitive activity, their prior knowledge about programming and the definition of the problem also affects them. In the interview records made with PRI1, *"I had a little difficulty because I had little prior knowledge and my training on this subject in previous years."* statement and SC11's reflective report: *"I knew some of the concepts due to my field of study, and I did not have difficulty in those parts. I had difficulty trying to understand some detailed concepts."* expressing herself as follows reveals the importance of prior knowledge when starting to learn.

Participants' curiosity also motivates them to initiate an activity related to programming. During the interviews, ELC1 said, *"We were not limited to what was given on the website. Our curiosity about the subject increased. With this curiosity, we went to different sites and did various research."* and TEC2 said, *"Everyone came here because they were curious about this job and everyone has an idea. Even the possibility of realizing these ideas, whether in our school or elsewhere, excited us and united us."* In addition, the statements in PRI7's reflective report, *"The curiosity and excitement I felt towards*

the subject constantly stimulated me." show how the sense of curiosity affects the participants' initiation of learning. It is understood from their expressions in the interviews and reports how the sense of curiosity in the participants regarding the programming training motivated them to start the activity. Participants state that they attended the training because they were curious about the subject, did research, and found the activities interesting and exciting. From these views, it is understood that the participants initiated programming-related activities with the motivation of curiosity.

Similar to the sense of curiosity, the enthusiasm for research enables participants to initiate an activity related to cognitive programming in face-to-face and online learning environments. The statements in COM1's reflective report, *"Right now, I want to investigate why the LED does not light up even though I have completed the circuit. I am stuck on this issue."* and during the interviews, TEC1 said, *"I think it is a productive study because we have friends who are willing to research and no one hides or withholds their knowledge from each other."* These statements show how the participants' enthusiasm for research motivates participants toward learning.

Exploration

Information exchange, recommendations, researching, investigating, divergent ideas, and brainstorming indicate the participants' exploration of programming education. Exploration indicators that show participants' cognitive presence were observed in BLEs. In addition, findings regarding these indicators were identified in the interviews with the participants and the participants' reflective reports.

As an example of information exchange, PSY1 established the electronic circuit in the laboratory environment by looking at PRI5. COM1 went among them and looked. *"What did you do, brother?"* he asked PRI5. When PRI5 gave information about the electronic circuit he prepared, COM1 said, *"Oh my God, you are like a monster."* Participants exchanged information by going to each other in the classroom, calling other participants to join them, or informing the class about a particular topic related to programming. In this way, participants carry out the process of cognitive exploration through information exchange. However, while MAT2 states that he learned how to get information from her friends, PRI7 states that she finally succeeded by consulting her friends with knowledge.

Participants frequently made recommendations while exchanging information during programming training. For example, ELC1 commented to COM1 about how he could use the electronic relay in his project. COM2 suggested by writing, *"Keep the top of the vehicle open and close it in rainy weather using the rain sensor:).".* These expressions are thought to support the indicator of making recommendations in the exploration process observed in the BLE.

In addition, it was found that the participants explored the topic by researching both in the laboratory and online environments. The best example is PRI4, which searched for tone codes online and found out which note was which. Additionally, it was determined that COM2, PRI3, PRI4, PRI5, and PSY1 stated that they conducted exploratory research. Participants stated that they were doing research supporting the role of the research indicator observed in the classroom and online environments in the exploration process.

The study's findings show that the participants also explored the topic through investigation. It was observed that all participants went to each other in the laboratory

environment and investigated their applications. However, in the interview with MAT1, he explained how he made the investigation: *"I took the information from my friends by using the method of observing and asking questions, and immediately went and applied it to myself."* In the PRI7 reflective report, *"Since I saw the parts in the Arduino set for the first time, I learned about parts and investigated them."* She wrote and stated how she made her investigation. From the participants' statements and observations, it is understood that investigating while learning programming-related issues in the COI is an essential indicator of the exploration process.

In addition, while the participants were exploring, they had divergent ideas on many issues and brainstormed on some issues. For example, in a problem encountered in electronic communication, PRI3, COM1, and COM3 brainstormed different ideas regarding using Bluetooth and IR. It was observed that the entire class examined the materials in the laboratory environment and thought about which materials they could use in which part of their projects. In addition, SCI2's statement in the forum discussion about plant irrigation systems that the water needs of each plant are different is an excellent example of this. However, in the interviews with the participants, COM1 and MAT1 stated that they had different opinions from time to time with other participants and that these contributed to their exploration. They also said they tried some applications with their PRI7 and SCI2 friends and brainstormed.

