Computers & Education 134 (2019) 1–14

Contents lists available at ScienceDirect

Computers & Education

journal homepage: www.elsevier.com/locate/compedu

Impact of pedagogic agent-mediated metacognitive support towards increasing task and group awareness in CSCL

Fatma Gizem Karaoglan Yilmaz, Ramazan Yilmaz*

Faculty of Education, Department of Computer Education and Instructional Technology, Bartın University, Bartın, Turkey

ARTICLE INFO

Keywords:
Computer-mediated communication
Cooperative/collaborative learning
Human-computer interface
Improving classroom teaching
Interactive learning environments

ABSTRACT

Today, there is an increasing interest in computer supported collaborative learning (CSCL) in teaching and learning practices considering the knowledge and skills that 21st-century learners should have. Nevertheless, depending upon factors such as low self-regulation and self-directed learning skills, students may fail in CSCL environments and processes due to the reasons of not knowing what to do, not being able to manage tasks and responsibilities, requiring external guidance support. Therefore, it is believed that providing external support in the CSCL process is important. The purpose of this study was to investigate the impact of metacognitive support provided towards increasing task and group awareness in CSCL through a pedagogic agent. The study was designed as an experimental study with pretest-posttest control group and mixed methods approach was employed. The findings indicated that the metacognitive support provided through a pedagogic agent for the experimental group members in CSCL had a significant impact on the motivation of students, metacognitive awareness and group processes (transactive memory system, group cohesion, group atmosphere). This research is important in terms of presenting practical suggestions to improve learning and results in CSCL by providing pedagogic agent-mediated metacognitive support. Based on the research findings, various suggestions were made for teachers and instructional designers.

1. Introduction

Collaborative learning, which is a type of learning where the knowledge is constructed by the group members while learners are working together for a common goal, is regarded as an essential skill for 21st-century learners. Today, the issue of supporting collaborative learning applications with digital tools is emphasized with the inclusion of education technology tools into teaching and learning. According to ISTE (2017) student standards, students should use digital tools in order to widen their perspectives, enrich their learning by collaborating with others and be able to work efficiently in team works carried out locally and globally. This reveals the importance of computer-supported collaborative learning (CSCL) for the contemporary teaching and learning.

Participation of learners in collaborative learning by employing technology is one of the skills 21st-century learners are expected to have (ISTE, 2017). In general terms, CSCL aims to establish an effective communication and collaboration between the learners and enhance the cognitive and social development of the individual by engaging computers in collaborative teaching and learning (Kirschner, Kreijns, Phielix, & Fransen, 2015; Kreijns, Kirschner, Jochems, & Van Buuren, 2007). The issue of how collaborative learning supported by technology can strengthen the communication between individuals and group work is at the center of the aforementioned area of research (Alsancak, 2010). Research has shown that CSCL has many advantages such as improving cognitive

* Corresponding author.
E-mail addresses: gkaraoglanyilmaz@gmail.com (F.G. Karaoglan Yilmaz), ramazanyilmaz067@gmail.com (R. Yilmaz).

https://doi.org/10.1016/j.compedu.2019.02.001
Received 6 May 2018; Received in revised form 31 January 2019; Accepted 5 February 2019
Available online 07 February 2019
0360-1315/

and social development and knowledge sharing behaviors of students (Noroozi, Weinberger, Biemans, Mulder, & Chizari, 2012). However, researchers indicate that CSCL processes might fail due to various reasons. Particularly, the cohesion, interaction processes and task and group awareness of group members are among the important factors which determine the effectiveness of CSCL (Fransen, Kirschner, & Erkens, 2011; Fransen, Weinberger, & Kirschner, 2013; Noroozi, Biemans, Weinberger, Mulder, & Chizari, 2013; Weinberger, 2011). For this reason, researchers intervene in order to increase the task and group awareness of group members in CSCL environments.

