Article

The Effect of the Metacognitive Support via Pedagogical Agent on Self-Regulation Skills

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Abstract

Flipped Classroom (FC) has become an increasingly popular model in many disciplines in today's educational system. In order for the FC model to be effective, it is important for the student to have self-regulation skills. It is especially important that students have advanced self-regulatory skills so that the online learning process of the FC model can be successfully completed. It is believed that the metacognitive support (MS) provided by the pedagogical agent during the online process of the FC model will contribute to the development of self-regulation skills of the students. The purpose of this research is to examine the impact of MS via pedagogical agent in the FC model on students' self-regulation skills.The research was carried out according to experimental design, and the participants of the research consist of 102 university students. The data of the study were collected using self-regulated learning scale. As a result of the research, it was seen that the students of the experimental group who were provided MS with the pedagogic agent were found to have a statistically significant higher level of self-regulation skills than the control group students who were not provided with MS. Several suggestions have been made for the use of pedagogical agent-assisted MS in the design of FC courses.

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Introduction

When the literature was examined, flipped classroom (FC) which was defined by different researchers as inverted classroom (e.g., Bates & Galloway, 2012; Gannod, Burge, & Helmick, 2008; Lage, Platt, & Treglia, 2000; Morin, Kecskemety, Harper, & Clingan, 2013; Talbert, 2012) was defined by Johnson (2012) as a blended learning model in which students reach out to the content on the curriculum outside the classroom, and the time in class is used to clarify discussion, practice, and content. Strayer (2012) stated that the FC should not be perceived as a new model and stated that the teachers wanted students to read the course material before they came to the class for decades and at the time of the class they wanted to learn the concepts at a deeper level. However, the reason why the FC model is perceived as new is that the interactive technologies are used regularly and systematically in the learning process (Strayer, 2012). Studies in this context can be summarized as follows from the studies conducted by different researchers (Fulton, 2012a, 2012b; Morgan, 2014) in parallel with the technological developments in existence nowadays. For example, teachers can prepare videos about their lessons and reach to their students through video sharing sites such as Youtube. Using an open source coded learning platform such as Moodle, they can also create web pages about their lessons and share links and other additional resources with their students. Thus, less resources can be allocated to printed materials, course content can be easily updated at any time, and students can start working on the final version of the course content from the moment the update is made. In other words, the FC model which is a blended learning type consisting of a combination of online and face-to-face learning is a popular model because it provides that content is presented to students as online before face-to-face classes, and it is learned more deeply through discussions and practices in face-to-face classes.

FC has some advantages such as because the homework is done in class, it is possible for teachers to better observe the parts of students have a difficulty and their learning styles; it is possible to enable the students to be able to progress at their own learning speed, to enable the class time to be used more effectively and creatively, to enable the teachers to update the course content when they want, to enable students to watch videos prepared by other teachers about the same course, it helps parents the problems to disappear since parents cannot help students' homework due to some reasons (such as solving difficult math problems), and it allows students who cannot attend classes to access learning

materials and reduce costs (e.g., all books are not needed to be reprinted to update the course content. With an update on the relevant video, and the current version of the content will be available to all students at the same time), to enable teachers to learn new things from each other by watching the videos of other teachers who work in the same field (Bergmann & Sams, 2012; Enfield, 2013; Fulton, 2012a, 2012b; Morgan, 2014). Besides, there are limitations such as students need to access to computers or Internet connection difficulties about whether these videos are watched before class and checking whether these videos are watched by students, and students need to motivate themselves (Bergmann & Sams, 2012; Enfield, 2013; Morgan, 2014).

To get the most out of advantages of the FC model and to be influenced at least from its limitations, successful completion of the online learning process of course which is seen as the first step of the model is very important. Because the problems that will be experienced during the online learning phase can also negatively affect the face-to-face activities of the course. When the literature is examined, it is stated that the students are not motivated and cannot manage their own learning processes, and thus they fail in online learning environments. (e.g., Karaoglan Yilmaz & Keser, 2016; Yilmaz, 2014; Yilmaz & Keser, 2017). In the study conducted by Grabau (2015), it is stated that learners need to have interpersonal skills such as self-efficacy, self-regulation skills, good communication skills, time management skills, teamwork, and goal-directed behaviors to some extent, and FC courses' online requirements could be completed successfully. Similarly, the results of the study conducted by Yilmaz (2017) indicated that e-learning readiness and its subfactors which are computer self-efficacy, Internet self-efficacy, online communication self-efficacy, self-directed learning, learner control, and motivation toward e-learning are predictors of student satisfaction and motivation in FC model. In this context, it can be said that the self-regulated learning (SRL) skills of the students become important.

