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The effect of the flipped learning approach designed with community of inquiry model to the development of students' critical thinking strategies and social, teaching and cognitive presences

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Abstract
Considering the lack of interaction and feedback process of the pre-class component of the flipped learning approach, in this research this component was designed with the community of inquiry model and an e-learning environment was developed in line with the model's theoretical framework. By exposing its impacts on students' development of critical thinking skills and social, teaching and cognitive presences, this study aimed to determine the working and failing aspects of this learning approach. In this study, in which repeated measures design was used, the study group consisted of 35 undergraduate students studying at a state university. Scales were used to measure students' critical thinking strategies and their perceived presences, and the forum tool was used to collect student posts. The implementation process lasted for 15 weeks. Findings demonstrated that it was possible to eliminate the lack of the interaction and feedback processes, and to develop students' critical thinking strategies and their perceptions of teaching, social and cognitive presences, by designing the pre-class component of the flipped learning approach with the community of inquiry framework. Additionally, it was discovered that the critical thinking strategy had a positive and significant link with how the community of inquiry was perceived, and that this relationship accounted for 60% of the variance in the perception of community of inquiry. The study's conclusions are supported by recommendations for future research.

Keywords Online · Flipped learning · Community of inquiry · Critical thinking strategy

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1 Introduction

Due to the various benefits and educational advantages of blended learning, it is becoming more and more popular in higher education. But this situation also presents fresh challenges for educators to work through. One of these challenges is having the proper understanding and implementation of the online component of blended learning, which concentrates on online education and has numerous characteristics that are distinct from those of the face-to-face component. The integration of new communication technologies and pedagogical ideas in this multidimensional learning method needs to be thoroughly debated and researched. A methodology and framework that details the entire process can enable such an approach (Garrison et al., 2010).

In blended learning approaches, the fundamental dynamics of educators, students (Steen-Utheim & Foldnes, 2018) and even classroom environments are changing. Flipped learning, a type of blended learning, is a good example that reflects these dynamics. According to Abeysekera and Dawson (2015), flipped learning is a collection of pedagogical strategies that typically remove information transfer from the classroom and use the in-class time for active and social learning. The flipped learning approach divides learning activities into two components: pre-class and in-class (Brady & Voronova, 2023; Förster et al., 2022; Han & Klein, 2019; Ishak et al., 2020; Jensen et al., 2018; Loizou & Lee, 2020). With this method, students are expected to acquire the fundamentals pre-class through literature, recorded lectures, videos, etc. Teachers then devote time in-class to implementing the content through challenging problem-solving, in-depth conceptual exploration, and peer discussion or debates (Bi et al., 2023; Jensen et al., 2018; Jones & Sturrock, 2022). For successful involvement in in-class activities as well as for overall learning achievement, students' timely and frequent participation in pre-class activities is essential (Förster et al., 2022; Han & Klein, 2019).

In the past ten years, extensive research on the flipped learning approach's in-class component has produced promising findings (Fischer & Yang, 2022). Numerous studies have highlighted the benefits of the flipped learning approach on various learning outcomes. Compared to traditional classes, flipped classrooms have been linked to improved learning outcomes and better levels of engagement (Elmaadaway, 2018; Hew & Lo, 2018; Kazanidis et al., 2019). According to Fulton (2012), using this approach allows the instructors to recognize the challenges that the students encounter when carrying out their responsibilities in the classroom and modify the curriculum as necessary. Similarly, the teacher can easily observe the interest and behavior of the students. This circumstance offers a chance for prompt feedback and fruitful conversation regarding the challenges the students are facing (Halili & Zainuddin, 2015). Students can be more satisfied with this approach (O'Flaherty & Phillips, 2015) and learning success and contentment can both be raised (Missildine et al., 2013). However, flipping the course alone does not produce positive results in every sense. The flipped learning approach's various drawbacks and limitations are highlighted in addition to these encouraging findings and remarks in the literature.

Less emphasis has been placed to the flipped learning approach's pre-class component (Fischer & Yang, 2022). The interaction and feedback processes during individual learning are considered insufficient in this approach, according to the relevant

literature (Ash, 2012; Rivera, 2015; Sams & Bergman, 2013; Thoms 2012). Enfield (2013) and Antonio (2022) suggested that the lack of feedback and interaction significantly affected the pre-class process negatively. Enfield (2013) claimed that while studying via video or other content, students were deprived of the chance to rapidly fix errors and misunderstandings. This is in contrast to face-to-face instruction, where students have these possibilities. Although the literature has highlighted a variety of drawbacks of the flipped learning strategy (Akçayır & Akçayır, 2018; Gündüz, 2020; Schlairet et al., 2014; Sun et al., 2017), this study only addresses the drawbacks that are under its scope.

Findings showing that the pre-class component of flipped learning is weak also raises the question of how the results would change if this problem was addressed and this component was strengthened. One of the models that can be considered to effectively structure the pre-class component of flipped learning is the community of inquiry. The community of inquiry model offers an effective online learning framework and theoretically explains online learning on the basis of social constructivist approaches. The community of inquiry framework reflects the dynamic nature of higher learning and has proven useful for guiding research and practice in online higher education (Garrison & Arbaugh, 2007; Garrison et al., 2010). The model prioritizes educational conversation processes that can lead to an epistemic connection and focuses on the desirable development of an online learning community (Shea & Bidjerano, 2010). A meaningful educational experience, according to the model, is made up of three presences: teaching, social and cognitive (Garrison & Vaughan, 2008).

1.1 Theoretical framework

1.1.1 Flipped learning

In flipped learning approach, pre-recorded educational videos are watched outside of the classroom setting (usually at home). This increases the amount of time allotted for group projects, debates, and interactive activities during the class time. By encouraging participation in discussions, group projects and collaborative learning activities throughout the session, this approach seeks to maximize the opportunities for active learning (Mok, 2014). In this approach, the teacher guides students rather than conveying knowledge, and students are in charge of their own learning processes and pace management (Lai & Hwang, 2016). For teachers to focus on the skills at the higher levels of Bloom's taxonomy during the session, the adoption of the flipped learning can save time (Sams & Bergmann, 2013). Figure 1 shows the comparison of the traditional model and the flipped model according to Bloom's taxonomy.

As presented in Fig. 1, by completing activities that require skills in the lower levels of taxonomy at home, learners are given the opportunity to face activities that require more intense cognitive activity during the class. The flipped learning model focuses on bringing content that fits the lower levels of Bloom's Taxonomy out of the classroom (remembering and understanding) and allocating in-class time to higher-level learning (applying, analyze, evaluate, and create). In this approach, the teacher works side by side with the students and as a facilitator instead of being a "wise on

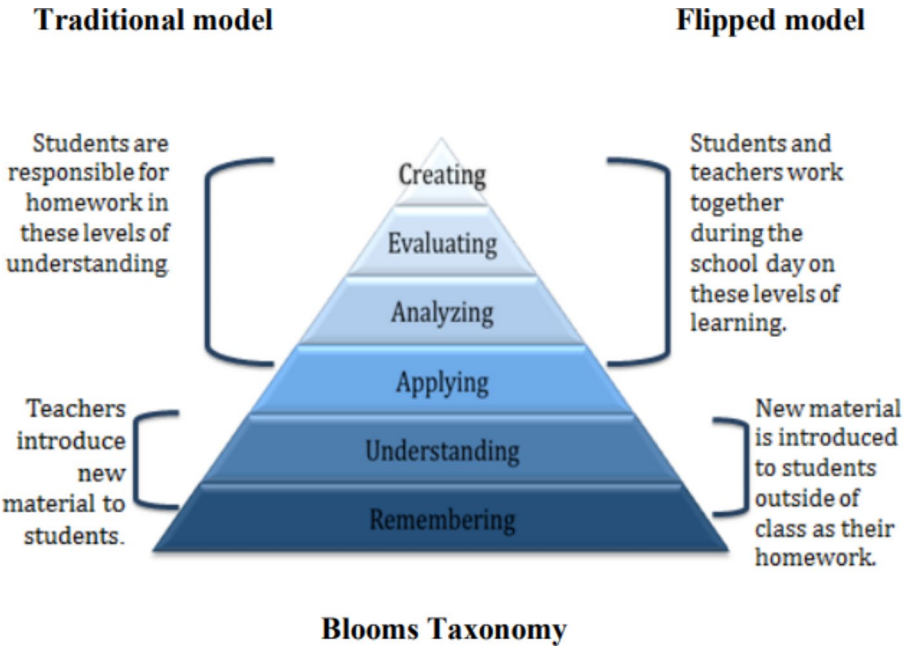

Fig. 1 Traditional and flipped model in Bloom's Taxonomy (Williams, 2013)

the stage" (See & Conry, 2014). Although flipped learning makes the time spent during the class more productive with high-level learning (Elmaadaway, 2018; Fischer & Yang, 2022; Halili & Zainuddin, 2015; Hew & Lo, 2018; Kazanidis et al., 2019; Missildine et al., 2013), students experience lack of interaction and feedback in the pre-class processes (Antonio, 2022; Ash, 2012; Enfield, 2013; Rivera, 2015; Sams & Bergman, 2013; Thoms 2012), which creates disadvantages for this component. One of the theoretical frameworks that can be used to design this component of flipped learning in such a way that students can interact and receive feedback is the community of inquiry.