Integration

Cognitively exploring participants began converging ideas, establishing connections between ideas, and creating solutions due to divergent ideas and brainstorming. Thus, integration indicators regarding the cognitive presence of the participants were determined.

As an example of the convergence of ideas, during the brainstorming session about PRI5's cat feeding project in the laboratory environment, COM3 said that the card should be placed in a protected container so the cat cannot damage it. COM1 also said this idea could be possible and even placed in a box. Regarding establishing a connection between ideas, TEC1 stated that everyone gets another person's idea or opinion by sharing their ideas, the place they do not understand, or their work with the group, providing separate knowledge and experience.

Participants also created new solutions by making connections between ideas. For example, COM2 stated that they could improve the project by using a module for LCD and getting rid of the cable complexity. In the interviews, MAT1's determination that everyone saw each other's problems, participated in the discussion environment, and helped create solutions is an essential indicator of the indicator of producing solutions in the integration process.

Resolution

After other cognitive processes, participants' indicators, such as making applications, sharing application results, testing solutions, and defending solutions, were reached in the resolution phase. Participants generally conclude the programming activities they initiate in a cognitive sense by making applications. In this context, it was observed that the participants in the class developed applications to find solutions to the problems they encountered in programming education. SCI1 stated that she understood the issue and first defined the variables according to the pins she connected, then

used the conditions to cause the LEDs to blink according to the values that can be read from the sensor.

Additionally, the participants shared the results of the applications they developed with other participants. PRI5 stated that he implemented a servo motor and shared his results with the class while other participants examined how it worked. PRI1 showed that entering larger values for voice tone produces a higher-pitched sound.

Participants also tested and defended the solutions they produced. COM3 explained that when they did not adjust the tolerance, it did not work in daylight, but only at night by shining a flashlight. Therefore, he said that it was necessary to give the tolerance value. He explained how the system acts under what conditions. ELC1 also stated that they conveyed the problems and solutions they encountered to their friends.

In this way, cognitive presence indicators were determined from observations made in BLEs and the opinions expressed by participants. The cognitive process, generally activated by a sense of curiosity upon encountering a problem, enables the creation of solutions and applications with the processes of exploration and integration.

Social Presence in Programming Education

Analyzing the data from the research conducted in BLEs revealed indicators regarding emotional expression, open communication, and group cohesion of social presence in programming education. Categories and indicators related to social presence are given in Table 3.

Table 3. Social presence

Categories	Indicators
Emotional expression	Self-disclosure, expressing emotions, use of humor
Open communication	Continue the discussion, asking questions, thanking, appreciating, expressing agreement, referring, and complimenting.
Group Cohesion	Address the group and participants by name, congratulations, greetings, and farewells.

Emotional Expression

Participants made emotional expressions by opening up, expressing their feelings, and using humor in BLEs during the programming training. Additionally, findings regarding emotional expressions were found in the interviews and reflective reports.

It was observed that the participants self-disclosed in the laboratory by giving examples from their lives. It is seen that participants share about themselves in online forum correspondence and instant messaging, as in the face-to-face learning environment. COM1 stated that the cat is susceptible, PRI5 will be out of town for a few days for the wedding, and the cat will be alone and needs to be fed. While expressing herself, SCI2 stated that she chose to listen well even as a student and thought she could not understand a subject she did not know without listening.

Participants also gave examples from their own experiences in the interviews held with them and in the reflective reports they wrote. The fact that the participants talk and share about themselves shows that they opened up about themselves in the programming training. Opening themselves up to other participants enables them to express themselves emotionally to other participants. For this reason, self-disclosure behavior is considered an important indicator of social presence.

The fact that participants express their emotions as they self-disclose during the programming training is another

crucial indicator that reveals their emotional expressions in the context of social presence. ELC1 stated that this COI socializes people; it is a comfortable environment where they can not only give lectures or review educational material but also chat with the group or with other friends and joke with each other, as in other social networks. Furthermore, MAT1 asserted that the environment was conducive to friendly interaction, while PRI7 indicated that the training was enjoyable and conducive to a positive mood. In the BLE, participants shared their feelings with other participants by laughing, expressing their happiness, excitement, and reservations, sending emoticons, and wishing them well.