In the researches conducted by Paris and Paris (2001) about learning and success of students in recent years, it is emphasized that cognitive strategies, metacognition, motivation, task engagement, and social supports in classrooms have been studied by emphasizing the importance of SRL. The impact of the students on the learning has been revealed by several studies, and different researchers of SRL have revealed different models (e.g., Boekaerts, 1997; Pintrich, 1995; Zimmerman, 2000) and made different definitions. For example, Pintrich (1995) defined SRL as active, goal-directed self-control of behavior, motivation, and cognition for academic tasks by an individual student, while Zimmerman (1986) defined as behaviorally, metacognitively, and motivationally active as one's own learning (as cited in Schwonke et al., 2013). SRL has been defined by Haslaman (2011) as a process in which students determine their own target, select the appropriate strategies to achieve this goal, monitor themselves in this process, control the situation of reaching and not reaching the target, change the strategies when necessary, make new regulations, and evaluate

themselves in case of reaching the target. In summary, SRL skills help to describe the ways of how students approach tasks, apply strategies, monitor their performance, and interpret the outcomes of their efforts toward achieving specific learning goals.

In the literature review process carried out in the scope of this research, in numerous studies (e.g., Butler & Winne, 1995; Dignath & Büttner, 2008; Paris & Paris, 2001; Ragosta, 2010), it was found that SRL skills which are effective on the learning of the students can be taught. Within the scope of this research, in determination of students' SRL skills, a scale developed by Haslaman (2011) and identified as forethought, performance, and self-reflection factors of the SRL process was used under the guidance of different SRL models accepted by the literature. These factors are listed here:

- Forethought includes the arrangements that students make (such as the determination of the characteristics of the learning task, the selection of appropriate resources, the selection of the appropriate cognitive strategies which is appropriate for task) before the students start any learning activity or task.
- The performance phase consists of two subdimensions, including self-control or self-regulation and self-observation. The self-control or self-regulation dimension of the performance phase involve the personal control and regulation of the students with regard to the learning task (such as controlling and rearranging the cognitive strategies when necessary, maintenance of motivation, focusing on and maintaining the topic, controlling the activity plan, and making changes when needed). The self-observation dimension of the performance phase involves monitoring what students are doing in the process of achieving the goal related to the learning task (such as the use of cognitive strategies, motivation and emotional state, and self-efficacy perception).
- Self-reflection phase contain evaluations of students at the end of any learning activity or task they carried out (such as assessment of cognitive strategies and task performance, self-assessment in terms of personal and affective, assessment of self-efficacy perceptions, and evaluation of an activity plan).

As is evident from the explanations of the factors of the SRL scale developed by Haslaman (2011), the results and experience of a phase in this cyclical process are accepted as the feedback of the previous phase. In addition, metacognitive support (MS) is one of the pedagogical approaches that can be used to support the development of students' SRL skills when the relevant steps are examined in detail. Metacognition is defined by Winne and Perry (2000) as the awareness learners have about their general academic strengths and weaknesses, cognitive resources they can apply to meet the demands of particular tasks, and their knowledge about how to regulate engagement in tasks to optimize learning processes and outcomes. When the literature is examined, it is seen that there

are many studies conducted about MS (e.g., Jumaat & Tasir, 2016; Künsting, Kempf, & Wirth, 2013; Molenaar, Sleegers, & van Boxtel, 2014; Schwonke et al., 2013; Yilmaz & Keser, 2017), which is defined as support for the actuate of the students' metacognition in the learning process (Yilmaz, 2014; Yilmaz & Keser, 2017). In addition, it is stated that MS is indicated by educational researchers as one of the most used support types especially in online learning environments (Jumaat & Tasir, 2016). In this context, it is important to provide MS to develop self-regulation skills in online learning processes of the FC model. In the study conducted by Yilmaz (2014) and with the participation of 127 university students, it is revealed that providing MS in online learning environments increased the students' metacognitive awareness. In the study conducted by Lee, Lim, and Grabowski (2009), it is stated that learners are not very successful generating their own meaning, especially in computer-based learning environments in which learners are required to make decisions about their learning process, since they rarely regulate their own learning process cognitively or metacognitively. And it is revealed that in computer-based learning environments, the metacognitive feedbacks provided to the students are effective for understanding the subjects and improvement of the self-regulation skills of the students. In the study conducted by Schwonke et al. (2013), students studied in computer-based geometry classes with hint card using with or without MS. During learning, students' log-file data were recorded, and it is stated that MS supports learning more efficiently (i.e., less learning time without impairing outcomes). It was also determined that low-prior knowledge students developed a deeper conceptual understanding. In the study conducted by Künsting et al. (2013), the effect of MS on simulation-based scientific discovery learning was investigated using a virtual physics laboratory. The results of the study showed that MS has positive effects on learning outcome, actual cognitive strategy use, and learning emotions.