1.1.2 Community of inquiry model

An inquiry-based learning method is one that involves the learner creating hypotheses and evaluating them through experiments and/or observations in order to uncover new causal relationships (Pedaste et al., 2012). Inquiry-based learning demands that students, to the greatest extent feasible, be in charge of directing the acquisition of information, including the pace at which it occurs. They should also oversee validating the ideas put forth. In other words, learners should not turn to the teacher as their only source of information (Love et al., 2015). The method of flipped learning which requires students to study out of class, on their own pace and focus on higher order learning in-class time, makes inquiry-based learning an appropriate match. The theoretical framework describing inquiry-based learning in online environments is the community of inquiry.

The community of inquiry model argues that learning in online environments occurs through the interaction of three core elements (social presence, cognitive presence, teaching presence) within the community. The model refers to the behaviors and processes required to nurture knowledge construction through the development of various forms of presences (Garrison et al., 2000, 2001), the model's creators, claim that elements of a community of inquiry can either improve or limit the educational experiences and learning results. To create and maintain a collaborative community of inquiry, the composition and interactive implications of each presence must be understood (Garrison et al., 2010). According to the community of inquiry model, the most fundamental element for success in higher education is cognitive presence. The ability of students to construct and confirm meaning through sustained reflection and discourse is referred to as cognitive presence and as opposed to concentrating on particular individual learning outcomes, cognitive presence focuses on higher-order thinking process (Garrison et al., 2001). Cognitive presence occurs when a certain content is supported by critical thinking in epistemological, cultural and social terms (Anderson, 2008). Cognitive presence draws on critical thinking literature and is operationalized with the practical inquiry model (Garrison et al., 2001). In the triggering event phase of the practical inquiry model, a topic or problem is identified for further information. In the exploration phase, students are expected to explore the subject individually or collaboratively through critical thinking and discussion. The integration is the phase in which students create meaning from the ideas developed during exploration, and in the resolution phase, students apply their newly acquired knowledge to educational or workplace environments (Dagen & Ice, 2008; Traver et al., 2014). In order to enhance higher-order learning outcomes in online contexts, academics are examining both cognitive presence levels and critical thinking by using practical inquiry model (Sadaf et al., 2021).

According to Garrison (2011), social presence in the academic setting entails fostering an environment that values and promotes the contribution of explanatory ideas as well as investigative questions. Maintaining critical thinking and discourse requires a sense of belonging that must develop over time. Social presence can develop when participants interact with each other during learning activities (Çakıroğlu, 2019). Social presence enables participants to identify with a group, communicate purposefully in a safe environment, and gradually develop personal and emotional relationships that reflect their individual personalities (Garrison, 2009). This component's primary significance lies in its role in promoting cognitive presence, which indirectly supports the learning community's critical thinking processes.

Teaching presence is essential in balancing cognitive and social issues that are consistent with intended educational outcomes. This can be achieved by any of the participants in the community, as well as by the active leadership of a teacher (Garrison et al., 2000). Teaching presence plays a key role in creating and maintaining a community of inquiry (Garrison et al., 2010). Building and maintaining a community of inquiry requires a caring, focused and carefully managed teaching presence. The findings of research on the community of inquiry model concur that teaching presence is a significant factor of student satisfaction, perceived learning, and sense of community (Garrison & Arbaugh, 2007).

1.1.3 Critical thinking strategy

The theoretical foundation of the community of inquiry is centered on critical thinking and discourse, which are essential components of inquiry (Garrison, 2011). Community, critical reflection, and knowledge building are fundamental to learning, especially online learning (Garrison & Archer, 2000). One of the key objectives of contemporary education is the promotion of critical thinking (Hitchcock, 2018). However, everyone can agree that developing this skill is one of the primary but unmet objectives of education (Willingham, 2008).

Critical thinking is defined as the degree to which students apply their prior knowledge to new situations in order to solve problems, reach decisions, or make critical evaluations according to standards of excellence (Pintrich et al., 1991). One of the fundamental components of the community of inquiry model, cognitive presence, is based on the literature on critical thinking (Garrison et al., 2001). The community of inquiry model places emphasis on the development of critical thinking skills in students as well as the use of learning, reflection, and evaluation techniques based on a critical thinking strategy. Therefore, the development of a critical thinking strategy in a learning environment designed with a community of inquiry approach needs to be specifically addressed. In a learning environment based on deep and meaningful learning, if community of inquiry forms with all its elements, it encourages critical thinking in learners and raises their cognitive presence (Kanuka & Garrison, 2004) which enables them to articulate their viewpoints using the right justifications and evidence (Gwee & Damodaran, 2015). However, how individuals might develop critical thinking skills is a different concern given the complexity of critical thinking. In this regard, Golding (2011) put forth a strategy called "Using thought-encouraging questions in a community of critical thinking". This strategy consists of five types of thinking: initiating, suggesting, reasoning and elaborating, evaluating and concluding. These types of thinking are parallel to the stages of the practical inquiry model. According to the strategy, by asking specific questions for each type of thinking, students can be helped to become critical thinkers. The following examples can be given for each type of thinking, respectively: (1) What are some questions about … (2) What are some possible ideas about … (3) If … were true, what would follow (4) What are some reasons to agree with … (5) What conclusions can we draw?

1.2 Literature review

Regarding the scope of this research, it is noteworthy that the majority (92%) of the 13 related studies, which were stated to be used the community of inquiry model together with the flipped learning approach in the literature, were carried out in the last 5 years. Kim et al. (2014) developed a flipped learning design based on the revised community of inquiry model framework and identified 9 design principles relevant to various disciplinary contexts. Wu et al. (2017) showed that designing flipped learning with the community of inquiry model facilitates meaningful and positive collaboration, improves students' presence perceptions, and leads to more active participation in high-level interactive learning activities. In a study comparing traditional classrooms with flipped classrooms, Kim (2017) revealed that students' teach-

ing, social and cognitive presences markedly develop in flipped classrooms, and the importance of the instructor did not decrease despite the changing roles as moderators and facilitators. Le Roux and Nagel (2018) emphasized the value of instructional videos, claimed that student presentations greatly increased their cognitive presence but had less of an impact on their social presence, and demonstrated the significance of constructivist pedagogy for flipped learning in order to promote deep learning. Kay et al. (2019) compared the experiences and performances of university students with lecture-based, active learning and flipped learning approaches, and reported that the active learning group was the group with the highest teaching and social presence scores. In their study, no significant differences were found between the three approaches in terms of cognitive presence or learning performance. In an experimental study comparing traditional and flipped learning approaches, Stover and Houston (2019) revealed that perceptions of teaching and social presences and satisfaction levels differed in favor of the flipped learning group. Academic achievement and the perception of cognitive presence, on the other hand, did not vary between groups. Delivering students feedback that includes learning analytics findings in a flipped learning design, has been shown by Yılmaz (2020) to have a statistically significant and positive impact on students' perceptions of community of inquiry and reflective thinking skills.

Students' perceptions of all presences improved to a very high degree, according to Günbatar (2021a), who conducted a research to assess the effectiveness of the teaching process utilizing the flipped learning model. In another study, Günbatar (2021b) used the problem-based teaching technique with a flipped learning approach and examined the students' views. Results of his study revealed that video materials start the learning process in terms of cognitive presence, problem-based activities contribute to motivation and a respectful communication environment in terms of social presence and teaching presence and deepen the meanings of the subjects. Jia et al. (2021) found that fully-online flipped learning designed with the community of inquiry model and traditional flipped learning approaches do not differ in terms of academic performance. Antonio (2022) reported that teaching, social and cognitive presence is observed in students learning with a flipped learning pedagogy in flexible learning modality. Özüdoğru (2022) determined that there is no significant relationship between presences and academic performance in the flipped learning approach.

When the relevant literature was explored, it became clear that some research lacked any application based on the theoretical framework of the community of inquiry in the created courses. In these studies, only the instrument of the model was used to measure the students' perceptions of presences during the process. In other research, it has been observed that only a brief description of the course designs was provided, and it was not made obvious how exactly these designs were based on the framework of the inquiry community. Regarding the learning environments used, it can be noted that some studies didn't disclose the elements of the environment they employ, while others made use of LMSs like Blackboard and Moodle and messaging services like Line, WeChat, and WhatsApp. In a long-term education period, it would be difficult to follow the educational discussions, which are shown as posts one after the other, via Line, WeChat and WhatsApp groups. Opening a separate page for each topic is not among the possibilities offered by these applications at the present time.