The use of humor is another indicator of emotional expression in programming education, along with self-disclosure and expression of emotions. The participants use humor in their communication in the classroom environment and express themselves by making jokes. For instance, about the project carried out by COM2, COM1 made fun of the fact that there were not so many cables in the last spaceport. Afterward, he stated that he was saying it as a joke and that his friend was working hard and did an excellent project. MAT1 also said there was much hilarity about such situations in the learning environment, not only about the lesson but also that some conversations or sharings could turn into a joke.

Participants express that it is a humorous and friendly learning environment and that they carry this environment into their homes. Participants' opinions show that using humor creates a friendly atmosphere in the learning environment. Observations made in the BLE also support this. In this context, it is understood that using humor in the BLE is an indicator that helps express emotions in the COI.

Open Communication

Participants' social presence indicators related to open communication were found as continuing the discussion, asking questions, thanking, appreciating, expressing agreement, referring, and complimenting. Participants engaged in open communication by continuing discussions in face-to-face and online environments, asking each other questions, engaging in behaviors such as thanking, appreciating, complimenting, and referring to their friends, and stating issues on which they agreed.

As an example of argumentative behavior in a laboratory, COM1 asked whether the sun-tracking system moved until it coincided with the light. COM3 said yes and continued until it was equal and directly in front of the light. COM1 continued the discussion by asking if they had ever encountered a situation where the system was not up to par with the light. COM3 stated there was no problem with this gear system and that they used the tolerance and delay values accordingly. Participants continued the discussion by discussing a particular topic in the laboratory or participating in existing discussions.

Likewise, when forum messages and instant messages are examined online, it is seen that the participants continue to discuss. SC11 continued the discussion by writing in her message that if the system gave an audible warning every time food fell into the bowl, the cat would be more easily aware that the food had arrived. Additionally, in the interviews, the participants stated that everyone saw each other's problems, participated in the discussion environment, and helped to find solutions.

The participants' opinions about participating in the discussion environment and continuing to discuss with each other show the interaction between the participants, and open

communication is achieved. The interactions provided by the discussion continuation behavior observed in the BLE and discussion-based open communication among the participants support these views. For this reason, it is thought that the participants' behavior of continuing the discussion indicates social presence regarding open communication.

It is seen that asking questions provides interaction as much as continuing the discussion in programming education. Participants were observed asking questions in BLEs, and findings regarding questioning behavior were identified in interviews and reflective reports. For example, COM3 asked about the servo motor. ELC1 also explained its working logic. He talked about examples of usage in daily life. Everyone gained knowledge by listening. This is how interaction is achieved through questioning behavior.

In addition, the participants thanked each other on various issues and appreciated each other's work. Participants stated issues on which they agreed and referenced other participants. For instance, in the interview with SC11, she stated that she learned soldering from ELC1 in one of the lessons and that it was an outstanding experience for her, so she thanked and appreciated him. In addition, most participants complimented them by stating that the people in the environment were very kind.

Group Cohesion

Participants' social presence indicators related to group cohesion were determined as addressing the group and participants by name, congratulations, greetings, and farewells. It was observed that the participants generally addressed the group while they were in the community during the programming training. However, when interacting one-on-one, participants address each other by their names. ELC1 addressed the class and explained how the stepper motor works and its differences from DC motors. PRI5 addressed COM1 by name and stated that they obtained different light spectrums with his contributions.

In this context, it is thought that the behavior of participants speaking to the whole class and addressing other participants by their names ensures group harmony. In addition, participants celebrate each other's birthdays and important days, greet each other when entering face-to-face and online environments, and say goodbye when leaving the environment. These indicators show that group harmony is achieved.

Teaching Presence in Programming Education

As a result of the analysis of the data obtained within the scope of the research, codes related to the teaching presence in programming education given in the BLE were revealed. Teaching presence in programming education was examined under instructional design and organization, facilitating discourse, and direct instruction categories. Indicators related to teaching presence categories are given in Table 4.

Instructional Design and Organization

As a result of data analysis, the instructional design and organization indicators were found to be using the environment effectively, adjusting the curriculum, establishing time parameters, and designing methods. Participants expressed their opinions about using the environment effectively in their interviews and reflective reports. In the online learning environment, PRI7 stated that she benefited more from the videos sent by her friends along with the messages. She also stated that they had already

expressed this by talking in class. She added that conversations and texts or visuals are also crucial. Other participants expressed similar views on using the BLE effectively.