When the literature is reviewed, even if it is stated that the learning environments (Cigdem, 2015; Delen, Liew, & Willson, 2014; Yilmaz & Keser, 2017) were used to describe the use of such features as glossary, note-taking, tagging, wiki, calendar, news flow, adaptability, and learning analytics to provide MS, in the scope of present research, the pedagogical agent was utilized for the MS in the online learning process of the FC model. Because, in a study conducted by Yilmaz and Kilic Cakmak (2011), it is stated that researches conducted in recent years has foreseen that some of the problems that students experience in interaction with virtual learning environments can be eliminated with pedagogical agents. It is also stated that the pedagogical agent can also be used as a social model for students in virtual learning environments because of its advantages such as visual and auditory communication, gesture and mimic utilization, and designing in human-like features (Yilmaz & Kilic Cakmak, 2012). Although there is no generally accepted definition of the agent concept used for different purposes in different disciplines, as a character in the computer environment,

it is actuated by the user in a virtual environment and agents used in software developed for educational purposes are called pedagogical agents (Yilmaz & Kilic Cakmak, 2011). In the online learning process of the FC model applied in this research, it is made benefit of MS which is one of the agents (Singh, Singh Yadav, Patel, & Anand Singh, 2005) that help students to learn the relevant content effectively, using pedagogical methods and techniques which are one of the most widely used pedagogical agents defined according to their roles and functions. Because, it is thought that MS, which will be provided with pedagogical agent during online learning process of FC model, will contribute to the development of self-regulation skills of students. In addition, this study, which takes into account the aforementioned findings and uncertainties regarding SRL, which cannot be denied the influence of students on their learning, seems to be important as it allows the MS to be provided with a pedagogical agent to determine the effect on SRL skills. Within this context, in this research, it is aimed to determine the effect of the MS via pedagogical agent on the students' self-regulation skills. Within the scope of this general objective, the following questions were sought:

1. Does MS provided with pedagogical agent on FC model has a significant effect on students' self-regulation skills?
2. Does the MS provided with the pedagogical agent on the FC model has a significant effect on the forethought dimension of the SRL process?
3. Does the MS provided with the pedagogical agent in the FC model has a significant effect on the self-control or self-regulation dimension of the SRL process?
4. Does the MS provided with the pedagogical agent on the FC model has a significant effect on the self-observation dimension of the SRL process?
5. Does the MS provided with the pedagogical agent in the FC model has a significant effect on the self-reflection dimension of the SRL process?

Method

Research Model and Participants

The experimental design in this study is a pretest and posttest control group design. The participants of the study were 102 freshman students studying at a state university. Of the participating students, 56 (54.9%) were female and 46 (45.1%) were male. Participants' ages ranged from 18 to 23 years. And these participant students took applied courses on basic computer hardware, operating systems, word processor, spreadsheet, making presentations and using the Internet during Computing I course, and have basic computer and Internet literacy skills. Students were randomly assigned to two classes, and these classes formed the experimental groups of the study. Which class will be which

experimental group was determined through an random assignment. With such random assignment, each group had almost the same number of students. After the random assignment of groups, experimental group had 52 students, and these students used a pedagogical agent with MS interaction platform, while control group had 50 students and they used an interaction platform but pedagogical agent with MS was not provided.

Learning Environments and Procedure

The study was conducted on students who took Computing I course in the FC model. An e-course was opened using the Moodle learning management system (LMS) to be used in the online learning process of the FC model. In the e-learning environment, content and materials were presented weekly in order to prepare students for the related lesson in that week before coming to the face-to-face lesson. These content and materials are lecture videos and lecture notes about the topic of that week. Lecture video and notes were designed by the researchers, and while the content and materials designed for the experimental group included MS with pedagogical agent support, the content and materials designed for the control group did not include MS.

Considering the applications in the literature, MS support has been given through both LMS and pedagogical agent in the designed video and lecture notes. Before the students in the experimental group studied on the weekly course contents via the LMS, the ''Let's think before starting the course'' activity was opened to the students via the LMS. The students were asked various questions through the pedagogical agent within this activity, and students were asked to answer these questions and send them through the system. The questions in this activity are the questions about planning own learning process of MS, and it is tried to provided that the students try to answer these questions to plan their own learning process. In the scope of this event, ''Do you have the prior knowledge about this topic?'', ''What do you know about this subject and what is your knowledge level?'', ''What benefits do you think it will provide you with learning this?''. After the students answered the questions in this activity, the relevant learning contents on that week in LMS were opened to student access.