Therefore, this process would likely result in getting disoriented. Reaching the posts made by themselves, their peers, or the course instructor, as well as separating this material from other information, are additional challenges that await students in such environments. When learning platforms like Blackboard and Moodle are used, the situation is partially different. Such LMSs allow tracking of topics and posts. On the other hand, factors like the lack of features that preserve students' individual post histories and modules that provide details about other students who are active in the system can restrict the growth of students' community of inquiry presences. In the e-learning system developed within the scope of present study, it is aimed to develop the perceptions of the community of inquiry by removing such limitations and adding features that support learning on the basis of collaborative constructivist theories.

1.3 Problem statement

In order to increase motivation, satisfaction, and learning outcomes, it is essential to provide more effective student-teacher-content interaction as well as cognitive and social support for students as they create knowledge in online learning environments (Akyol & Garrison, 2008, 2011; Polat, 2013). The flipped learning approach, which gives students the chance to acquire fundamental concepts and skills at home and advanced material in a classroom setting, offers both considerable benefits and drawbacks (Antonio, 2022; Ash, 2012; Enfield, 2013; Rivera, 2015; Sams & Bergman, 2013; Thoms 2012). These drawbacks, however, can be avoided if the community of inquiry framework is used in the design of the flipped learning. Yet, it is vital to examine whether such a design will enable critical thinking, that is at the core of the community of inquiry model and result in higher-level learning, and how it will impact students' perceptions of the community of inquiry and hence, their learning experiences. Although there are studies in the literature in which the pre-class component of the flipped learning approach is designed within the framework of the community of inquiry (Antonio, 2022; Günbatar, 2021a, b; Jia et al., 2021; Kay et al., 2019; Kim, 2017; Kim et al., 2014; Le Roux & Nagel, 2018; Stover & Houston, 2019; Solimani et al., 2019; Yılmaz, 2020; Özüdoğru, 2022; Wu et al., 2017), these studies are not sufficient in number in terms of forming a clear understanding of the subject and the findings obtained in these studies need further research. On the other hand, no study has been found on the extent to which the flipped learning environments designed with the community of inquiry model support the critical thinking. In addition, an example of a flipped learning environment developed by considering the theoretical background of the community of inquiry model has not been found in the literature. Therefore, the first objective of this study was to develop a flipped learning environment designed with the community of inquiry model. To reveal the effects of community of inquiry model based flipped learning approach on students' educational experiences, several research questions were designated. The development of the three presences of community of inquiry that constitute an effective educational experience, was one of the focal points to this study. Given the importance of critical thinking in education as one of the most important skills and being the hearth of community of inquiry model, one research question has been designated to reveal its

development and another for its relationship with community of inquiry in the flipped learning design. Research questions are as follow:

RQ1: How do students' perceptions of presences change over time?

RQ2: How do students' critical thinking strategies change over time?

RQ3: What kind of a relationship is there between students' presence perceptions and their critical thinking strategies?

2 Method

The repeated measures design, a semi-experimental research method, was employed in this study. All participants in a single group get all experimental treatments when a repeated measures design is used, and the group serves as its own control. With this design, the performance of a group under one experimental treatment is contrasted with that group's performance under a different experimental treatment (Creswell, 2014).

2.1 Study group

The study group of this research consisted of first year students who took the "Electronic Circuit Elements" course from the 2nd semester courses of the Department of Computer Education and Instructional Technologies at a state university in 2020. The study initially involved 52 students, but 17 of them did not voluntarily complete all the scales, so their data were not included in the analysis. Consequently, 35 students were involved in the study. Ages of 35 students forming the study group varied between 19 and 21. Twenty of the students were female and 15 of them were male.

2.2 Data collection process

As seen in Table 1, students' critical thinking strategies were measured using the "Motivation and Learning Strategies Scale" before and after the 15-week implementation period. On the first week of implementation, activities made were mainly focusing on orientation. In the seventh week of the implementation process, the task of moderating the discussions was shared among the student groups, so the instructional presence was largely shared with the students. Taking into account that the reflection of this situation to the students might arise as early as the eighth week, students' perceptions of the community of inquiry were measured three times in series in the second, eighth, and fifteenth (post-implementation) weeks.

Table 1 Design of the Study

Pre - Implementation	2nd Week	8th Week	Post - Implementation
Motivated Strategies for Learning Questionnaire (Critical Thinking Strategy)	Community of Inquiry Instrument	Community of Inquiry Instrument	Community of Inquiry Instrument Motivated Strategies for Learning Questionnaire (Critical Thinking Strategy)

Through the e-learning environment (www.boteyazilim.com) developed within the scope of this research, students made posts and discussed on the topics of the course over the forum module for 15 weeks. These posts were collected and interpreted at the end of the process. The collection of all data was based on volunteerism.

2.3 Data collection tools

2.3.1 Motivated strategies for learning questionnaire

The "Motivated Strategies for Learning Questionnaire" was used to measure students' critical thinking strategies. The "critical thinking strategy" dimension of the scale was included in this study. The questionnaire was developed by Pintrich et al. (1991) and adapted into Turkish by Büyüköztürk et al. (2004). The scale is a 7-point Likert type scale consisting of 81 items, and the critical thinking strategy dimension is measured with 5 items. High scores in this dimension indicate that the critical thinking strategy is developed. The Cronbach Alpha internal consistency coefficient for this dimension of the scale is 0.74.

2.3.2 Community of inquiry instrument

The "Community of Inquiry Instrument" was used to measure participants' perceptions of community of inquiry. The instrument was developed by Arbaugh et al. (2008) and adapted into Turkish by Olpak and Kılıç Çakmak (2018). The instrument, which consists of 34 items and 3 dimensions, is in a 5-point Likert form. The instrument's three presence dimensions—teaching presence, social presence, and cognitive presence—each have 13, 9, and 12 items respectively. The internal consistency (Cronbach α) values of the factors were determined as 0.97 for teaching presence, 0.95 for social presence and 0.97 for cognitive presence. The internal consistency value of the measurement tool is 0.98.

2.3.3 Forum module

The forum module, which was embedded in the e-learning system infrastructure for students to discuss and post, was also a data collection tool within the scope of this study. Students' posts on weekly topics were collected at the end of the process and were used for supporting the findings.

2.4 Implementation process

The implementation of this study was carried out in the Electronic Circuit Elements course and lasted for 15 weeks. Curriculum topics were covered by being distributed throughout this process. For the flipped learning approach designed with the community of inquiry model, an e-learning system must also be suitable as an infrastructure for the realization of the determined applications. In this direction, a ready-made e-learning environment was not used within the scope of this study, instead an environment that could meet these expectations was developed. On Saturdays, the les-

son materials were published to the online system. After this lesson was posted, a forum was launched for discussions. This forum remained available for discussions until the following lesson was posted. With each newly opened forum, the forum opened for the previous lesson was closed to posting and was left open to reading access only. On Wednesdays following the uploading of the educational videos, online lessons were held through the Zoom video conference platform for the in-class dimension of flipped learning. In these lessons, using Golding's (2011) strategy of "Using thought-encouraging questions in a community of critical thinking", thought-encouraging questions were asked, and students were encouraged to think in this way, to produce questions, and to become "critical thinkers" in this direction. Questions were answered, and question-solving activities were carried out. Except for the group moderation weeks, all students were given equal chance to access all content for 15 weeks.

2.4.1 E-Learning system

Wordpress infrastructure was used for the learning system developed within the scope of this study. The system has been developed as completely mobile compatible considering the range of devices used by students and has been available to internet access at www.boteyazilim.com. The main page of the system consisted of user login/registration buttons, upper and lower menus to facilitate navigation, a button for accessing the course page, and announcements in the form of dynamic slides. In the announcements section located in the upper area of the main page, in addition to the updated announcements for each course, there were announcements specific to certain weeks; announcements regarding the situation if a change has been made in the system, and some general information about the class. Each of the announcements that appear in the form of a slide left its place to the next announcement after waiting on the screen for 10 s. The screenshot of the main page of the system is given in Fig. 2.

The Forum button on the main page opened the forum module where discussions about the course were made. To open the forum module, users had to enter the password created specifically for the forum. A screenshot of the system's forum page is given in Fig. 3.

