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Comparing the Effectiveness of Online, Flipped, and In-Class Critical Thinking Instruction on Critical Thinking Skills and Dispositions in Higher Education: Flipped Classroom Produces the Greatest Gains

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Comparing the Effectiveness of Online, Flipped, and In-Class Critical Thinking Instruction on Critical Thinking Skills and Dispositions in Higher Education: Flipped Classroom Produces the Greatest Gains

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Abstract

This study aimed to investigate the effect of online, flipped, and in-class critical thinking teaching on critical thinking skills and dispositions of university students. Pretest-posttest control group quasi-experimental design was employed in this study that has three experimental groups and one control group. In the first experimental group, critical thinking teaching was conducted fully online. In the second experimental group, flipped classroom approach was employed while teaching critical thinking. In the third experimental group, critical thinking teaching was conducted in face-to-face classes. Watson-Glaser Critical Thinking Test and Sosu Critical Thinking Dispositions Scale were used to collect the data. Online, flipped, and in-class explicit critical thinking instructions enhanced university students' critical thinking skills and dispositions with a large effect. Also, the most effective learning environment to promote critical thinking skills and dispositions was flipped, online, and in-class, respectively.

Introduction

Critical thinking (CT) can be defined as a reflective, reasonable, and functional way of thinking which is employed by individuals while deciding what to believe or what to do (Ennis, 1991). Individuals can defend themselves against false information in today's world thanks to CT (Epstein & Kernberger, 2012) which is a logical way of dealing with arguments, ideas, and evidences (Ruggerio, 1988). Individuals question and evaluate every piece of information they acquire through CT and they can decide to believe it or not (Lewis & Smith, 1993). CT was defined as "purposeful, self-regulatory judgment which results in interpretation, analysis, evaluation, and inference, as well as explanation of the evidential, conceptual, methodological, criteriological, or contextual considerations upon which that judgment is based" in a Delphi project by APA (Facione, 1990, p.2). Considering this definition, it can be said that CT is a sophisticated thinking process (Halpern, 2003) and involves some cognitive skills such as evaluating evidence, arguments, or claims, identifying assumptions, deducing conclusions (Pascarella & Terenzini, 1991), making inferences through induction or deduction (Facione et al., 2000; Lai, 2011).

However, CT is not only about these cognitive skills but also some dispositions such as being innovative, self-confident, open-minded, objective, or willing to seek the truth (Ennis, 2018). Thanks to CT dispositions,

individuals can recognize when a skill is required and use the right skill in the right context in life. Also, CT dispositions are about being willing to exert the mental effort to use CT skills (Halpern, 1998). It can be said that CT dispositions are as essential as CT skills because individuals need CT dispositions to use CT skills in daily life and individuals who have both CT skills and dispositions at the same time can be considered as adequate critical thinker (Profetto-McGrath, 2003). So, the enhancement of both CT skills and dispositions should be aimed in the education of successful critical thinkers (Facione, 1990).

Great importance is attached to the improvement of CT at every school level (Stassen et al., 2011) and it is seen as an important outcome (Halpern, 1998) and primary goal (Astin, 1993; Stedman & Adams, 2012) of education systems today because CT which is accepted as primary element of 21st century education (Trilling & Fadel, 2009) is vital for academic achievement (Orhan, 2022) and it will advance the quality of education (Ren et al., 2020). Also, CT is the foundation of democratic society and it is an essential tool for individuals to liberate force in education and powerful resource in their personal and civic life (Facione, 1990). In addition, CT is a vital skill in the world of employment and work as well (Al-Zou'bi, 2021). CT is regarded as one of the essential skills to be required in the world of work in near future (Schleicher, 2016; World Economic Forum, 2020).

Critical Thinking Teaching

Although the importance of CT is a widely-accepted belief, there is an on-going debate on how it should be taught (Bellaera et al., 2021; Caceres et al., 2020). CT can be promoted through a proper education (Butler et al., 2017; Scriven & Paul, 2005). However, different suggestions on how this proper education should be performed can be found in the literature. These different suggestions can be grouped broadly under two titles which are implicit and explicit CT instruction.

In implicit instruction, CT is not taught explicitly (Hager & Kaye, 1992) and it is expected that CT skills will promote naturally through activities such as role play, pair work, group work, and discussion that are mostly used while teaching the course content (Gann, 2013). It can be said that teacher has a second agenda which is to promote CT during the course. As CT depends on content and has a strong relation with it, individuals cannot use CT skills without having necessary knowledge on the course content (McPeck, 1981; Willingham, 2008). Therefore, CT should be immersed in the course content and promoting CT skills should be secondary aim of each and every course because CT skills are not independent from the content and they cannot be learned at once (Ruggerio, 1988).

In explicit instruction, CT is taught explicitly without the subject area in a separate course because CT teaching does not need any content (Ennis, 1997). Also, CT can be promoted through well-planned activities and the only way to do this is that teaching CT explicitly in a separate course (Van Gelder, 2005). In this separate course which does not have any other content and whose only aim is to promote CT, individuals do not struggle with learning the information on the subject area and they only focus on CT skills and spend their time and effort to acquire CT skills (Gann, 2013). Also, it is much easier to transfer CT skills to different areas or real-life situations if they are acquired independently of a subject area (Ennis, 1997; Haskell, 2001).

There are many previous studies investigating the effect of implicit (Bağ, 2020; Lopez et al., 2020) and explicit (Arısoy & Aybek, 2021; Taghinezhad & Riasati, 2020; Zulkifli & Hashim, 2020) teachings on CT skills or dispositions. These studies reported that all CT teachings (explicit or implicit) significantly promoted CT skills or dispositions of the students. However, most of the previous experimental (Marin & Halpern, 2011; Orhan & Çeviker Ay, 2023) and meta-analysis (Abrami et al., 2008; Çeviker Ay & Orhan, 2020) studies concluded that explicit CT instruction is much more effective than implicit instruction to promote CT skills or dispositions.