In the video and lecture notes which are opened to the students, pedagogical-assisted MS for the experimental group students is included as well. The MS in the video and lecture notes was also tried by the pedagogical agent in certain parts of the content and in the end by metacognitive questions. The questions asked here were related to the self-monitoring process of MS, and the students' attention was tried to be focused on the learning contents, and in-depth understanding of learning contents was tried to be provided. Students are asked to answer the questions in the learning content by answering on the ''Let's think while attending the class'' panel via the LMS. When the students complete the

online processes and attended the face-to-face courses in the computer lab, the students were asked to complete the applications by distributing the application tasks to the students about that week. During the implementation process, forum-based discussion environment was opened through LMS in order to provide interaction and cooperation between students and teachers. Students shared knowledge and discussed on topics about performing applications in the discussion environment, clues, learning practical points, learning unknown points, and so on. The knowledge sharing and discussions were also continued at the end of the semester, and students could participate in the discussions at the time and place they requested. In the discussions of the students in the experiment group, the questions based on MS supported by the pedagogical agent were asked by the teacher to try to increase the depth of the discussion, and it is tried to be provided that students revision their knowledge and learning. In the context of this event, which is the continuation of the ''Let's think while attending the course'' activity, ''Is there any point you do not understand about the videos you watched and you performed an application so far?'', ''What was the most challenging part?'', ''How could you perform this application more practically?''. Knowledge sharing in the discussion environment continued until the end of the week.

At the end of the relevant week, the activity ''Firstly, let's think at the end of the lesson'' has been opened to the students' access through LMS. This event is aimed at evaluating the student's own learning process in MS and in which students in the control group are asked to submit metacognitive questions via the pedagogical agent and send their answers to the panel on the LMS. Within the scope of this activity, students can evaluate their learning process and they were asked questions such as ''Where can you use in your daily life you learned this week?'', ''Is there any point that you learned wrong or incomplete?'', ''What other learning strategies should you try to complete if you have learning deficiencies?''.

The questions directed to the students through the panel within the context of ''Let's think before the class starts,'' ''Let's think while attending the class,'' and ''Firstly, let's think at the end of the lesson'' are presented through video-based pedagogical agent. The pedagogical agent designed using the Photoshop program is animated using the CrazyTalk program, and gestures and mimics are added. Questions were conveyed to the students as audible, while agent conversations are being spoken. The questions asked by the agent were added to the course videos in a similar way. Pedagogical agent-supported MS questions included in the course notes in the form of e-books were added to the e-book in image format. Screenshot of a pedagogic agent-assisted video is included in appendix.

When the current research on pedagogical agent design is examined, it is stated that instead of cartoon character for adult learners, human-like agent design may be more useful in terms of learning process and results

(Yilmaz & Kilic Cakmak, 2012). For this reason, it has been decided that the agent design was going to be human-like. Furthermore, when multimedia design features are taken into consideration, voice and text elements were used in the interaction of the agent with the learners. Gesture and mimic expressions were also included in agent design considering emotional expressions in the learning process. The research was conducted during a semester in the scope of the course of Computing I. In the first week of research process, necessary information was provided to students about LMS environment used and how course activities were going to be performed. Then, pretest was carried out to the students. During the 10 weeks after pretest carried out, application process continued. After the application process, posttest was carried out.

Instruments

Within the scope of this study, SRL scale was used in order to self-regulation levels of the students. SRL scale was developed by Haslaman (2011). Aforementioned 10-point Likert scale includes 59 items in which the answers are *(1) = It does not reflect me at all* and *(10) = It reflects me exactly*. The SRL scale consists of three dimensions: forethought, performance, and self-reflection. And performance consists of subdimensions including self-control or self-regulation and self-observation. The Cronbach alpha value for the whole scale was found as .98. Cronbach's alpha value for the subdimensions; .95 for forethought, .95 for self-control or self-regulation, .92 for self-observation, and .94 for self-reflection. Some of the sample items related to the scale are that "I decide my own learning goals before I start learning activity.", "I control whether I reached my goals after the learning activity.". High scores from the scale indicate high self-regulation levels, and low scores from the scale indicate low self-regulation levels. The SRL scale was used as a pretest at the beginning of the study and as a posttest at the end of the study.

Data Analysis

Whether the scores of the students in the study group from the SRL scales showed a normal distribution or not was tested via the Kolmogorov–Smirnov test. The test results showed that the data showed a normal distribution ($p > .05$) and in analyzing the data ANCOVA parametric test were used. In significance tests in the study, .05 significance level was taken as a ground.

Findings

Students' Responses to SRL Scale

Descriptive statistics, determined from students' responses to SRL scale of experimental group, are presented in Table 1.

Table 1. Descriptive Statistics of Experimental Group.

Scale	Number of items	Pretest score	*SD* of pretest score	Posttest score	*SD* of posttest score
Self-regulated learning	59	375.21	73.26	487.35	61.86
Forethought	17	124.42	23.44	145.96	17.89
Self-control/self-regulation	21	134.90	29.21	171.58	28.03
Self-observation	11	63.73	21.06	87.98	15.84
Self-reflection	10	52.15	14.40	81.83	11.92

Table 2. Descriptive Statistics of Control Group.