Table 4. Teaching presence

Categories	Indicators
Instructional design and organization	Using the environment effectively, adjusting the curriculum, establishing time parameters, designing methods
Facilitating discourse	Setting the discussion environment, evaluating the effectiveness of the process, creating a climate for learning, encouraging, validating, or reinforcing participants' contributions, and seeking to reach an agreement.
Direct instruction	Presenting content and questions, reinforcing learning through evaluation and explanatory feedback, responding to technical concerns, providing information from a variety of sources, focusing discussion on specific topics, identifying misconceptions

Adjusting the curriculum, another indicator of instructional design and organization, also facilitated the effective use of the environment. It is seen that the participants included their opinions about the adjustment of the curriculum in the interviews and reflective reports. TEC2 asserted that the subjects were complex, yet adjusting the curriculum from simple to complex and easy to difficult facilitated the learning process. PRI4 posited that learning a subject in the curriculum is advantageous and then modularly moving on to another topic. From the participants' opinions, it is understood that the curriculum is well-adjusted.

When designing and organizing instruction, it is essential to establish time parameters in conjunction with adjusting the curriculum. The participants expressed their opinions about establishing time parameters in the interviews and reflective reports. PRI6 posited that the BLE was conducive to time-saving and efficient learning. TEC1 also asserted that online education offers a significant advantage in terms of repetition and time. The participants expressed their opinions about the advantages of timing and emphasized the importance of establishing time parameters.

In blended learning, time parameters are created to ensure instructional availability. Additionally, methods are designed in the context of instructional design and organization. In reflective reports and interviews, participants expressed their opinions about the design of methods in programming education. ELC1 indicated that the problem-solving process was facilitated by the discussion method and exchange of ideas and that he considered the questioning method to be similarly efficacious. Moreover, SC11, PHY1, and PRI3 asserted that the show-and-make method was successfully implemented. Furthermore, other participants indicated that the design of methods such as discussion, problem-solving, and demonstration in the BLE influenced their teaching presence in programming education.

Facilitating Discourse

Indicators of facilitating discourse in the COI have been identified as setting the discussion environment, evaluating the effectiveness of the process, creating a climate for learning, encouraging, validating, or reinforcing participants' contributions, and seeking to reach an agreement. It has been determined that the participants, along with the educator, facilitate the discourse in order to ensure teaching presence.

An example of setting the discussion environment is SC11, which asks friends with different suggestions to write

comments. Asking participants to express their opinions about the applications in the laboratory environment is an excellent example of setting the discussion environment. Discussions were requested by sharing, asking questions, asking for suggestions, and making suggestions in online forums and instant messaging environments. Furthermore, the participants indicated they could resolve their issues by establishing a discourse during the interviews.

It is thought that evaluating the effectiveness of the process in the BLE facilitates discourse in programming education and ensures the realization of teaching presence. PRI5 evaluated the effectiveness of the process by stating that the sharing environment was very nice and that TEC2 indicates that he would utilize these methods in his class. Participants also regularly evaluated the effectiveness of the process in their reflective reports.

Another indicator to facilitate discourse in ensuring teaching presence in programming education is the creation of the learning climate in the BLE. The participants indicated they had the opportunity to engage in discourse about the topics they had learned, both in person and online. It was reported that the students had the opportunity to discuss these issues in class and during breaks when they would drink tea and sit in the university garden. Furthermore, they indicated that they engage in continuous online discourse. The participants indicated that this conversational environment fosters a climate conducive to learning.

It can be reasonably assumed that encouraging, validating, or reinforcing participants' contributions may also facilitate discourse. The participants' contributions were encouraged, approved, and reinforced with words such as a good project, a different solution, and well done. Furthermore, the participants indicated in their interviews and reflective reports that they were encouraged, motivated, and made to feel at ease and that their efforts were encouraged. The opinions expressed by the participants indicate that they are encouraged to contribute to the learning environment and that their contributions are duly acknowledged and reinforced. Moreover, observations made in the BLE also demonstrate that participants are encouraged to contribute and approved and that their contributions are reinforced.