In short, there are many studies investigating the effect of different CT instructions independently or comparing the effects of these instructions. Although previous studies concluded that CT can be improved with both explicit and implicit instruction, explicit instruction is more effective. However, another question arises here. Should CT be taught only in-class or are any other learning environments including digital technologies effective to promote CT? Related literature indicates that online learning (OL) environments enhanced with digital technologies have high potential to promote CT skills and dispositions (Alsulami, 2016; Boucher et al., 2013; Caceres et al., 2020; Chang et al., 2022; Tathahira, 2020).

Online Critical Thinking Teaching

OL in higher education has been demanded highly for the last twenty years with the rapid growth of new technologies (Tathahira, 2020; Phirangee et al., 2016) and this demand has reached its peak especially after Covid-19 pandemic. Therefore, the higher education systems have been in a dramatic change due to this increasing demand (Astleitner, 2002; Goodsett, 2020). Education systems have moved from a physical classroom to online environments recently thanks to digital technologies (Saad´e et al., 2012). OL environments have a potential to promote CT and some benefits (Tathahira, 2020) when compared to in-class teaching. OL is flexible, much more self-paced and students are free to watch/review online course materials when or where they want. Also, online CT teaching allows students to reflect more on the content, interactions, exercises, and assignments because they do not have any time limit. In addition, in an OL environment, students do not have to think and respond quickly like in traditional in-class environment and they can ponder, examine, investigate, and query before giving an answer. Besides, peer-pressure and self-consciousness that can be a problem for interactions in class do not exist in OL environments thanks to its asynchronous and individualized nature (Horton, 2000). Therefore, it can be said that OL is a compatible, effective, useful, and conducive learning environment to promote CT. However, maintaining the same quality in OL environments that can be achieved in-class education can be challenging (Goodsett, 2020). OL should encourage interaction and student reflection, provide hands-on exercises and activities in a real-life context, and motivate students (Wan Husssin et al., 2019). Also, interplay between content, interactivity, and instructional design is required for OL environments to be effective to enhance CT (Saad´e et al., 2012).

Although it is widely accepted that involving the aim of promoting CT in higher education curriculums is vital for a favorable higher education system, it is still ambiguous how to best promote CT in OL environments (Caceres et al., 2020). Some previous studies investigating how to teach CT online suggest online synchronous or asynchronous discussions as an effective way to promote CT (Foo & Quek, 2019; MacKnight, 2000; Yang et al.

2008). Also, some other tools or platforms such as podcasts, concept mapping tools, and online group collaboration platforms have emerged as important ways to enhance CT online (Kumta et al., 2003; Mandernach, 2006; Şendağ & Odabaşı, 2009). In addition, some online CT courses consist of modules which deliver the units of the course content online are also popular nowadays (Goodsett, 2020). These online courses which may involve videos, tutorials, simulations, and interactive exercises serve as an effective way to promote CT.

Most of the previous research indicated that online project based learning (Cortazar et al., 2021; Kurubacak, 2007), online problem based learning (Schell & Kaufman, 2009; Şendağ & Odabaşı, 2009), and online discussions (Al-Husban, 2020; Arend, 2009; Pena & Almaguer, 2012) significantly promoted CT. Leng et al. (2009) concluded that e-learning model successfully promoted university students' CT in their study aiming to examine the effectiveness of an e-learning model to enhance CT. Similarly, in their systematic review study aiming to understand trends in CT studies in e-learning environments, Chou et al. (2019) concluded that CT was significantly promoted in most of the studies investigating the effect of CT teaching in e-learning environments and CT-infused e-learning activities were more effective to promote CT than face-to-face activities. Yang et al. (2013), who conducted an experimental study with university students to examine the effect of online CT-infused English language instruction using Moodle on CT skills and dispositions, concluded that online instruction promoted CT. Jolley et al. (2022) carried out an experimental study to examine the effect of online, domain-specific, and explicit CT instruction consisting of eight modules on CT skills and concluded that teaching CT online significantly increased CT skills. In a similar way, McClellan (2016) investigated the effect of online CT course consisting of modules that teach CT explicitly and concluded that online CT teaching promoted CT skills of university students. Carmichael and Farrell (2012) investigated the effectiveness of online CT course consisting of seven modules aiming to teach different aspects of CT and concluded that online CT teaching is effective to enhance CT skills of university students. Also, Stedman and Adams (2014) concluded that online and explicit CT instruction promoted CT more than face-to-face CT course in their study aiming to compare the effects of online and face-to-face CT course on CT.

Flipped Critical Thinking Teaching

Previous literature indicated that active and learner-centered strategies such as pair or group activities, discussions, role plays, case studies, and concept mapping are effective to promote CT (Brown et al., 2014). However, teachers cannot use these strategies a lot in class because most of the class time has to be devoted to teachers' lectures in traditional classes (Von Colln-Appling & Giuliano, 2017). Therefore, flipped classroom (FC) approach has important potential to promote CT (Alsulami, 2016; Boucher et al., 2013) because this approach enables teachers to free up in-class time for learner-centered and active learning strategies (Bergmann & Sams, 2012). Teachers can guide, help, and observe the students more in class thanks to FC because they do not have to spend time to lecture the basic information (Missildine et al., 2013; Prokhorova et al., 2021). Therefore, passive learning tasks of knowledge by students is moved outside the class and in-class time is devoted to learner-centered learning activities aiming to construct the knowledge through the extensive interactions, engagement, collaborative learning, and feedback (Bergmann & Sams, 2012; Lai et al., 2020).