Scale	Number of items	Pretest score	*SD* of pretest score	Posttest score	*SD* of posttest score
Self-regulated learning	59	375.76	77.50	400.76	78.27
Forethought	17	124.16	26.41	127.86	26.61
Self-control/self-regulation	21	135.52	33.08	145.46	32.34
Self-observation	11	64.02	20.49	70.62	20.42
Self-reflection	10	52.06	11.66	56.82	14.19

From Table 1, it is seen that the average scores of the experimental group were 375.21 from the self-regulation skill pretest and 487.35 from the self-regulation skill posttest.

Descriptive statistics, determined from students' responses to SRL scale of control group, are presented in Table 2.

From Table 2, it is seen that the average scores of the control group were 375.76 from the self-regulation skill pretest and 400.76 from the self-regulation skill posttest.

Findings in line with the purpose and research questions and interpretations of the findings are given later.

Within the scope of the first research question, the answer to whether pedagogical agent with MS have a significant effect on self-regulation skills of the students was searched.

The adjusted averages of self-regulation skill levels of the students were found as $\bar{x} = 487.58$ for experimental group and $\bar{x} = 400.52$ for control group. When the self-regulation skill pretest scores of the students in these environments were

Table 3. The Results of Covariance Analysis Related to Students' Self-Regulation Skills Based on the Pedagogical Agent With MS.

Source of variance	Sum of squares	Degree of freedom (*df*)	Mean square	*F*	Significance (*p*)
Self-regulation skills pretest	423522.17	1	423522.17	583.46	.00
Pedagogical agent with MS	193197.76	1	193197.76	266.15	.00
Error	71862.72	99	725.89		
Total	686489.02	101			

Note. MS = metacognitive support.

controlled, covariance analysis was used to see if there was a significant difference in their posttest scores based on the pedagogical agent with MS, and the results are given in Table 3.

From Table 3, when students' self-regulation skills pretest scores were controlled, it was seen that there was a significant difference in their adjusted averages in terms of pedagogical agent with MS with a large effect size, $F(1, 99) = 266.15$; $p = .00 < .05$; Cohen's $f = .73$. In other words, self-regulation skills differed depending on the pedagogical agent with MS. The result of the analysis showed that the self-regulation skills of those experimental group (pedagogical agent with MS) differ significantly from those given control group. In other words, it was seen that experimental group self-regulation skills were higher than control group.

Descriptive statistics, determined from students' responses to SRL scale, are presented in Figure 1.

Within the scope of the second research question, the answer to whether pedagogical agent with MS have a significant effect on forethought subdimension of self-regulation skills of the students was searched.

The adjusted averages of forethought levels of the students were found as $\bar{x} = 145.96$ for experimental group and $\bar{x} = 127.86$ for control group. When the forethought pretest scores of the students in these environments were controlled, covariance analysis was used to see if there was a significant difference in their posttest scores based on the pedagogical agent with MS, and the results are given in Table 4.

From Table 4, when students' forethought skills pretest scores were controlled, it was seen that there was a significant difference in their adjusted averages in terms of pedagogical agent with MS with a large effect size, $F(1, 99) = 101.02$; $p = .00 < .05$; Cohen's $f = .51$. In other words, forethought skills differed depending on the pedagogical agent with MS. The result of the analysis showed that the forethought skills of those experimental group

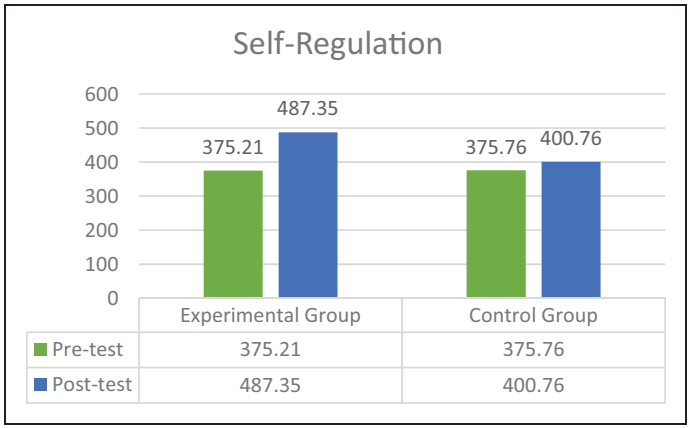

Figure 1. Descriptive statistics of groups.

Table 4. The Results of Covariance Analysis Related to Students' Forethought Based on the Pedagogical Agent With MS.

Source of variance	Sum of squares	Degree of freedom (*df*)	Mean square	*F*	Significance (*p*)
Forethought pretest	43023.85	1	43023.85	533.21	.00
Pedagogical agent with MS	8151.33	1	8151.33	101.02	.00
Error	7988.10	99	80.69		
Total	59364.21	101			

Note. MS = metacognitive support.