Another indicator for ensuring teaching presence and facilitating discourse in a BLE is seeking to reach an agreement. Areas of agreement/disagreement regarding the discussion topics are determined to ensure that participants reach an agreement and understand the topic. For instance, following a discourse on programming, it was unanimously agreed that a solid grasp of mathematics is essential for those wishing to engage in programming. In the interviews, the participants indicated that an agreement was reached by an individual who intervened in the discussion environment and made the issue understandable.

Direct Instruction

The results of the data analysis indicated that the indicators related to direct instruction were determined as presenting content and questions, reinforcing learning through evaluation and explanatory feedback, responding to technical concerns, providing information from various sources, focusing discussion on specific topics, and identifying misconceptions.

The instructor delivered direct instruction through the presentation of course content and the posing of questions. COM3 indicated that the training content prepared by the instructor was highly informative, while MAT1 and TEC2 asserted that they derived benefits from the use of visuals and

videos. Furthermore, other participants indicated that content and questions related to programming education are presented and that the presented content contributes to their learning.

It has also been observed that the instructor evaluates the learning process and provides explanatory feedback to reinforce learning in BLEs. Likewise, COM1, COM2, and PRI4 indicated in their interviews that the instructor's feedback was descriptive.

Another role for the educator when providing direct instruction in a laboratory or online environment is to respond to technical concerns. The observations made, and the opinions of the participants indicated that connections generally caused technical problems. The instructor or other participants solved technical problems.

Participants also stated that they benefited from various sources and were not limited to one source. Furthermore, observations made in the laboratory environment and forum posts also corroborate these ideas. Information is provided from various sources such as links, text, visuals, or video content.

Focusing the discussion on specific topics, another indicator of direct teaching, along with the information provided from various sources, contributes to the participants' in-depth learning of the subject. For example, COM1 said that by entering the plant type into the program, the required humidity and temperature amount can be specified accordingly. COM2 stated that an audio warning could also be used. He said resistance can also heat water to a certain degree. Additionally, other participants focused the discussion about their projects on specific topics.

It was determined that the participants had misconceptions from time to time; they expressed them, and the instructor or other participants corrected their misconceptions. It has been observed that there are general misconceptions about writing codes and electronic pins in the laboratory environment. It can be understood from the posts shared by the participants in the online environment that they have misconceptions. In interviews and reports, participants stated that the misconceptions they encountered were resolved.

Discussion and Conclusion

The present study examined the social, cognitive, and teaching presence of teachers who participated in programming training in a BLE. The research yielded responses to the research questions that aligned with the study's objective and insights into the BLE's social, cognitive, and teaching presence. Although these three components are generally included in the COI studies, studies with extended frameworks have also been conducted (Carroll, Lang, & Connolly, 2024; ElSayad, 2023; Lee, Looi, Faulkner, & Neale, 2021; Wang, 2026).

The indicators of the cognitive presence of teachers participating in programming training in the BLE were presented within the framework of initiating, exploring, integrating, and analyzing the activity. Also, Kaczkó and Ostendorf (2023) state that in studies on cognitive presence, indicators of the original coding schemes were followed, and indicators capturing criterion-guided questioning were included. The study concluded that the participant's initiation of cognitive activities on issues related to programming education in the BLE was related to their definition of the problem, whether they had prior knowledge, their level of curiosity, and their desire for research. Nevertheless, in related studies, it is stated that the indicators of initiating the activity are identifying the problem and the feeling of uncertainty (Garrison, Anderson, and Archer, 1999; Garrison, Anderson,

and Archer, 2001). Armellini and De Stefani (2016) also asserted that the professional development of English teachers in the BLE encompasses cognitive, social, and emotional aspects. In their study examining the role of teaching presence, they identified findings regarding the participants' problem identification and indicators of feeling uncertain at initiating the activity. The findings of this study indicate that the participant's perception of the problems they encounter, their sense of curiosity, their prior knowledge of the subject, and their desire for research are indicative of the initiation of the activity.