The messaging button directed users to the page that was added to the system as a module and allowed students to communicate among themselves or with the teaching staff. There were also announcements sent by the administrator of the e-learning system to all students on this page. Messages sent from this page reached the target person or persons instantly. In case of a message or an announcement, a red colored warning appeared with the text "You have an unread message", or "You have an unread announcement" at the top of the page the user was on, depending on the type of message received. In addition, if it was not read within 5 min, the system sent the information that a message or announcement had been received as an e-mail to the users. A screenshot of the messaging module of the system is given in Fig. 4.

In the center of the main page, the button "Click to access the course content" was located. On the page opened when this button was clicked, the introduction video of the Electronic Circuit Elements course, the explanation text about the content of the

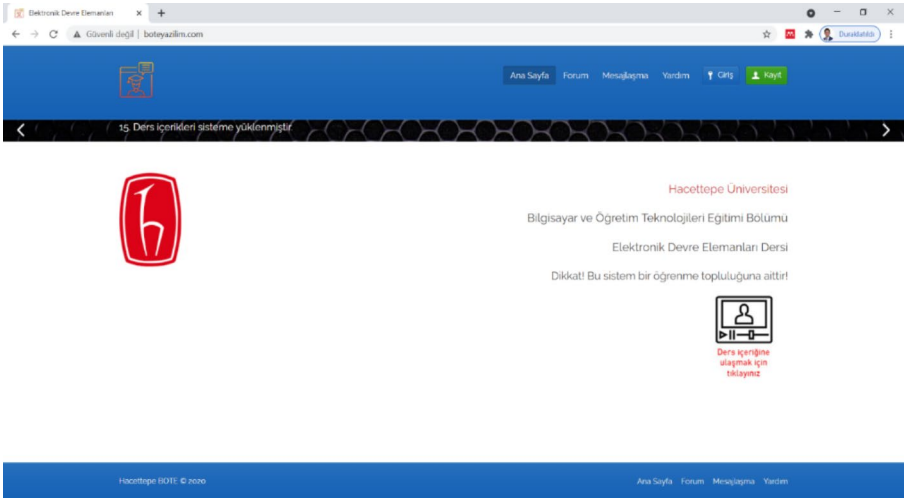

Fig. 2 Main Page Screenshot

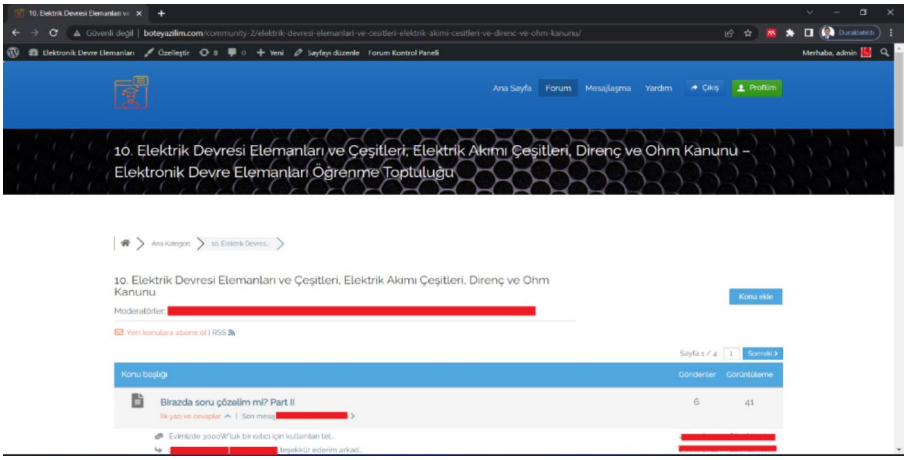

Fig. 3 Forum Page Screenshot

course and the learning approach, the module showing who was online, the module that showed the profile photos of the students registered in the system, and the buttons of course topics (1st Lesson, 2nd Lesson …. 15th Lesson) were shown. Sample screenshots of the introduction and course content page of the e-learning system are given in Figs. 5 and 6.

The e-learning system was a Web-based and publicly accessible system. Any internet user could access the home page of this system and the course introduction page. The "forum" section, which was created for discussions about the course, was protected with a second password so that students could express themselves more confidently with the awareness that their posts could only be seen by the teaching

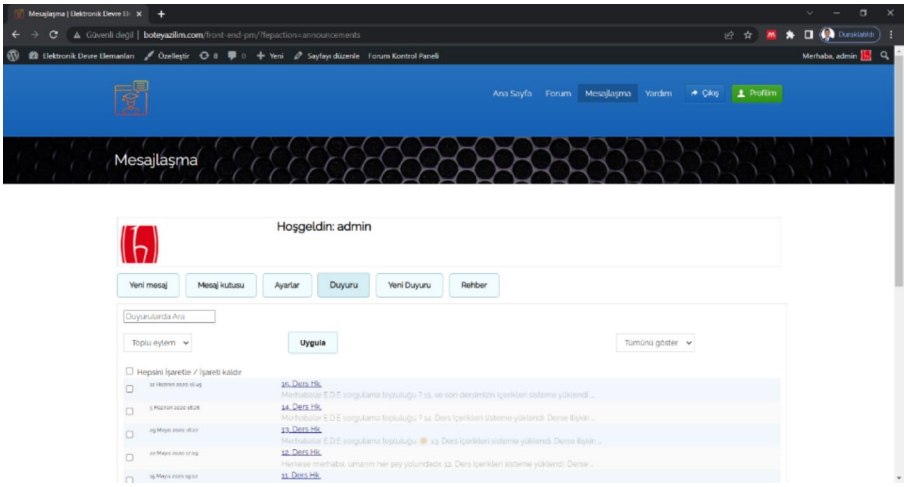

Fig. 4 Messaging Module Screenshot

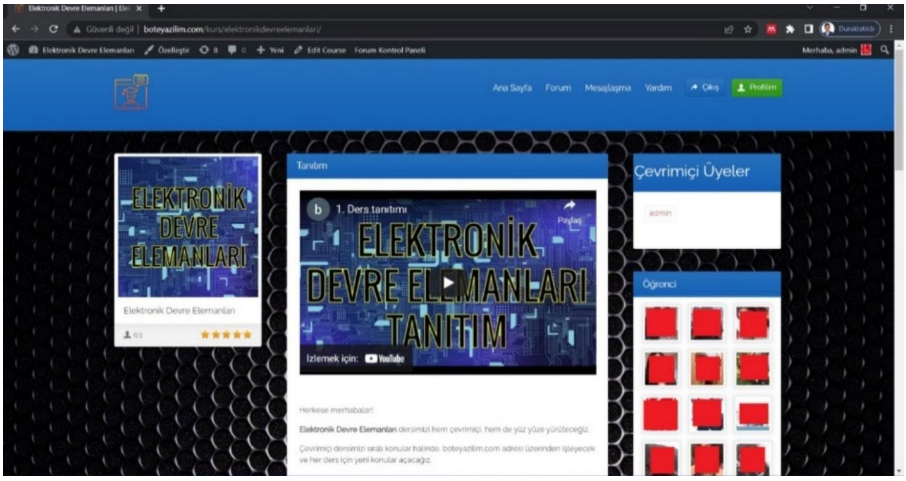

Fig. 5 Introduction Page Screenshot

staff, assistant and classmates of the course. Thus, only the teaching staff, assistant and students of this course were able to access the forum. In the forum, users could open discussion topics and see the posts made under these topics in order of posting time. Students, if they wished, could be instantly informed about new forums, topics or new posts by "subscribing" to the topics or the entire forum, via e-mails sent automatically by the system. In the forum module, there was a profile page feature where the content and statistics of each student's activities in the forum were kept and any student could access it at any time by clicking on the name of the relevant person. This feature made it possible to view information about the student's forum posts, topics they've opened, likes they've given and received, and activity history

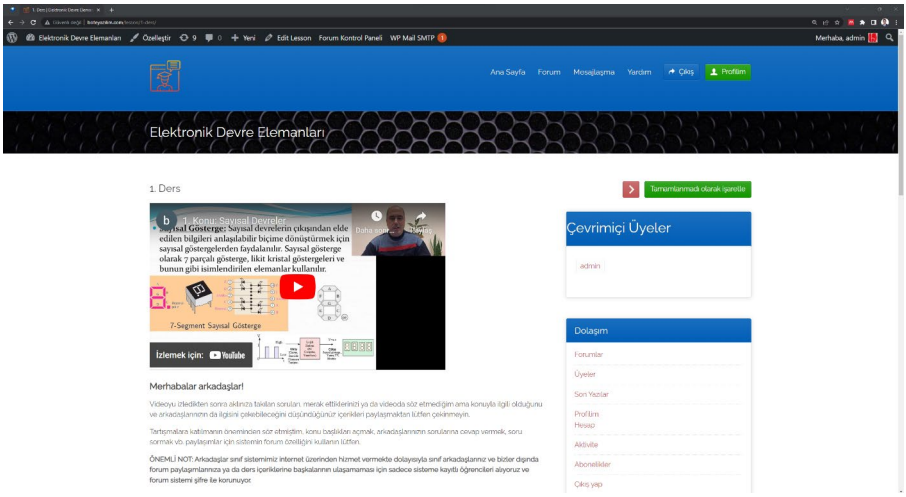

Fig. 6 Course Content Page Screenshot

as a member. A screenshot of this feature of the system containing a student's post history is presented in Fig. 7.