(pedagogical agent with MS) differ significantly from those given control group. In other words, it was seen that experimental group forethought skills were higher than control group.

Within the scope of the third research question, the answer to whether pedagogical agent with MS have a significant effect on self-control or self-regulation subdimension of self-regulation skills of the students was searched.

The adjusted averages of self-control or self-regulation levels of the students were found as $\bar{x} = 171.83$ for experimental group and $\bar{x} = 145.20$ for control group. When the self-control or self-regulation pretest scores of the students in these environments were controlled, covariance analysis was used to see if there was a significant difference in their posttest scores based on the pedagogical agent with MS, and the results are given in Table 5.

Table 5. The Results of Covariance Analysis Related to Students' Self-Control/Self-Regulation Based on the Pedagogical Agent With MS.

Source of variance	Sum of squares	Degree of freedom (*df*)	Mean square	*F*	Significance (*p*)
Self-control/self-regulation pretest	67723.63	1	67723.63	284.34	.00
Pedagogical agent with MS	18076.70	1	18076.70	75.90	.00
Error	23579.48	99	238.18		
Total	108689.81	101			

Note. MS = metacognitive support.

From Table 5, when students' self-control or self-regulation skills pretest scores were controlled, it was seen that there was a significant difference in their adjusted averages in terms of pedagogical agent with MS with a large effect size, $F(1, 99) = 75.90$; $p = .00 < .05$; Cohen's $f = .43$. In other words, self-control or self-regulation skills differed depending on the pedagogical agent with MS. The result of the analysis showed that the self-control or self-regulation skills of those experimental group (pedagogical agent with MS) differ significantly from those given control group. In other words, it was seen that experimental group self-control or self-regulation skills were higher than control group.

Within the scope of the fourth research question, the answer to whether pedagogical agent with MS have a significant effect on self-observation subdimension of self-regulation skills of the students was searched.

The adjusted averages of self-observation levels of the students were found as $\bar{x} = 88.09$ for experimental group and $\bar{x} = 70.51$ for control group. When the self-observation pretest scores of the students in these environments were controlled, covariance analysis was used to see if there was a significant difference in their posttest scores based on the pedagogical agent with MS, and the results are given in Table 6.

From Table 6, when students' self-observation skills pretest scores were controlled, it was seen that there was a significant difference in their adjusted averages in terms of pedagogical agent with MS with a large effect size, $F(1, 99) = 77.98$; $p = .00 < .05$; Cohen's $f = .44$. In other words, self-observation skills differed depending on the pedagogical agent with MS. The result of the analysis showed that the self-observation skills of those experimental group (pedagogical agent with MS) differ significantly from those given control group. In other words, it was seen that experimental group self-observation skills were higher than control group.

Table 6. The Results of Covariance Analysis Related to Students' Self-Observation Based on the Pedagogical Agent With MS.

Source of variance	Sum of squares	Degree of freedom (*df*)	Mean square	*F*	Significance (*p*)
Self-observation pretest	23221.83	1	23221.83	230.06	.00
Pedagogical agent with MS	7871.12	1	7871.12	77.98	.00
Error	9992.93	99	100.94		
Total	40897.41	101			

Note. MS = metacognitive support.

Table 7. The Results of Covariance Analysis Related to Students' Self-Reflection Based on the Pedagogical Agent With MS.

Source of variance	Sum of squares	Degree of freedom (*df*)	Mean square	*F*	Significance (*p*)
Self-reflection pretest	6859.59	1	6859.56	66.25	.00
Pedagogical agent with MS	15864.61	1	15864.61	153.21	.00
Error	10251.27	99	103.55		
Total	33051.02	101			

Note. MS = metacognitive support.

Within the scope of the fifth research question, the answer to whether pedagogical agent with MS have a significant effect on self-reflection subdimension of self-regulation skills of the students was searched.

The adjusted averages of self-reflection levels of the students were found as $\bar{x} = 88.09$ for experimental group and $\bar{x} = 70.51$ for control group. When the self-reflection pretest scores of the students in these environments were controlled, covariance analysis was used to see if there was a significant difference in their posttest scores based on the pedagogical agent with MS, and the results are given in Table 7.

From Table 7, when students' self-reflection skills pretest scores were controlled, it was seen that there was a significant difference in their adjusted averages in terms of pedagogical agent with MS with a large effect size, $F(1, 99) = 153.21$; $p = .00 < .05$; Cohen's $f = .61$. In other words, self-reflection

skills differed depending on the pedagogical agent with MS. The result of the analysis showed that the self-reflection skills of those experimental group (pedagogical agent with MS) differ significantly from those given control group. In other words, it was seen that experimental group self-reflection skills were higher than control group.