Today, FC has gained importance and has been popular because of advancement in digital technologies, especially in higher education (Davies et al., 2013; O'Flaherty & Phillips, 2015). It is a widely-recognized approach that can enable effective use of in-class time for collaborative learning, problem solving, and discussion under the guidance of the teacher (Srisuwan & Panjaburee, 2020) and it has been used by instructors to move the instruction before the class via computer and network technologies and have more time for practice and interaction in class (Shyr & Chen, 2018). It has also been a popular approach to teach CT recently.

Chang et al. (2022) concluded that FC was greatly beneficial to promote students' CT in their experimental study examining the effectiveness of FC on CT. Etemadfar et al. (2020) concluded that FC significantly improved CT of language learning students in their study. Smith et al. (2018) carried out an experimental study to examine the effect of flipped CT course on CT skills of university students. Pre-class part of the course includes videos which try to teach CT explicitly and online quizzes for immediate feedback and in-class activities focus on exercises that apply CT skills. Smith et al. (2018) concluded that flipped CT course significantly improved students' CT skills. Similarly, Asmara et al. (2018) carried out an experimental study aiming to investigate the effect of flipped and explicit CT instruction on CT skills of university students and concluded that flipped CT instruction promoted CT skills more than in-class teaching. In their study aiming to compare the effects of in-class lecture and FC on university students' CT dispositions, Dehghanzadeha and Jafaraghaeeb (2018) concluded that FC approach promoted CT dispositions more than in-class lecture. Kong (2015) carried out a study to examine the effect of CT-infused teaching with FC approach on CT skills of secondary school students and found that FC was effective to promote CT. There are also other studies concluding that FC has a positive effect on CT (Al-Zoubi & Suleiman, 2021; DeRuisseau, 2016; Kong, 2014).

The Current Study

There are many studies examining the effect of explicit or implicit CT instruction in class and most of these studies concluded that both explicit and implicit CT instruction are effective to promote CT skills and dispositions indicating CT is a teachable skill. However, another important question arises here. Should CT be taught only in class or can any other learning environments (online and flipped) be effective to promote CT? With the quick advancement of computer and internet technologies, OL and FC approach have been demanded highly for the last twenty years in higher education (Tathahira, 2020; Phirangee et al., 2016) and this demand has dramatically increased especially after Covid-19 pandemic. As discussed above, theoretical background indicated that OL and FC have important potential to promote CT and previous experimental studies concluded that OL and FC are effective to enhance CT skills and dispositions (Alsulami, 2016; Boucher et al., 2013; Caceres et al., 2020; Chang et al., 2022; Tathahira, 2020).

However, even though the number of studies aiming to examine the effect of online and flipped CT teaching has increased recently (Chou et al., 2019), the capacity of OL and FC approach to promote CT is still worth exploring, especially in higher education (Saad´e et al., 2012). Thus, it can be said that this study is important because it aims to provide additional evidence regarding the effectiveness of online and flipped CT instructions on CT skills and dispositions. Also, the development of CT in OL environments has mainly focused on asynchronous or

synchronous online discussions in previous studies (Chou et al., 2019; Puig et al., 2019). Although online CT courses consisting of modules which teach CT explicitly are also effective to promote CT (Goodsett, 2020), the studies investigating the effect of these online courses are scarce. Therefore, it can be said that there is a clear need to investigate the effect of online CT courses. Thus, with the aim of investigating the effect of online CT courses on CT skills and dispositions, this study is important. Besides, although there are some previous studies comparing the effectiveness of online and flipped CT instructions with traditional in-class CT instruction, the studies comparing the effect of fully online and flipped CT teachings on CT skills and dispositions are really scarce. Therefore, this study differs from previous research with its aim of investigating the effect of different learning environments (online, flipped, and in-class) on CT comparatively and it provides important evidence for the most effective learning environment to promote CT in this era. This study aimed to investigate the effect of CT teachings performed in different learning environments (online, flipped, and in-class) on CT skills and dispositions of university students. To this end, answers to the following questions were sought for:

1. Is there a significant difference between the Watson-Glaser Critical Thinking Test (WGCTT) pretest and posttest scores of the students in experimental group (EG) I (online), EG II (flipped), and EG III (in-class), and control group (CG)?
2. Is there a significant difference among the WGCTT posttest scores of the students in EG I, II, III, and CG?
3. Is there a significant difference between Sosu Critical Thinking Dispositions Scale (CTDS) pretest and posttest scores of the students in EG I, II, III, and CG?
4. Is there a significant difference among the CTDS posttest scores of the students in EG I, II, III, and CG?

Method

Research Design

Pretest-posttest CG quasi-experimental design was employed in this study. CT skills and dispositions of university students were determined as dependent variables of the study while online, flipped, and in-class CT teachings were independent variables of the study. Design of the study can be seen in Table 1.

Table 1. Design Used in the Study

Groups	Pre-test	CT Teaching	Post- test
Experimental Group I	WGCTT+CTDS	online	WGCTT+CTDS
Experimental Group II	WGCTT+CTDS	flipped	WGCTT+CTDS
Experimental Group III	WGCTT+CTDS	in-class	WGCTT+CTDS
Control Group	WGCTT+CTDS	X	WGCTT+CTDS

Note that WGCTT is Watson-Glaser Critical Thinking Test-Form S; CTDS is Sosu Critical Thinking Disposition Scale

In the first EG, CT teaching was conducted fully online using "*Critical Thinking*" online course by Tom Chatfield on *SAGE Campus*. In EG II, FC approach was employed while teaching CT. In other words, students had online and face to face lessons. In EG III, CT teaching was conducted in face to face classes. In CG, no experimental procedures were followed, and the students continued their courses according to existing curriculum. The Watson-Glaser Critical Thinking Test-Form S (WGCTT) and Sosu Critical Thinking Disposition Scale (CTDS) were

implemented as pretests and posttests in all groups.