In addition to being able to respond directly by "quoting" from other users' posts, users also had the opportunity to appreciate other students' posts by using the "like" button. Information about who liked the posts was located in the lower left part of the sharing card. In addition, the number of posts made by each participant was included in the sharing cards. A sharing card containing a student's post is given in Fig. 8.

A "badge" feature was also added to the system. The badge appeared on users sharing cards as half stars, then full stars, 2 stars, 3 stars,… and finally a trophy, after every 10 posts based on the quantity of posts made by them. Students were regularly reminded that the badges awarded served merely as incentive tools and that the quality of posts mattered more than their quantity. However, in order to increase the number of posts and earn a better badge, some of the students posted sometimes unrelated of the discussion topics. Therefore, the badges were removed from the system at the request of the majority of students.

The forum module was also a data collection tool. As shown in Fig. 9, students opened topics, discussed, learned, taught and created knowledge for 15 weeks. After the 15 weeks implementation process, the post data were collected from the system for this study.

2.4.2 Educational videos

Since it is not an easy task to prepare videos to be used for the flipped learning approach, it requires a substantial amount of effort and time from the instructors before the semester starts (Brady & Voronova, 2023). For the topics divided into number of weeks, 62 lectures and question solution videos were shot. The length of the lecture videos varied from 1 to 25 min. The duration of the question-solving videos varied between 2 and 40 min, depending on the intensity of the topics. During the

Fig. 7 Forum-Activity Page Screenshot

preparation process of the videos, which were multimedia materials, "12 principles of multimedia learning" suggested by Mayer (2017) and "Five ways to increase the effectiveness of instructional video" suggested by Mayer et al. (2020) were taken as a basis. The multimedia learning theory proposed by Mayer (2017) is based on dual coding (Paivio, 1986), limited capacity (Baddeley, 1999; Sweller et al., 2011) and active processing (Mayer, 2009; Wittrock, 1989) theories. Multimedia learning theory aims to create multimedia teaching messages that are based on the cognitive processes of "selecting, organizing and integrating" and that do not overload the visual and verbal channels in working memory.

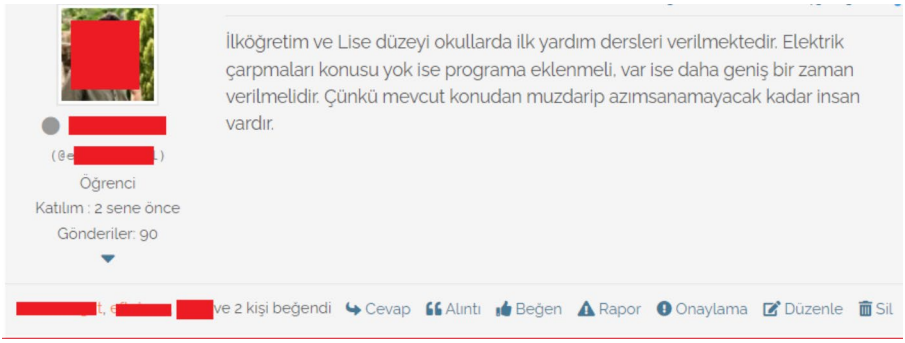

Fig. 8 Sharing Card Screenshot

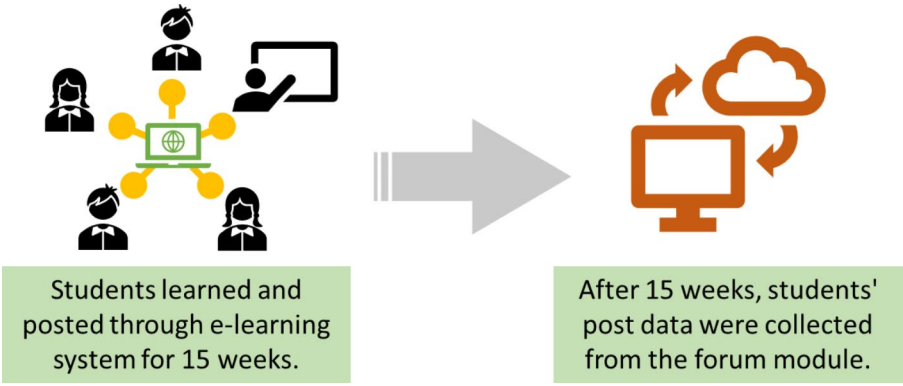

Fig. 9 Data Collection from the Forum Module

2.4.3 Designing a learning approach

Within the scope of this study, "Guidelines for Practice" (Garrison, 2011), which include suggestions for providing teaching, social and cognitive presences in the e-learning experience, were the framework around which this study was built on. Based on this very comprehensive practice guide, from the perspective of teaching presence and its three sub-dimensions "design and organization", "facilitating discourse" and "direct instruction", the social and cognitive presences were designed in detail. The community of inquiry model consists of three intersecting elements, and an activity for the formation of one element can affect other elements as well. Nevertheless, which type of presence these efforts primarily targeted is presented in parentheses below.

Adaptation training was organized by the teaching staff in the first lesson so that students could adapt to learning with the flipped learning approach designed with the community of inquiry model, which was new to them. In the first lesson, which took place in a face-to-face classroom environment, detailed information was given to the students about the learning and evaluation methods and techniques of the class. Students were informed that due to collaborative constructivist approach's nature, the

learning process was shaped in a way that involves them as active participants who search for, question, and create shared meaning (design and organization – social presence).

In the first week of the implementation process, practices were carried out for the students to adapt to the e-learning system, open topics, create questions and get used to the method of creating knowledge by researching, questioning and discussing (design and organization – cognitive presence). At every opportunity, students were encouraged to open topics, ask questions, and participate in open topics (design and organization – cognitive presence). It was stated by the teaching staff to the students that they should not be limited to the information in the videos, that what they desired to learn about the subjects was more significant, and that the active participation of the students in the process was expected (design and organization – cognitive presence). Right after the first lesson, students started to register to the system and they were able to access the course content. At this stage, ice-breaking activities (Chlup & Collins, 2010) were used (design and organization – social presence). Videos on the subject of "digital circuits" were uploaded to the system and a forum called "Introduction and Digital Circuits" was opened for the course. In this forum, the researcher opened a topic called "Meeting" and introduced himself to the students and gave information to the students about his purpose and function of being with them. Students also introduced themselves under this topic. Then, a topic titled "Expectations from the Course" was opened, which also served as an icebreaker for information exchange and shaping the course. With these activities that acted as icebreakers, the students not only made their first interaction with the system, but also communicated with their course assistant (researcher) and classmates and gained knowledge about each other (design and organization – social presence). After these two ice-breaking practices, a student opened a topic with the title of "Your Predictions About the Class" completely of his own accord. The student who opened the topic, asked his friends to share their predictions about the class based on the information given by the teaching staff in the face-to-face lesson, their experiences with the e-learning system, and their feelings and thoughts about the learning approach planned to be implemented. This topic served as the third icebreaker by eliciting student reflections about it.

In order to prevent the isolation that could be experienced due to the nature of e-learning, several adjustments were done. The "online members" module was added to the e-learning system, which showed the students who were active in the system at the time (design and organization – social presence). Moreover, separate WhatsApp groups were created for both students and moderator groups. Notifications were sent to students on new developments on a continuous basis, both through the system and via e-mail. Constant stimuli were sent to them in an effort to surround them with other students, the teaching stuff, and the researcher. Students were given both written communication tools and voice dialogue chances to help them address any problem. Students were encouraged to contact the teaching staff or researcher in such situations (design and organization – social presence). Student disputes that were brought up to the teaching staff and the researcher were attempted to be settled gently while being careful not to discourage the students (facilitating discourse - social presence).