Discussion and Conclusions

The results of this research conducted to determine the effect of pedagogical agent-assisted MS on self-regulation skills of students in the FC environment reveal that the self-regulation skills of students with pedagogical agent and MS provided experimental group are more advanced than those in the control group. The results show statistically significant difference in favor of the experimental group when the SRL scale is compared in terms of ''forethought,'' ''self-control/self-regulation,'' ''self-observation,'' and ''self-reflection'' subdimensions. From this point of view, it can be said that providing MS with a pedagogical agent, the FC model is useful in improving students' self-regulation behaviors at the beginning of the online lesson process, continuing to process, and end of process.

MS strategies for computer and Internet-based learning environments come to the forefront with the idea that they are effective in giving students self-learning skills, in other words, they support learning autonomy (Yilmaz, 2014). From this perspective, students are alone with online sources of knowledge in the online learning process, which is the preliminary stage of FC courses. One of the main problems here is how students plan to study on these resources. In the studies, it is revealed that self-directed learning skills are important in planning of students' online course study, and students who do not have these skills experience motivation and satisfaction problems in FC courses (Yilmaz, 2017). At this point, the MS provided by the pedagogical agent allows the students to plan their own learning process. With MS provided by the pedagogical agent, the students ask themselves questions to determine the purpose of the videos they watch, what they will benefit from watching them, what strategies they will use to increase the effectiveness of the video surveillance process (such as taking notes while watching), and they plan about prestudy process accordingly. The results of the research show that this planning improves the effectiveness of the forethought dimension of the self-regulating process of students. Similarly, with the MS provided in the video monitoring process, it is aimed that students control the learning process and think deeply about their learning up to that point. According to the results of the research, it is seen that the self-regulation process contributes to self-control and self-observation dimensions in this support. It is aimed to evaluate self-understanding whether the student understands the knowledge described in the video with the MS provided at the end of the studying period. By this way, students have been trying to increase their awareness of the process by identifying well

understood or not understood, easy or difficult points in the video. If the student who is aware of them attend the course ready to face-to-face course, it allows that the course is processed more efficiently. This contributes to the development of the students' self-reflection dimension.

When the literature is examined, it is seen that there are various research results in support of these research results. In the current research, it is seen that the effect of self-regulation skills and metacognitive awareness of MS learners through pedagogical agent are examined. In a study by Molenaar, Chiu, Sleegers, and van Boxtel (2011), pedagogical agent-supported metacognitive activities have been found to improve students' metacognitive knowledge. In a study by Molenaar, van Boxtel, and Sleegers (2011), metacognitive scaffolding provided by the pedagogical agent did not have a significant effect on group performance nor was there a significant effect on acquired individual domain knowledge. Baylor (2002) concluded that using a pedagogical agent in the constructivist attribute of his work on prospective teachers has increased the metacognitive awareness of prospective teachers. Although the results of the pedagogical agent-assisted MS study on metacognitive knowledge and awareness in these studies have been examined, it can be said that the results of the research are in parallel with the results of our research, given that metacognitive knowledge and awareness are a dimension of the SRL process.

On the other hand, when the studies in the literature were examined, in some researches, the effect of MS provided using the tools and features of learning environment without using pedagogical agent in computer-based learning environment was examined. For example, in a study by Lee, Lim, and Grabowski (2010), providing metacognitive feedback in computer-based learning environments has led to the development of self-regulation skills of learners. In the literature review made by Devolder, van Braak, and Tondeur (2012), it is stated that scaffolding strategies can be used in computer-based learning environments with support for SRL. Researchers have concluded that scaffolding strategies are particularly effective in self-regulation control processes. In the results of our research, it was also found that the MS of the pedagogical agent improved the "control, correction" dimension scores of self-regulation. In the work done by Zion, Adler, and Mevarech (2015), it has been seen that in the online discussion, individual and social MS developed the metacognitive performances of the students. Yilmaz (2014) reached the conclusion that providing MS in online learning environments increased the metacognitive awareness of providing MS in the study of the effect on learners' metacognitive awareness. The study by Lee et al. (2009) concludes that metacognitive feedback to learners in computer-based learning environments is effective in understanding complex issues and improving learners' self-regulation skills. Feyzi-Behnagh et al.'s (2014) metacognitive scaffolds provided to learners in the study using the medical intelligent tutoring system environment achieved the result that learners developed self-judgments of accuracy. Overall, these results indicate that MS

is effective in improving self-regulation skills that will be provided to learners in the personalized learning environments. It is seen that the results of these researches are generally consistent with the results of our research.