Research Setting and Study Group

The study was carried out in School of Foreign Languages (SFL) of a state university in northern Turkey. Students need to take a nation-wide examination to be entitled to enter this university. The SFL offers one-year English preparatory education which is delivered in two terms (14-week each term and 20 hours each week). This one-year English education is compulsory for the students who are going to study at departments whose medium of instruction is partly or fully English. However, the students who are going to study at departments whose medium of instruction is fully Turkish can also join the English preparatory courses if they wish. At the beginning of the year, all students have to take a placement test because students are assigned to classes according to the results of this test. The aim of this test is to create classes which are equal to each other in terms of English language proficiency. Same course materials are used in all of the classes.

There were 41 classes in the SFL in the spring term of the academic year of 2021-2022 and the study group (95 university students) was recruited from these classes. Four of these 41 classes were randomly chosen and they were randomly assigned as EGs and a CG. Students have not received any training in CT before and all of them participated in the study voluntarily. A-priori power analysis for ANCOVA was conducted via Faul et al.'s (2007) G*Power 3 software program before the study and it revealed that the minimum sample size for conducting ANCOVA (4 groups and 1 covariate) in this study to detect a large effect (η_p^2=0.20) based on the previous literature would be 73. Therefore, we can say that sample size of 95 in this study was adequate.

Table 2. Demographic Characteristics of the Students

		EG 1		EG 2		EG 3		CG	
Demographic Characteristics		f	%	f	%	f	%	f	%
Gender	Female	14	58.3	13	56.5	14	58.3	11	45.8
	Male	10	41.7	10	43.5	10	41.7	13	54.2
Educational Background of Mother	Primary	3	12.5	1	4.3	2	8.3	2	8.3
	Secondary	3	12.5	3	13.0	4	16.7	2	8.3
	High school	9	37.5	9	39.1	7	29.2	10	41.7
	University	8	33.3	8	34.8	9	37.5	9	37.5
	Master/PhD	1	4.2	2	8.7	2	8.3	1	4.2
Educational Background of Father	Primary	2	8.3	2	8.7	2	8.3	1	4.2
	Secondary	4	16.7	2	8.7	3	12.5	2	8.3
	High school	8	33.3	8	34.8	6	25	10	41.7
	University	8	33.3	9	39.1	11	45.8	11	45.8
	Master/PhD	2	8.3	2	8.7	2	8.3	0	0

There were 24, 23, 24, and 24 students in EG I, EG II, EG III, and CG, respectively. 58.3% of EG I students were females. Most of their mothers (70.8%) and fathers (66.6%) are university and high school graduates. 56.5% of

EG II students were females. Most of their mothers are high school and university graduates (73.9%) while majority of their fathers are graduates of university (39.1%) and high school (34.8%). 58.3% of EG III students were females. Majority of their mothers (66.7%) and fathers (70.8%) are university and high school graduates. 45.8% of CG students were females. 41.7% of their mothers are high school graduates while 37.5% of them have university degree. 45.8% of their fathers have university degree while 41.7% of them are high school graduates. The mean age of the EG I, EG II, EG III, and CG students were 18.58 (SD=0.71), 18.95 (SD=0.76), 18.83 (SD=0.81), and 18.79 (SD=0.83), respectively. The ages of all the students ranged from 18 to 20. Also, there was not statistically significant difference among the pretest scores of the students in four groups for CT skills ($F_{(3, 94)}$=2.684; p>0.05) and dispositions ($F_{(3, 94)}$=1.052; p>0.05).

Procedure

In all EGs, CT was taught explicitly in a separate course. In the morning, all of the students (three EGs and one CG) continued the same preparatory English courses according to existing curriculum from Monday to Friday and the students in EG II and EG III joined the pre-scheduled CT courses (two class hours) in the afternoon once a week while EG I students completed their CT courses online. No experimental procedures were followed in CG. Objectives and the content of the CT teachings in three groups were similar and only learning environments (online, flipped, and in-class) were different. Before the experimental procedure started, I had a meeting with each group and explained the aims of the study and administered the pretests. Also, posttests were administered after the CT teaching ended in each group. Experimental procedure started in the 7th week of the spring term and CT teachings continued for six weeks in total. Therefore, it can be said that the study lasted for 8 weeks including administration of pretests and posttests. I was the instructor of the courses for all EGs. I created three separate virtual classrooms on *Google Classroom* for each EG and invited the students to join these classrooms. We kept in touch via these classrooms outside the school and students asked their questions if they wanted here. No experimental procedures were followed with CG students and they just continued their regular lessons.

Online Critical Thinking Teaching

In the first EG, CT teaching was conducted fully online in an asynchronous mode using "*Critical Thinking*" online course by Dr. Tom Chatfield on *SAGE Campus*. I sent an e-mail to *SAGE Campus* team explaining my intention to use "*Critical Thinking*" online course for research purposes and they agreed to collaborate. They created an account for me and for the students and gave me a course assigner role. With this role, I created a cohort and invited the students to be able to monitor their progress. The course is designed for undergraduate students with little or no prior experience of CT. Also, it is cross-disciplinary so can be used by students across all disciplines. It aims to equip students with the skills and habits of CT and to teach practical techniques to critically deal with sources, evidence, and arguments in a confident and discerning way. The course has six modules and each module has three or four topics (see Table 3). It takes about two hours to complete each module and it takes about 12 hours to complete the course in total. The students had continuous access to the course content and they were free to choose the place and time to do the course and they had a chance to watch/review the course material again and again if they wanted.