Students were given an appropriate level of control over the determination of activities, research topics, learning resources, student groups, and modules integrated

into the system (design and organization – social presence). For example, in the 3rd week of the course, education was suspended for 3 weeks at the university where the application was made due to the Covid-19 pandemic. However, since this study was being conducted on an online platform and it was possible to continue, the decision to continue or suspend the course was left to the students. For this purpose, a topic called "About the 3-week break" was opened and students were asked to make a decision on this subject. All of the students who answered expressed a desire to continue the lesson, and it was decided to continue the lesson in this direction. In practice, the teaching presence was shared between the teaching staff and the students (direct instruction - social presence). Videos were prepared by the teaching staff and the researcher, but the responsibility of moderation of the discussions in the e-learning system was given to the student groups. Meanwhile, the roles of the teaching staff and researcher were limited to monitoring the discussions, intervening where necessary, and guiding the moderator groups (facilitating discourse - cognitive presence). The choice of group mates was left to the students (design and organization – cognitive presence). The students were assigned moderator responsibilities beginning with the seventh week. The instructor's responsibilities in online learning are comparable to those of the moderator, and these responsibilities are valued for their contribution to establishing teaching presence (Dikmen, 2021). For each moderator group, a WhatsApp group consisting of students and researcher was created and they were in contact throughout the week. For them to be able to get prepared, the videos for each responsible moderator group were shared only with them, 1 week before the forum was opened (design and organization – cognitive presence).

Students were asked to add their own photos to their profile page, and it was ensured that they were registered in the system with their own real names, aiming the formation of the perception that they were in the system as real individuals (design and organization – social presence). Although the "Electronic Circuit Elements" course covered in this research was a very comprehensive and intensive course, attention was paid to keep the educational videos as short as possible. In this way, it was hoped to convey to the students that the processes of collaborative knowledge creation were more significant than assimilation of the information of the lesson's extremely intense videos (design and organization – cognitive presence). Students were informed that research assignments, participation in discussions, final exam and reflection report would be effective in the evaluation of the course, and it was often emphasized that the quality of their participation in the discussions would be the determining factor, not the quantity (design and organization – cognitive presence). The contribution of these tasks to the evaluation was determined as 20% for research assignments, 30% for participation in discussions, 40% for the final exam and 10% for the reflection report, respectively.

The questions asked by the students and the topics they opened were always welcomed and an encouraging and supportive attitude was followed towards the students (facilitating discourse - social presence). The language used by teaching staff in both the synchronous courses and the online platform did not portray a very formal attitude, and students were encouraged to engage (facilitating discourse - social presence). The teaching staff and researcher used the "like" button that was added to the system to commend the commendable posts without interfering with the flow of the

discussions that didn't need their assistance on the forum (direct instruction - cognitive presence). Students also used this feature and supported their friends by using the "like" button for the posts they appreciated. The participation of the students was constantly followed by the researcher both on the system and in the synchronous lessons. Meetings were held with the "hiding" students about whether there was a connection problem, whether there was a reason for their incomplete contribution to the discussions, etc. (facilitating discourse - social presence).

2.5 Data analysis

The data of this research were analyzed with IBM SPSS v 23.0. The data obtained in the study did not provide the normality assumption, which is a prerequisite for parametric tests. For this reason, transformation was applied on the data. Data transformation means restating data with different units and can be used to normalize data (Alpar, 2017). The data showed negative skewness and one of the methods that can be used to normalize negatively skewed data is to transform the data into quadratics. In this study, this method was applied to normalize the data. As a result of the transformation process, the data provided a normal distribution. Repeated Measures ANOVA, Bonferroni Test, Simple Correlation Analysis, Simple Linear Regression Analysis and Dependent Sample t-Test were used for related research questions. The assumptions of all statistical tests and analyzes have been tested.

3 Findings and discussion

The findings and discussion of this research are presented in this section, in the order in which the research questions were presented and in response to these questions.

3.1 The change of community of inquiry perceptions over time

The first research question of the study was designated as "How do students' perceptions of presences change over time?". The data obtained from the 3 measurements with "Community of Inquiry Instrument" was used for this research question. The means for all teaching, social, and cognitive presence items are shown in Tables 2 and 3, and 4, respectively, without being square-transformed.

Repeated Measures ANOVA was performed for each sub-dimension and the total scores. Repeated-measures ANOVA relies on the assumption of sphericity. To test this assumption, Mauchly's test of Sphericity was conducted. Mauchly's test of sphericity was not significant for teaching presence, $\chi^2(2)=4.50$, $p=.11$ and social presence, $\chi^2(2)=4.09$, $p=.13$. As for cognitive presence, $\chi^2(2)=8.52$, $p=.01$, and total scores $\chi^2(2)=6.79$, $p=.03$, Mauchly's test indicated that the assumption of sphericity had been violated. Therefore, Huynh-Feldt correction was applied for cognitive presence ($\varepsilon=0.85$), and total scores ($\varepsilon=0.88$). The results are given in Table 5.

The repeated measures ANOVA revealed that, between at least two measurement times, there were significant differences between students' perceptions of the community of inquiry in terms of all three dimensions and total scores. According to

Table 2 Teaching Presence Item Means

Teaching Presence Items		First Measurement		Second Measurement		Third Measurement	
		$\overline{X}$	SD	$\overline{X}$	SD	$\overline{X}$	SD
1.	The instructor clearly communicated important course topics.	3,97	1,04	4,23	0,49	4,40	0,77
2.	instructor clearly communicated important course goals.	4,11	0,93	4,23	0,55	4,37	0,77
3.	The instructor provided clear instructions on how to participate in course learning activities.	4,46	0,74	4,31	0,47	4,43	0,78
4.	The instructor clearly communicated important due dates/time frames for learning activities.	3,69	1,30	4,17	0,71	4,14	1,09
5.	5. The instructor was helpful in identifying areas of agreement and disagreement on course topics that helped me to learn.	3,54	1,07	4,06	0,73	3,74	1,01
6.	The instructor was helpful in guiding the class towards understanding course topics in a way that helped me clarify my thinking.	3,94	0,94	4,09	0,74	3,83	1,04
7.	The instructor helped to keep course participants engaged and participating in productive dialogue.	3,89	0,96	4,14	0,73	4,03	0,95
8.	The instructor helped keep the course participants on task in a way that helped me to learn.	3,57	0,81	3,77	0,88	3,74	0,95
9.	The instructor encouraged course participants to explore new concepts in this course.	3,43	1,27	3,66	0,76	3,54	0,95
10.	Instructor actions reinforced the development of a sense of community among course participants.	3,46	1,17	3,77	0,77	4,03	0,89
11.	The instructor helped to focus discussion on relevant issues in a way that helped me to learn.	3,31	1,25	3,77	0,77	4,06	0,76
12.	The instructor provided feedback that helped me understand my strengths and weaknesses.	2,54	1,27	3,26	0,78	3,51	0,74
13.	The instructor provided feedback in a timely fashion.	2,37	1,24	4,09	0,92	4,14	1,03

the results given in Table 5, there was a significant effect of time on teaching presence [$F(1, 34)=8.46$, $p=.00$, $\eta_p^2=0.20$], social presence [$F(1, 34)=15.93$, $p=.00$, $\eta_p^2=0.32$], cognitive presence [$F(1.70, 57.79)=13.74$, $p=.00$, $\eta_p^2=0.29$], and total scores [$F(1.77, 60.00)=16.98$, $p=.00$, $\eta_p^2=0.33$] at the $p<.05$ level. Partial eta-squared -the ratio of variance associated with an effect, plus that effect and its associated error variance (η_p^2) values indicate small ($\eta_p^2 \geq 0.01$), medium ($\eta_p^2 \geq 0.06$), or large ($\eta_p^2 \geq 0.14$) effects (Richardson, 2011). As shown by the partial eta-squared values in Table 5, all the repeated measurement mean scores were largely affected by time. The Bonferroni test was performed to determine when the difference emerged. The results are given in Table 6.

As a result of the Bonferroni test given in Table 6, a relationship had emerged in terms of teaching presence scores $\overline{X}_{TP1} < \overline{X}_{TP2} = \overline{X}_{TP3}$, in terms of social presence

Table 3 Social Presence Item Means

Social Presence Items		First Measurement		Second Measurement		Third Measurement	
		$\overline{X}$	SD	$\overline{X}$	SD	$\overline{X}$	SD
14.	Getting to know other course participants gave me a sense of belonging in the course.	3,11	1,30	3,29	0,89	3,60	1,26
15.	I was able to form distinct impressions of some course participants.	2,66	1,21	3,66	0,94	3,91	1,09
16.	Online or web-based communication is an excellent medium for social interaction.	2,74	1,22	2,97	0,98	2,94	1,19
17.	I felt comfortable conversing through the online medium.	2,83	1,34	3,23	1,06	3,34	1,06
18.	I felt comfortable participating in the course discussions.	2,43	1,24	3,06	0,97	3,46	1,12
19.	I felt comfortable interacting with other course participants.	2,77	1,29	3,31	1,02	3,57	1,14
20.	I felt comfortable disagreeing with other course participants while still maintaining a sense of trust.	2,71	1,25	3,31	1,05	3,54	1,12
21.	I felt that my point of view was acknowledged by other course participants.	2,60	1,19	3,63	0,88	3,69	0,99
22.	Online discussions help me to develop a sense of collaboration.	2,74	1,24	3,29	1,18	3,71	1,20

$\overline{X}_{SP1} < \overline{X}_{SP2} = \overline{X}_{SP3}$, in terms of cognitive presence $\overline{X}_{CP1} < \overline{X}_{CP2} = \overline{X}_{CP3}$, and in terms of total scores $\overline{X}_{CoI1} < \overline{X}_{CoI2} = \overline{X}_{CoI3}$. Therefore, it was seen that the first measurement was significantly lower than the second and third measurements in all of the community of inquiry perceptions, and there was no significant difference between the second and the third measurements.