A review of the relevant literature shows that task and group awareness tools have been employed in the recent years for this purpose. Visual tools such as maps, radar, reflector which aim to demonstrate the social interaction of group members and scripts are used to improve the task and group awareness in CSCL (Weinberger, Ertl, Fischer, & Mandl, 2005; Weinberger & Fischer, 2006; Weinberger, Stegmann, & Fischer, 2007). In addition to the use of these tools and scripts, researchers emphasize the importance of examining the impact of providing awareness support through strategies towards increasing individual awareness such as scaffolding and metacognitive support on group processes. In the light of aforementioned information, the aim was to examine the impact of metacognitive support, which was provided for group members through a pedagogic agent regarding task and group awareness, on motivation, metacognitive awareness and group processes (transactive memory system, group cohesion and group atmosphere). It is believed that the findings will guide researchers and implementers on the design of CSCL environments and processes and expand the flow and depth of the research on the subject.

2. Theoretical background and literature review

2.1. Task and group awareness in CSCL

Task awareness is the awareness and knowledge of the individual in a group on a learning task. The behaviors that individuals in the group are expected to display and task phases can be given as examples. On the other hand, *Group awareness* is defined as up-to-date information of an individual in the group on the activity and situation of others for coordinating and completing a part of the group task. For instance, the prior knowledge levels of the group members and their participation to the group activities are indicators of group awareness (Gijlers, Weinberger, Van Dijk, Bollen, & Van Joolingen, 2013). Liccardi, Davis, and White (2007) define group awareness as the awareness of a member of the group on roles, responsibilities, activities, actions and situations of other members within the process. When the studies are examined, it is seen that scripts and awareness tools are employed in CSCL environments with the purpose of increasing task and group awareness of group members in CSCL (Bodemer & Dehler, 2011; Dehler, Bodemer, Buder, & Hesse, 2011; Janssen, Erkens, & Kirschner, 2011; Miller & Hadwin, 2015).

Task and group awareness tools support cognitive, behavioral and social development processes of group members by increasing their task and group awareness in CSCL environments and coordinate collaboration among group members (Bodemer & Dehler, 2011; Janssen & Bodemer, 2013; Miller & Hadwin, 2015). Thus, these tools support the development of group performance (Engelmann, Dehler, Bodemer, & Buder, 2009). The task and group awareness tools can also be used for producing external feedback for group members in CSCL processes and monitoring and evaluating group collaboration (Butler & Winne, 1995). In addition, these tools provide an opportunity for evaluating whether the chosen strategies are operating as expected and the products are in accordance with the standards (Janssen et al., 2011).

When the studies are examined, it is seen that the group awareness tools can be effective in increasing group's collective actions and visualizing social interaction (Kirschner & Kreijns, 2003) and participation of group members in collaboration processes (Janssen, Erkens, Kanselaar, & Jaspers, 2007), increasing effectiveness of collaboration (Janssen & Bodemer, 2013), improving problem solving skills (Schreiber & Engelmann, 2010) and facilitating increased individual learning (Sangin, Molinari, Nüssli & Dillenbourg, 2011). Gijlers et al. (2013) indicate that providing an awareness support in the collaborative learning improve learning processes and results, contribute to the process of building a consensus, increase the off-task activities related to coordination and enable to have an extensive knowledge. Kirschner et al. (2015) found that using Radar and Reflector tools to increase awareness in CSCL environments supports the group's cognitive, social and socio-emotional development, encourages interaction and group processes in the groups, increases group satisfaction and lowers levels of contradictions among the group members. On the other hand, it was found that employing Radar and Reflector tools do not affect the product quality.

Pifarré, Cobost and Argelagós (2014) observed that the use of group awareness tool in the CSCL processes improved participation of students in learning processes and activities and their task performances through cognitive and metacognitive activities. In their study, Buder and Bodemer (2008) found that the use of group awareness tool in the CSCL process supported group collaboration processes in terms of manipulation check, group decisions, and individual correctness. Similarly, Kimmerle and Cress (2008) concluded that the use of group awareness tools in the CSCL processes increased the awareness of students in terms of making individual contribution and enabled individuals to know themselves. In Sangin et al.'s (2011) study, it was found that the use of knowledge awareness tool improved the learning results, increased knowledge verification and negotiation processes and affected the sensitizing process positively. Phielix, Prins, Kirschner, Erkens, and Jaspers (2011) found that the use of peer feedback and reflection tool in the CSCL environment enhanced satisfaction of group members from the group processes and social performance.