Table 3. Modules of "*Critical Thinking*" Online Course

Module 1: How to think about evidence	
This module teaches what it means to think critically, why objectivity and skepticism are important, and how speed can affect the quality of your thinking.	Topic 1: Introducing critical and uncritical thinking
	Topic 2: Introducing objectivity and skepticism
	Topic 3: Introducing fast and slow thinking
Module 2: How to argue	
This module teaches how to spot and set out an argument clearly, and how to challenge people's assumptions.	Topic 1: Spotting arguments
	Topic 2: Reconstructing an argument
	Topic 3: Premise or conclusion?
	Topic 4: Challenging assumptions
Module 3: How to evaluate explanations and reasoning	
This module teaches what it means to make a logical argument, how to reason about what's likely and to handle evidence effectively.	Topic 1: Being reasonable
	Topic 2: Reasoning with logic and certainty (deductive arguments)
	Topic 3: Reasoning with evidence and probability (inductive arguments)
	Topic 4: Evaluating arguments
Module 4: How to think carefully and deliberately	
This module teaches how to make a good explanation, how to develop it in practice and how researchers test explanations.	Topic 1: Explanations, hypotheses, and theories
	Topic 2: Evidence and proof
	Topic 3: Causation and correlation
Module 5: How to structure writing and reading	
This module teaches to identify rhetoric and its persuasive effects, how to spot bad arguments and to avoid falling for them, and how to identify biased thinking.	Topic 1: The power of rhetoric and persuasion
	Topic 2: Seeing through faulty reasoning
	Topic 3: Understanding and overcoming bias
Module 6: How to manage time and attention	
Understand the relationship between data, information and knowledge, practice techniques for search and discovery and finalise creating your personal digital literacy plan.	Topic 1: The digital context
	Topic 2: Making sense of what we are told
	Topic 3: Apply critical thinking in digital research

Each module starts with an opening video and ends with a closing video. Each of the topics includes interactive questions, quizzes, visuals, brief explanations, reflective points, and examples. Students are provided feedback on their true or false answers to the interactive questions in the course. Also, at the end of each topic, there is a short video in which Dr. Tom Chatfield summarizes the topic and after the video, the topic ends with "Ask yourself" and "Make a change" parts. In these parts, students were asked to think on some questions about the topic and there are some recommendations about future life. At the end of each module, students can download module summary handout which includes short notes and outlines learning outcomes. Students can keep these module

summary handouts to use for revision and as a refresher material whenever they want.

Flipped Critical Thinking Teaching

In EG II, FC approach was employed while teaching CT. In other words, students had online and face to face lessons together. Students were asked to watch videos and cover the course materials before the class. I used some of the videos from "*Critical Thinking*" online course by Dr. Tom Chatfield to assign the students to watch before the class. Pre-class materials also included short handouts prepared by me, reading texts, and some additional web links. Pre-class course materials were uploaded to the learning management system (LMS) officially used by the university where the students study. It takes about 1 hour to watch/review the course materials before the class. In class activities were conducted in pre-scheduled two class hours (each of them was 40 minutes). In class, firstly, some activities (quizzes on student response systems like *Kahoot* and *Plickers* and short discussions, etc.) were used to test whether or not students had watched/reviewed the course materials before the class as well as to correct the false learning if there were any. After that, some in-class activities (pair works, group works, discussions, role plays, critical readings, etc.) were used to foster deep learning and engagement and to practice the CT skills under the guidance of the teacher. Weekly course plan for EG II students is shown in Table 4.

Table 4. Weekly Course Plan for the Students in EG II (Flipped CT Teaching) and EG III (In-Class)

Week	Objectives
1	In this week, it was aimed to teach what CT means, why objectivity and skepticism are important, and how speed can affect the quality of your thinking.
2	In the 2nd week, it was aimed to teach how to spot and set out an argument clearly, and how to challenge people's assumptions.
3	The aims of this week were to teach what it means to make a logical argument, how to reason about what's likely and to handle evidence effectively.
4	In this week, it was aimed to teach how to make a good explanation, how to develop it in practice and how researchers test explanations.
5	In the 5th week, it was aimed to teach to identify rhetoric and its persuasive effects, how to spot bad arguments and to avoid falling for them, and how to identify biased thinking.
6	In the last week, it was aimed to teach how to understand the relationship between data, information and knowledge, to practice techniques for search and discovery and how to create a personal digital literacy plan.

In Class Critical Thinking Teaching

CT teaching was conducted in face to face classes in EG III. The CT teaching in this group was designed traditionally using some of the course content of "*Critical Thinking*" online course by Dr. Tom Chatfield, where the instructor presented course content and materials to students, followed by class activities such as group works, pair works, worksheets, discussions or role plays etc. in pre-scheduled two class hours (each of them was 40 minutes). In the courses, firstly students' attention was drawn to the subject by presenting a stimulating material

and they were informed of the objective of the lesson. After that, the topic/content was instructed to the students and learning was guided. Then, activities and exercises were conducted to allow students to practice the skills that they had learned. Finally, the students were given homework and the course was completed. Weekly course plan for EG III students can be seen in Table 4.