Among the students participating in the study, 52 participants shared posts in the forum. However, among these students, the number of submissions of 17 students who did not voluntarily fill in the scales used in this study were excluded from the scope of the study. In addition to these, the number of 34 posts made by the teaching staff and 21 posts made by the researcher in the forum were also subtracted from the total number of posts. The data obtained from the remaining 35 participants are given in Table 7.

As can be seen in Table 7, a total of 2592 posts were made during 15 weeks. When the number of posts of the teaching staff, the researcher and the students excluded from the study were subtracted, there were 2124 posts left. The curriculum topics divided into weeks were uneven in terms of content and need for research and posting. Therefore, a statistical test could not be conducted on the progress of the number of posts. However, when observed over time, it was seen that students continued to post, shared relatively little in the first weeks, but consistently posted a high number from the 9th week to the 15th week. This finding supports the relationship ($\overline{X}_1 < \overline{X}_2 = \overline{X}_3$) between the measurement times.

The findings of the first research question revealed that students' perceptions of presences were developed in the flipped learning environment designed with the community of inquiry model. In other words, students were involved in a flipped learning environment where individual experiences and ideas were recognized and

Table 4 Cognitive Presence Item Means

Cognitive Presence Items		First Measurement		Second Measurement		Third Measurement	
		$\overline{X}$	SD	$\overline{X}$	SD	$\overline{X}$	SD
23.	Problems posed increased my interest in course issues.	3,00	1,21	3,63	0,91	3,60	1,14
24.	Course activities piqued my curiosity.	3,20	1,35	3,34	1,03	3,80	0,90
25.	I felt motivated to explore content related questions.	3,31	1,23	3,34	0,97	3,71	0,83
26.	I utilized a variety of information sources to explore problems posed in this course.	2,80	1,30	3,83	0,92	4,26	0,85
27.	Brainstorming and finding relevant information helped me resolve content related questions.	3,00	1,31	3,71	0,75	4,11	0,90
28.	Discussing course content with my classmates was valuable in helping me appreciate different perspectives.	2,83	1,29	3,86	0,77	3,80	1,13
29.	Combining new information helped me answer questions raised in course activities.	3,46	1,01	3,86	0,81	3,89	0,90
30.	Learning activities helped me construct explanations/solutions.	3,31	1,32	3,91	0,78	3,71	0,86
31.	Reflection on course content and discussions helped me understand fundamental concepts in this class.	2,71	1,27	3,63	0,91	3,74	0,95
32.	I can describe ways to test and apply the knowledge created in this course.	2,54	1,15	3,20	0,72	3,57	0,95
33.	I have developed solutions to course problems that can be applied in practice.	2,54	1,22	3,00	0,80	3,29	0,99
34.	I can apply the knowledge created in this course to my work or other non-class related activities.	2,94	1,14	3,23	0,91	3,57	1,01

Table 5 Repeated Measures ANOVA Results

	Source	Type III Sum of Squares	df	Mean Square	F	p	η_p^2
Teaching Presence	Time	6653560.13	1	3750435.27	8.464	0.00	0.20
	Error (Time)	26726249.87	34	443084.64			
Social Presence	Time	3382707,79	1	1691353,90	15.93	0.00	0.32
	Error (Time)	7220769,54	34	106187,79			
Cognitive Presence	Time	10141474,65	1.70	5966942.77	13.74	0.00	0.29
	Error (Time)	25091647,35	57.79	434211.20			
Community of Inquiry	Time	554056155,70	1.77	313961651.40	16.98	0.00	0.33
	Error (Time)	1109545954,00	60.00	18492226.20			

discussed in the light of social knowledge, norms and values (Garrison, 2011) and experienced social, technological, and pedagogical processes that led to collaborative knowledge construction (Shea & Bidjerano, 2009, 2010). Students' perceptions of teaching presence developed, and they achieved personally meaningful and educationally valuable learning outcomes (Anderson et al., 2001). Students' perceptions of social presence developed and their ability to reflect their personal characteristics and

Table 6 Bonferroni Test Results

	(I) Time	(J) Time	Mean Difference (I-J)	Std. Error	p
Teaching Presence	1	2	-502.829*	161.594	0.01
		3	-560.486*	163.738	0.01
	2	1	502.829*	161.594	0.01
		3	-57.657	120.227	1.00
	3	1	560.486*	163.738	0.01
		2	57.657	120.227	1.00
Social Presence	1	2	-299.057*	70.453	0.00
		3	-428.629*	90.215	0.00
	2	1	299.057*	70.453	0.00
		3	-129.571	71.422	0.24
	3	1	428.629*	90.215	0.00
		2	129.571	71.422	0.24
Cognitive Presence	1	2	-499.371*	138.904	0.00
		3	-747.286*	174.800	0.00
	2	1	499.371*	138.904	0.00
		3	-247.914	115.788	0.12
	3	1	747.286*	174.800	0.00
		2	247.914	115.788	0.12
Community of Inquiry	1	2	-4041.143*	907.612	0.00
		3	-5411.314*	1149.762	0.00
	2	1	4041.143*	907.612	0.00
		3	-1370.171	807.133	0.30
	3	1	5411.314*	1149.762	0.00
		2	1370.171	807.133	0.30

*$p<.05$

Table 7 Findings Regarding the Posts Made by Study Group

Week	Total Posts	Excluded Posts	Net Post Count
1	111	56	55
2	59	14	45
3	45	14	31
4	230	17	213
5	89	23	66
6	33	9	24
7	60	15	45
8	41	16	25
9	172	26	146
10	400	91	309
11	162	15	147
12	217	23	194
13	447	59	388
14	418	88	330
15	108	2	106
Total	**2592**	**468**	**2124**

present themselves as "real people" to other participants in the learning community where they do not come together physically has increased (Garrison et al., 2000). In addition, with the development of students' perceptions of cognitive presence, their levels of construct and confirm meaning through sustained reflection and discourse (Anderson et al., 2001; Garrison & Arbaugh, 2007) also improved in the process.

The findings on how students' perceptions of presences change in a flipped learning environment designed using the community of inquiry model broadly correspond with previous research. Antonio (2022) stated that this learning approach provides flexibility and convenience to the students, offers more reinforcement, and the students' perceptions of the community of inquiry emerges in all three presences. Günbatar (2021a) measured the cognitive, social and teaching presence perceptions of the students at the end of the flipped learning process, which he designed for the effective teaching of technical and abstract concepts and his study revealed that these perceptions were at a very high level. According to Kim (2017), the flipped learning approach designed with the community of inquiry model considerably aided in the development of practical lessons and students' perceptions of the community of inquiry. According to Stover and Houston (2019), flipped learning design improves students' attitudes toward lessons that are typically regarded as difficult or boring, increases their satisfaction, and improves their perceptions of social and teaching presences. Wu et al. (2017) stated that this learning approach facilitates meaningful and positive cooperation and leads to more active participation and revealed that students' perceptions of community of inquiry develop in all three dimensions.

Contrastingly, Antonio (2022) underlined that during the asynchronous lessons, the interaction of the students with the instructor and the time allocated for synchronized meetings were insufficient. It is possible that this situation was due to the learning approach that Antonio designed. In his study, a flexible learning toolkit was developed with pre-recorded video lectures, reading materials, activity sheets and lecture notes and it was delivered to students via e-mail. After the students independently studied these materials, synchronous in-class online meetings were held. Stover and Houston (2019), similar to Antonio (2022), designed a flipped learning approach by presenting educational materials to participant students, requiring them to study the materials and then join the in-class activities. It can be seen that in these studies, the pre-class process was not structured according to the theoretical framework of the community of inquiry. It is evident that in these studies, students were left to work on their own during the pre-class activities rather than having them organized in accordance with the community of inquiry's theoretical framework. At the end of the process, Stover and Houston (2019) stated that the cognitive presence perceptions of the students did not change during the process. However, in such a design, it is necessary to provide opportunities for the development of students' commitment to the community in pre-class activities. Students should be given the chance to carry out and maintain their communication with the community and learn collaboratively through critical thinking and discourse. Students shouldn't encounter a shortage of engagement or time if learning experiences are created in this way, which also can help students build presences. The discrepancy between the findings of this study and those of the previous studies is assumed to be the outcome of these circumstances.