When the results in the literature are evaluated, it can be said that MS will be effective in improving self-regulation skills of learners provided in virtual learning environments. When the researches are examined, it is stated that the features of the learning environment such as glossary, note-taking, tagging, wiki, calendar, news flow, adaptability, and learning analytics can be used in MS (Cigdem, 2015; Delen et al., 2014). However, it is stated that researchers can use the pedagogical agent as a social model for learners in virtual learning environments because of the advantages such as visual and auditory communication, gesture and mimicry utilization, human-like features, and so forth (Yilmaz & Kilic Cakmak, 2012). For this reason, it can be stated that the use of pedagogical agents may be more effective in improving self-regulation skills because of the features that learners in virtual learning environments have, even though MS uses various tools and features of the learning environment. In the development of self-regulation skills of learners in online learning environments, it is useful to provide MS with the pedagogical agent to evaluate the process at the beginning of the learning period, to follow the process while continuing to the learning process, and to evaluate the process at the end of the learning period.

University students are the participants of this research conducted to determine the effect of pedagogical agent-supported metacognitive guidance on students' self-regulation skills. Given that age and experience are important factors in the development of self-regulation skills, it has been indicated that students' characteristics such as age levels, cognitive development levels, epistemological beliefs, and locus of control may influence the use of self-regulation learning strategies (Paris & Paris, 2001). For this reason, it is necessary to take into account the individual differences of students in their SRL strategies training. In this context, it would be useful to conduct a similar study on younger age groups, such as middle school and high school students, where the FC model is applied and to examine the results. In terms of developmental characteristics, the effect of MS, which is a pedagogical agent, is thought to be more effective in younger age groups. When the characteristics of planning, monitoring or control, and evaluation processes of SRL are taken into consideration, it is thought that the design features of the pedagogical agent may also affect learners' self-regulation skills. As a matter of fact, it can be seen that the characteristics of pedagogical agent such as gender, cartoon character, or human likeness can lead to a difference in learning process and results such as academic achievement (Baylor & Ryu, 2003; Baylor & Kim, 2004; Yilmaz & Kilic Cakmak, 2012). For this reason, in future research, the effect of the agent's design features on self-regulation skills can be examined. In future researches, learners' interaction processes with the agent can be examined by using features such as learning analytics of the learning environment.

Appendix

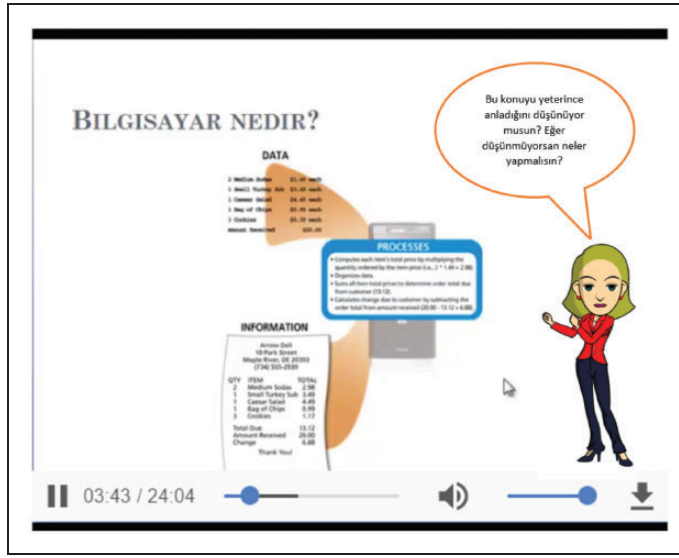

Figure A1. Screenshot of a pedagogic agent-assisted video.

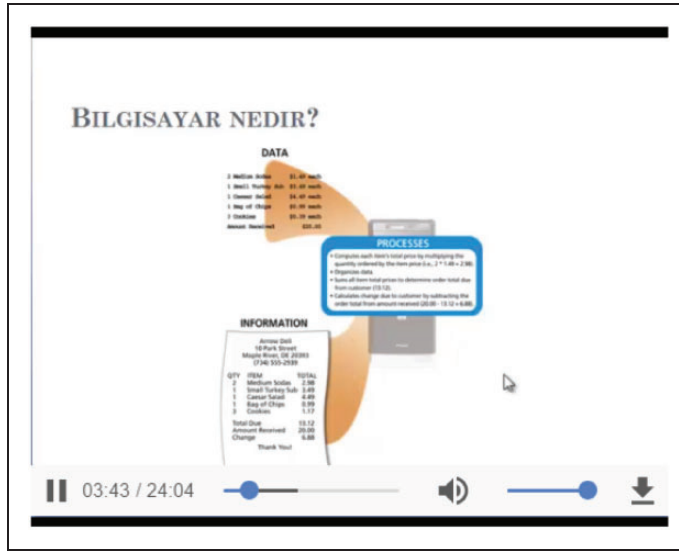

Figure A2. Screenshot of a video without pedagogic agent support.

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