Measures

Watson-Glaser Critical Thinking Test (WGCTT)

The university students' CT skills were determined with the WGCTT Form S which was developed by Watson and Glaser (1994) and translated into Turkish by Evcen (2002). The WGCTT Form S has 40 items and five subtests which are inference (10 items), evaluating arguments (6 items), deduction (10 items), recognizing assumptions (8 items), and interpretation (6 items). Turkish adaptation study by Evcen (2002) indicated that WGCTT Form S is moderately difficult and it has a significant correlation with academic achievement of the students. The reliability estimate of the total WGCTT Form S was found to be 0.48 and the correlation calculated between two administrations, which were performed four months apart, was significant (r = 0.40). The reliability coefficient of the test calculated for the current study was 0.69.

Sosu Critical Thinking Dispositions Scale (CTDS)

The university students' CT dispositions were determined with the CTDS which was developed by Sosu (2013) and translated into Turkish by the researcher (Orhan, 2023). The CTDS has 11 items and two sub-dimensions which are critical openness (7 items) and reflective skepticism (4 items). Turkish adaptation study with two independent samples indicated that the factor structure of the Turkish version of CTDS was consistent with the original scale. Also, it was found out that Turkish CTDS is invariant across different samples (undergraduate and graduate students) and genders. Besides, it presented an adequate convergent validity and discriminant validity. The reliability estimate of the total scale was found to be 0.92 for sample 1 and 0.94 for sample 2 in the adaptation study. The reliability coefficients calculated for the current study were 0.65, 0.53, and 0.67 for critical openness sub-dimension, reflective skepticism sub-dimension, and the total scale, respectively.

Data Collection

Following the ethical committee approval by Zonguldak Bülent Ecevit University, the data were gathered in the spring term of 2021-2022 academic year. The pretests and posttests were administered in class by me. Before administering the pretests, privacy and confidentiality issues were told to all of the students and they were informed about their right to withdraw from the study anytime they want. The WGCTT was administered in about 45 minutes and the CTDS was administered in about 15 minutes.

Data Analysis

In this study, the data were analyzed via SPSS 20 software. First of all, each variable was reviewed to check

whether there were any missing data and it was seen that there were no missing data. After that, skewness and kurtosis values were checked to verify the assumption of normality and it was seen that the data were normally distributed (see Table 5). Then, outliers per variables were investigated using Z transformation and multivariate outliers were checked with Mahalanobis Distance scores, and it was seen that there were no influential outliers in the data. Paired-samples t test was performed to investigate the effect of instruction on CT skills and dispositions of each group. Also, ANCOVA was used to compare the effects of online, flipped and in-class CT teachings on the students' CT skills and dispositions. Pretest scores of the students were determined as the covariate variable. Bonferroni test was conducted to investigate pair-wise differences among the adjusted means when ANCOVA test revealed significant difference. For the assumptions of ANCOVA, firstly, variance homogeneity was checked and Levene's test results revealed that the variances were homogeneous for CT skills (L_F=2.523; p>0.05) and dispositions (L_F=0.099; p>0.05). Then, it was investigated if the covariable had a linear relationship with the dependent variable for each group and the scatter plot indicated the linear relationship. Lastly, it was determined whether the slopes of the regression curves were same for all groups and it was seen that the slopes of the regression curves were equal for CT skills ($F_{(1, 3)}$=0.838, p>0.05) and dispositions ($F_{(1, 3)}$=2.117, p>0.05).

Table 5. Skewness and Kurtosis Values for Each Group

			Pretest				Posttest			
			Skewness		Kurtosis		Skewness		Kurtosis	
	N		Stat.	Std. E.	Stat.	Std. E.	Stat.	Std. E.	Stat.	Std. E.
EG 1	24	WGCTT	-0.057	0.472	-1.482	0.918	0.115	0.472	-1.067	0.918
		CTDS	0.105	0.472	-0.850	0.918	-0.089	0.472	0.722	0.918
EG 2	23	WGCTT	-0.479	0.481	-0.166	0.935	-0.788	0.481	-0.472	0.935
		CTDS	0.203	0.481	-0.871	0.935	-0.725	0.481	-0.359	0.935
EG 3	24	WGCTT	-0.449	0.472	-0.909	0.918	0.034	0.472	-0.655	0.918
		CTDS	-0.675	0.472	-0.431	0.918	-0.507	0.472	-0.672	0.918
CG	24	WGCTT	-0.693	0.472	-0.619	0.918	-0.634	0.472	-1.044	0.918
		CTDS	0.239	0.472	-1.041	0.918	0.228	0.472	-0.250	0.918
Total	95	WGCTT	-0.166	0.247	-0.629	0.490	-0.024	0.247	-0.790	0.490
		CTDS	-0.287	0.247	-0.088	0.490	-0.138	0.247	-0.518	0.490

Note that EG=Experimental group; CG=Control group; Stat.=Statistic; Std. E.=Standard error

Results

Results on CT Skills

As seen in Table 6, paired-samples t test results revealed that there was a significant difference between the WGCTT pretest and posttest scores of EG I (t_{24}=-9.642; p<0.05), EG II (t_{23}=-11.888; p<0.05), and EG III (t_{24}=-4.443; p<0.05) students in favor of the posttest. Online CT teaching (d=1.20), flipped CT teaching (d=1.74), and in-class CT teaching (d=0.63) significantly improved university students' CT skills with a large effect size. Also, there was not a significant difference between the WGCTT pretest and posttest scores of CG (t_{24}=-1.881; p>0.05).