The social presence of teachers who participated in programming training in a BLE was evaluated using three key indicators: emotional expression, open communication and interaction, and group cohesion and commitment. It appears that the emotional expressions of the participants are associated with their self-disclosure, the expression of their feelings, and the use of humor. Lim and Richardson (2022) noted some differences across academic fields for social presence, except for some applied disciplines, where most interviewees perceived the importance of social presence components to achieve learning outcomes. Zydney, deNoyelles, and Seo (2012) examined whether students used affective words and concluded that participants made emotional expressions to indicate their social presence. It has been posited that emotional expression indicators of social presence include the expression of emotions, self-disclosure, and the use of humor (Akyol, Garrison, & Özden, 2009; Armellini & De Stefani, 2016; Lowenthal & Dunlap, 2010; Rourke, Anderson, Garrison, & Archer, 2007). The findings of this study indicate that the participants' behaviors, including the expression of emotions, opening themselves to other participants, and the use of humor, can be considered emotional expressions that demonstrate their social presence.

In addition to the cognitive and social presence indicators identified in the COI in programming education, indicators related to the teaching presence component have also been identified. As Anderson et al. (2001) posit, the teaching presence of a teacher or instructional designer begins before the course begins, with the planning and preparation of the course of studies. Teaching presence is maintained throughout the course, with the instructor assuming the role of a facilitator of discussion and provider of direct instruction when necessary (Anderson et al., 2001). Additionally, it is stated that teaching presence directly affects cognitive presence and is mediated through social presence. (Sundgren, Jaldemark, & Cleveland-Innes, 2023). The indicators that demonstrate the achievement of teaching presence in the BLE were examined under the categories of instructional design and organization, facilitating discourse, and direct instruction by the theoretical framework.

The research findings indicate that teachers participating in programming training in a BLE demonstrate specific indicators of their social, cognitive, and teaching presence. In the context of programming training, participants' emotional expression, group cohesion, and interaction with other participants serve to demonstrate their social presence. The participants initiated cognitive activities, produced solutions through discovery and integration, and made real-world applications. In order to ensure the social and cognitive presence of the participants, the instructional design and organization were carefully crafted, discussions were facilitated, and teaching presence was ensured through direct instruction.

The coexistence of face-to-face and online learning processes in BLEs causes participants' social, cognitive, and

teaching presence indicators to have similarities and differences with the indicators in learning environments where only distance education processes are available. Considering the differences in face-to-face and distance education processes, this study is anticipated to help make instructional designs for BLEs. It is thought that programming training based on the COI framework will ensure the participants' social learning. In this context, it is envisaged that the social, cognitive, and teaching presence indicators revealed within the scope of the study will guide studies on programming education. However, the study's results are thought to contribute to theoretical and applied studies based on the COI in BLEs.

Limitations And Implications

Since the camera used as a data collection tool in the classroom environment was at a distance that could capture almost the entire class, one-on-one conversations in a low voice could not be reported clearly because they could not be heard clearly in the recordings. However, there is a problem with the observations since some abstract indicators cannot be detected by observation, and some situations cannot be observed due to the camera angle. Data obtained from camera recordings in a face-to-face classroom environment are limited.

Based on the research results, suggestions for programming training in BLEs are as follows:

- Instructional design and organization should be made, considering the participants' social, cognitive, and instructional abilities, and the discussion should be facilitated.
- In order to initiate programming-related activities, it should be determined whether the participants have the necessary preliminary knowledge, and they should be helped to identify the problems encountered.
- It should arouse curiosity in the participants and make them willing to do research.
- In order for participants to better learn the topics related to programming education, discussion environments should be created in the BLE, and participants should be encouraged to discuss.
- In the discussions, the participants' disagreements and points of agreement should be identified.
- An effort should be made to reach an agreement on issues where agreement can be reached.
- A friendly learning environment should be created where participants can express themselves comfortably, give real-life examples, and make jokes.
- The learning environment should be created considering time parameters, and the content should be presented by designing appropriate teaching methods.

In BLEs, a holistic approach should be taken to both face-to-face and online processes when creating communities of inquiry. Social cognitive learning theories should be utilized. From this perspective, it is anticipated that this study will shed light on other studies in the field.

Author Contributions

The authors contributed equally to the editing of the article and the preparation of the final text.

Ethical Declaration

The authors declare that the study was subject to the approval of the Gazi University ethics committee, numbered 07/11/2018-E.148644, and that the rules determined by the

Committee on Publication Ethics (COPE) were followed throughout the study.

Conflict Of Interest

This study is based on the first author's doctoral dissertation, and it was conducted under project number 04/2018-09 at the Scientific Research Projects Coordination Unit, Gazi University in Türkiye.

Declaration Of Generative AI Use

Generative artificial intelligence was not used at any stage of this study. The authors take full responsibility for the content of the manuscript.

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