3.2 The change of critical thinking strategy over time

The second research question of the study was designated as "How do students' critical thinking strategies change over time?". In this research question, the change in the critical thinking strategy scores of the students at the beginning and end of the process according to time were examined. For this purpose, dependent samples t-test was performed, and the results are given in Table 8.

As shown by the findings in Table 8, students' critical thinking strategies had changed significantly over time (t=-6.14, $p<.05$). In other words, the critical thinking strategies used by students improved significantly in the flipped learning environment designed with the community of inquiry model. No other study has been found in the literature examining the relationship between students' critical thinking strategies and their perceptions of the community of inquiry in flipped learning approach designed with the community of inquiry model. However, research on deep and meaningful learning can be addressed given that they are related to critical thinking, which is at the core of the community of inquiry framework (Akyol & Garrison, 2011; Garrison & Archer, 2000; Günbatar, 2021b; Le Roux & Nagel, 2018) found out in their experimental studies that, flipped learning classrooms designed with the community of inquiry model contributed to the deep and meaningful learning of the students. From this point of view, it can be said that this learning approach develops the critical thinking strategy and these findings of the study are in parallel with the literature.

3.3 The relation between community of inquiry perceptions and critical thinking strategy

The third research question of the study was designated as "What kind of a relationship is there between students' presence perceptions and their critical thinking strategies?". For this research question, students' critical thinking strategy and community of inquiry scores that were measured at the end of process were used. Simple correlation analysis was performed for this research question and the results are given in Table 9.

According to the results of the analysis given in Table 9, a significant relationship was observed between the critical thinking strategy and the perceptions of the community of inquiry. A high level of positive correlation was found between the variables ($r=.78$, $p<.01$). A simple linear regression analysis was carried out to determine the effect of the critical thinking strategy on how the community of inquiry was perceived, and the results are shown in Table 10.

Critical thinking strategy and the perceptions of community of inquiry were seen to be significantly correlated, as shown by the findings of the simple linear regres-

Table 8 Dependent Samples t-Test Results

	N	$\bar{X}$	SD	t	p
Critical Thinking Strategy (1st Measurement)	35	624.60	223.91	-6.14	0.00
Critical Thinking Strategy (2nd Measurement)	35	779.49	256.29		

*$p<.05$

Table 9 Findings Related to Simple Correlation Analysis

		Critical Thinking Strategy (2nd Measurement)	Community of Inquiry (3rd Measurement)
Critical Thinking Strategy (2nd Measurement)	Correlation	1	0.78**
	p		0.00
	N	35	35
Community of Inquiry (3rd Measurement)	Correlation	0.78**	1
	p	0.00	
	N	35	35

***p<.01*

Table 10 Findings on Simple Linear Regression Analysis

Variable	*B*	Std. Error	t	p
Constant	4691.99*	1845.91	2.54	0.02
Critical Thinking Strategy	15.88*	2.25	7.05	0.00

**p<.05*

sion analysis presented in Table 10 ($R=.78$, $R^2=0.60$). Critical thinking strategy was found to be a meaningful predictor (F (1, 33)$=49.68$, $p=.00$). 60% of the variation in the community of inquiry perceptions was explained by the critical thinking strategy. The significance test of the coefficient of the critical thinking strategy variable ($B=15.88$), which is the main predictor in the regression equation, also showed that this variable was a significant predictor. According to the results of the analysis, the regression equation was calculated as Community of Inquiry Score = 15.88 x (Critical Thinking Strategy Score) + 4691.99.

4 Conclusion and recommendations for future research

4.1 Conclusion

It is emphasized in the literature that the flipped learning approach has favorable impacts on a number of learning outcomes. However, it is stressed that the pre-class component of this approach is weak since there is not sufficient interaction and feedback taking place. In this study, this pre-class component of the flipped learning approach was designed with the framework of the community of inquiry. An e-learning system was developed in accordance with the community of inquiry model's theoretical underpinnings, and 35 students experienced learning with this approach over the course of a 15-week implementation process. The effects of this learning approach on the learners' critical thinking strategies and perceptions of presences were examined. Thus, the results of the effort to address the weaknesses in the flipped learning approach by supporting it with the community of inquiry model were tried to be determined.

All the processes of the course, which was created on the basis of the flipped learning approach, were handled in detail. Well-managed, structured and organized flipped classrooms provide better learning outcomes by encouraging independent learning and critical thinking (Breivik, 2015; Kellogg, 2013). The guidelines offered

by Mayer (2017) and Mayer et al. (2020) served as the foundation for creating the course's instructional videos. Garrison (2011) provided the basis for creating the flipped learning approach's pre-class component. According to the guidelines of the community of inquiry model, students are required to be engaged in a collaborative and reflective process that includes understanding a topic or problem, seeking relevant information, combining and integrating information, and actively confirming the meaning created. The e-learning system that was developed within the scope of this study in order to create a suitable infrastructure for the requirements of the theoretical framework was equipped with a large number of modules supporting collaborative learning. In order to ensure uninterrupted communication between student-student-teaching staff, various communication channels were offered to students, both inside and outside of the e-learning system. As a means to develop students' critical thinking strategy, which is at the center of the community of inquiry model, a strategy offered by Golding (2011) was used.

The study's results revealed that by designing the pre-class component of the flipped learning approach with the framework of the inquiry community model, it was possible to eliminate the disruptions in the interaction and feedback processes and develop students' critical thinking strategies and their perceptions of instructional, social, and cognitive presences. As the first key finding of the study, students' perceptions of community of inquiry showed a significant development. It was revealed that the scores of the students' presences before the implementation were significantly lower than the other two measurements, and the last two measurements did not show a significant difference.

Within the scope of this research, the effect of flipped learning approach on students' critical thinking strategies was also examined. In the study, students' critical thinking strategies were measured at two different times; before and after the implementation. As the second key finding of the study, students critical thinking strategies showed a significant development. In addition, the relationship between students' critical thinking strategies and their perceptions of presences was analyzed with end-of-process measurement scores. And as the third key finding of the study, it was revealed that there was a positive, high-level relationship between these two variables. The last key finding of the study was that the critical thinking strategy was a key predictor of students' perceptions of community of inquiry presences and that critical thinking strategy was accounted for 60% of the variance in the perception of community of inquiry in the flipped learning environment.

4.2 Implications and future research

In the traditional flipped learning approach, students experience a lack of interaction and feedback pre-class. Therefore, while designing flipped learning environments, pre-class processes should be designed effectively to avoid such shortcomings. The community of inquiry model is one efficient way of designing the pre-class component of flipped learning.

The features of existing LMSs or social media platforms are insufficient in executing course-related processes with a community of inquiry model. The shortcomings of these systems in terms of learning can also be reflected in the study results. For this

reason, it should be preferred to develop an e-learning system or using a system (if any) that can meet these needs in order to create and develop the presence elements of the community of inquiry model.

The critical thinking strategy strongly influences learning experiences positively in the community of inquiry. Critical thinking strategy therefore should be particularly addressed in studies conducted within this framework.

The participants of this study consisted of undergraduate students aged between 19 and 21 who were studying in the same department at a state university. Future studies can contribute to the scope of relevant findings in the literature by working with students of different ages, departments and education levels.

In this study, a semi-experimental study was conducted with a single group. In future studies, a flipped learning group designed with the community of inquiry model can be assigned as the experimental group and a traditional flipped learning group can be assigned as the control group, and the comparative effects of the implemented approach can be determined.

Students' perceptions of the presences were measured in 3 different time periods (2nd week, 8th week, post-implementation) in this research. In the middle of the implementation process of the study, the students were given moderator roles, and then measurements were made with the expectation that this situation might have a significant effect on the students' perception of presences. However, the results did not meet the expectations. This may suggest that the moderator duties given to the students were not sufficient enough to change their perception of presences. By offering students additional or alternative responsibilities, future research can investigate how their perceptions of presences vary.

5 Limitations

This study has certain limitations. The implementation of this study started with a study group consisting of 52 volunteer students. However, 17 students did not answer at least one of the scales that were applied repeatedly during the process. For this reason, the data of these 17 students were excluded from the scope of the study. This study is limited to data from the remaining 35 students.

"Electronic Circuit Elements" course was used in conducting this study and the curriculum topics divided into 15 weeks were uneven in terms of content and need for research and posting. Therefore, a statistical test could not be conducted on the progress of the number of posts. This situation created another limitation for this study. Future research can statistically test the progress of students' posts over time by conducting a study on a course that shows equality in terms of the distribution of topics.

Data Availability The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Conflict of interest None.

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