Table 6. Paired-Samples t Test Results for the WGCTT Pretest and Posttest Scores

		Test	N	$\overline{X}$	sd	t	p	d
WGCTT	Experimental Group I	Pretest	24	22.70	5.14	-9.642	.000	1.20
		Posttest	24	28.62	4.00			
	Experimental Group II	Pretest	23	22.60	6.02	-11.888	.000	1.74
		Posttest	23	32.52	5.07			
	Experimental Group III	Pretest	24	21.04	6.25	-4.443	.000	0.63
		Posttest	24	24.83	5.45			
	Control Group	Pretest	24	18.87	3.55	-1.881	.073	-
		Posttest	24	19.54	3.71			

As it can be seen in Table 7, there was a significant difference among the WGCTT posttest scores of the students in EG I, EG II, EG III, and CG ($F_{(3, 95)}$=50.656, p<0.05, η_p^2 =0.62). Also, Bonferroni test results revealed that the WGCTT posttest scores of the EG II students who participated in CT teaching with FC approach ($\overline{X}$:32.52) were significantly higher than the scores of EG I students who received online CT teaching ($\overline{X}$:28.62) and EG III students who had CT teaching in class ($\overline{X}$:24.83). Also, EG I students ($\overline{X}$:28.62) had significantly higher WGCTT posttest scores than EG III students ($\overline{X}$:24.83). In addition, all three EGs students had significantly higher WGCTT posttest scores than the scores of the CG students ($\overline{X}$:19.54). It was seen that the intergroup difference had a large effect on CT skills (η_p^2=0.62).

Table 7. ANCOVA Test Results for the WGCTT Posttest Scores of Students in Three EGs and One CG

Source	Sum of Squares	df	Mean Square	F	P	η_p^2	Sig. Difference
Corrected model	3350.073	4	837.518	99.645	.000	0.81	B – A B – C B – D A – C A – D C – D
Intercept	776.689	1	776.689	92.408	.000	0.50	
Pre-test	1182.203	1	1182.203	140.654	.000	0.61	
Group	1277.289	3	425.763	50.656	.000	0.62	
Error	756.453	90	8.405				
Total	69896.000	95					
Corrected total	4106.526	94					

Note that EG I=A; EG II=B; EG III=C; Control Group=D

Results on CT Dispositions

As seen in Table 8, paired-samples t test results revealed that there was a significant difference between the CTDS pretest and posttest scores of EG I (t_{24}=-5.489; p<0.05), EG II (t_{23}=-14.693; p<0.05), and EG III (t_{24}=-2.800; p<0.05) students in favor of the posttest. Online CT teaching (d=1.43), flipped CT teaching (d=2.78), and in-class CT teaching (d=0.67) significantly improved university students' CT dispositions with a large effect size. Also, there was not a significant difference between the CTDS pretest and posttest scores of CG (t_{24}=-0.976; p>0.05).

Table 8. Paired-Samples T Test Results for the CTDS Pretest and Posttest Scores

		Test	N	$\overline{X}$	sd	t	p	d
CTDS	Experimental Group I	Pretest	24	3.59	0.30	-5.489	.000	1.43
		Posttest	24	4.01	0.27			
	Experimental Group II	Pretest	23	3.56	0.21	-14.693	.000	2.78
		Posttest	23	4.29	0.28			
	Experimental Group III	Pretest	24	3.52	0.39	-2.800	.001	0.67
		Posttest	24	3.76	0.27			
	Control Group	Pretest	24	3.45	0.24	-0.976	.339	-
		Posttest	24	3.51	0.32			

As shown in Table 9, there was a significant difference among the CTDS posttest scores of the students in EG I, EG II, EG III, and CG ($F_{(3, 95)}$=30.513, p<0.05, η_p^2 =0.50). Also, Bonferroni test results revealed that the CTDS posttest scores of the EG II students who participated in flipped CT teaching ($\overline{X}$:4.29) were significantly higher than the scores of EG I students who received online CT teaching ($\overline{X}$:4.01) and EG III students who had CT teaching in class ($\overline{X}$:3.76). Also, EG I students ($\overline{X}$:4.01) had significantly higher CTDS posttest scores than EG III students ($\overline{X}$:3.76). In addition, all three EGs students had significantly higher CTDS posttest scores than the scores of the CG students ($\overline{X}$:3.51). It was seen that the intergroup difference had a large effect on CT dispositions (η_p^2=0.50).

Table 9. ANCOVA Test Results for the CTDS Posttest Scores of Students in Three EGs and One CG

Source	Sum of Squares	df	Mean Square	F	P	η_p^2	Sig. Difference
Corrected model	8.845	4	2.211	29.143	.000	0.56	B – A B – C B – D A – C A – D C – D
Intercept	4.681	1	4.681	61.697	.000	0.40	
Pre-test	0.923	1	0.923	12.166	.001	0.11	
Group	6.946	3	2.315	30.513	.000	0.50	
Error	6.829	90	0.076				
Total	1454.603	95					
Corrected total	15.674	94					

Note that EG I=A; EG II=B; EG III=C; Control Group=D

Discussion and Conclusion

Regarding the first and third research questions, the results of this study revealed that all explicit CT teachings conducted in different learning environments (online, flipped, and in-class) significantly enhanced university students' CT skills and dispositions with a large effect size. In line with the results of this current study, there are some previous experimental studies which concluded that online (Chou et al., 2019; Jolley et al., 2022; McClellan, 2016), flipped (Al-Zoubi & Suleiman, 2021; Asmara et al., 2018; Etemadfar et al., 2020; Chang et al., 2022) and

in-class explicit CT teachings (Arısoy & Aybek, 2021; Taghinezhad & Riasati, 2020) significantly promoted CT.

Previous experimental studies, including this one, showed that online and flipped learning environments are promising to promote CT. Today, there is a dramatic change in higher education systems (Astleitner, 2002; Goodsett, 2020) because of the increasing demand for OL in the last twenty years (Tathahira, 2020; Phirangee et al., 2016). Education systems, especially in higher education, have moved from traditional classrooms to OL environments thanks to rapid improvement in digital technologies (Saad´e et al., 2012). Therefore, online and blended learning environments are used widely in higher education in different disciplines and the results of this study have showed us that these learning environments can also be used to promote CT. These results are important because OL environments do not need a physical classroom and, hence, can offer an effective CT teaching to hundreds of individuals at the same time. This study revealed that OL environments can serve as an effective way to reach a lot of people to equip them with CT which is a widely-desired skill of 21st century instead of traditional classrooms which have limited space for students. Therefore, online CT courses consisting of different modules, like in this study, can be used to promote hundreds of individuals' CT skills and dispositions which are important in 21st century.

Regarding the second and fourth research questions, it was found out that flipped CT teaching was the most effective way to improve CT skills and dispositions and it was followed by online and in-class CT teaching, respectively. Previous studies concluded that flipped CT teaching (Asmara et al., 2018; Dehghanzadeha & Jafaraghaeeb, 2018) and online CT teaching (Chou et al., 2019; Stedman & Adams, 2014) are more effective ways to promote CT than in-class CT teaching. So, it can be said that the results of this study are confirmed by previous research.

Previous literature indicated that OL environments provide students-centered, interactive, and media-rich learning experience for individuals that can promote active learning, facilitate knowledge construction, and enhance metacognition (Huffaker & Calvert, 2003; Kantak & Winstein, 2012). Also, OL environments can hinder peer-pressure that can be shown as an important obstacle for classroom interactions in traditional classrooms because OL provides individualized learning environment for students (Horton, 2000; Murchu & Muirhead, 2005). Unlike the time-limited nature of a pre-scheduled class time in the traditional classroom, students have the necessary time to reflect, investigate, and query thanks to flexible, self-paced, and asynchronous nature of OL (Lee et al., 2009).

FC approach has potential to promote CT (Alsulami, 2016; Boucher et al., 2013) because in flipped learning environments, instruction of basic knowledge is moved before the class time (Bergmann & Sams, 2012) and in class time is devoted to active and learner-centered strategies such as pair or group activities, discussions, role plays, and case studies, etc. (Shyr & Chen, 2018) which are also effective to promote CT (Brown et al., 2014). Thanks to CT, in-class time can be used effectively for collaborative learning, extensive interactions, feedback, and discussion under the guidance of the teacher (Lai et al., 2020; Talbert, 2017). The finding of this study indicating online and flipped CT teaching is much more effective than in-class CT teaching to promote CT can be explained by this theoretical background. The advantages of OL and FC make them more promising ways to promote CT than in-class teaching. Therefore, this study provides important experimental evidence that is

supported by the theoretical background and previous research.

Also, this study indicated that flipped CT teaching is more effective than online CT teaching for promoting CT skills and dispositions. Teacher guidance and interaction are important in the process of promoting CT (Mathews & Lowe, 2011). Flipped learning environments, which employ online and in-class teaching together, have the advantages of online and in-class learning environments. Thanks to computer and network technologies, individuals can learn the basic knowledge in a flexible and self-paced manner before the class and they can spend in-class time with pair or group works, problem solving, collaborating, and discussions under the guidance of the teacher which enable meaningful teacher-student and student-student interactions. This blended nature of flipped environments makes them more advantageous than OL to promote CT because students can make use of the guidance and help of the teachers and teacher-student and student-student interactions are more effective in class. Therefore, the finding of this study indicating flipped CT teaching is more effective than online CT teaching to promote CT can be explained with this.

In short, this study revealed that CT skills and dispositions of university students can be improved with online, flipped, and in-class explicit CT teaching. However, the most effective learning environment to promote CT is flipped, online, and in-class, respectively. These results verified the effectiveness of OL and FC to promote CT skills and dispositions in higher education through experiment, expanded the related literature, and emphasized the importance of using online technologies while teaching CT. In addition, this study revealed that online CT courses consisting of different modules are effective to promote CT. This finding is important because it shows us that hundreds of individuals' CT skills and dispositions can be promoted at the same time with well-designed online CT courses. Also, this study showed that FC, which includes in-class and OL together, is the most effective way to promote CT filling the gap of previous literature. This finding is important to help us understand which learning environment is the most effective to enhance CT. All in all, the results of this study which are confirmed by the theoretical background and expectations obtained from previous experimental studies are noteworthy and expanded the related literature because they provide some essential evidence indicating OL and FC are promising ways to promote CT in higher education. This study has also made important contribution to the related literature because it differs from most of the previous studies with the aim of comparing the effectiveness of online, flipped, and in-class CT instructions. Universities, educators, administrators, and researchers can organize their teaching activities for individuals to provide them with the best effort to promote CT thanks to the results of this study.

Limitations and Implications for Other Studies

Even though this study is important to shed light on the effect of CT teachings in different learning environments, there are some limitations. The duration of CT teaching was limited to six weeks in this study and this can be seen as the first limitation of the study. Therefore, longer-term studies should be carried out to compare the effectiveness of CT teaching in different learning environments. Second, the data were gathered with quantitative measures in this study. Other studies with qualitative or mixed methods can be carried out to provide in-depth investigation of the advantages and disadvantages of online, flipped, and in-class CT teachings. Lastly, this study was conducted with university students. Therefore, it can be said that sample group can be seen as another

limitation and other experimental studies with students from different educational levels should be carried out to provide evidence for the effectiveness of online and flipped CT teaching for younger age groups.

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Availability of data

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

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