Schreiber and Engelmann (2010) examined the impact of the use of a knowledge and information awareness tool on the transactive memory system processes. The results verified the potential of tool use to launch the transactive memory system processes of the group and determined that it affected the group performance positively. Janssen et al. (2011) found that the use of a group awareness tool in the online collaboration process does not affect the group performance. In their study, Dehler et al. (2011) concluded that the use of group knowledge awareness tool guided students towards collaboration and shaped their communicational

behaviors. However, the knowledge test results showed that there is no significant difference between the experimental and control groups. Kwon, Hong, and Laffey (2013) concluded that the use of an awareness tool based on metacognitive scaffolding principles towards improving group coordination in online collaborative learning improves the loyalty of students to their groups and enhanced cooperation between group members, positive interaction and group productivity.

2.2. Pedagogic agent and metacognitive support in CSCL

When the literature is reviewed, it is seen that researchers make design interventions towards increasing task and group awareness in CSCL. Visual tools and scripts such as maps, radar and reflector are used particularly in CSCL environments to reveal the social interaction of group members. According to Järvelä and Hadwin (2013), it is possible to provide support for group members in CSCL in the forms of (a) structuring supports, (b) mirroring or visualization supports, (c) metacognitive awareness tools, and (d) guiding tools or systems. When the relevant studies are reviewed, it is seen that the studies carried out mostly focus on the impact of mirroring or visualization supports. In addition, researchers draw attention to the importance and necessity of research studies conducted on providing metacognitive support (Järvelä et al., 2015; Järvelä & Hadwin, 2013; Kirschner & Erkens, 2013; Winne, 2015).

Metacognitive support approach is based on the concept of metacognition which is the knowledge of an individual on his/her own cognitive processes and his/her ability to plan, monitor and evaluate these processes when necessary. In the most broadest sense, metacognition is defined as the awareness and control of an individual on his/her learning (Zimmerman, 1995). As for Brown (1987), the most essential think in metacognitive process is the regulation of cognition. Some metacognitive support strategies and techniques are used in the regulation of cognition. One of them is metacognitive support approach in which students ask questions to themselves, realize their mistakes and shortcomings in the learning process and control their mistakes and regulate their learning. According to Blakey and Spence (1990) in order to self-regulate their cognition, it is important that students should ask and answer questions towards planning their learning at the beginning of the learning process; monitoring their learning during the learning process and evaluating their learning at the end of the learning process. Studies reveal that including planning, monitoring and evaluation practices in the learning environment will increase metacognitive awareness and help students to control and regulate the learning process and products (Karaoglan Yilmaz, Olpak, & Yilmaz, 2018; Yilmaz & Keser, 2017). It is believed that metacognitive support will improve internal control processes and thus, increase the success of online learning particularly in online learning environments, where there is almost no external control. When the studies conducted on providing metacognitive support in online learning environments are reviewed, it is seen that this support is provided mostly in the planning, monitoring and evaluating the learning processes of the individual and through interfaces such as a pedagogic agent (Azevedo & Hadwin, 2005; Yilmaz & Keser, 2017). The review of the studies indicate that the use of a pedagogic agent in online learning environments affect the learning processes and results such as motivation, academic success and cognitive load (Dincer & Doganay, 2017), achievement, attitude and retention (Yilmaz & Kilic-Cakmak, 2012) and learning motivation, enjoyment, perceived usefulness and behavioral intention (Guo & Goh, 2016) positively.

Studies on providing metacognitive support in CSCL environments focus on providing metacognitive support through questioning activities (Kwon et al., 2013) and learning analytics tools (Pifarré, Cobos, & Argelagós, 2014). When the impact of providing metacognitive support to group members in CSCL processes is assessed, it is seen that it enhance the loyalty of group members to the group and the interaction between the members, increase group productivity (Kwon et al., 2013), improve cognitive performance and affect metacognitive learning activities, and task performance positively (Pifarré et al., 2014).

2.3. Research hypotheses

A review of literature, shows that the learning processes and results can be affected negatively in CSCL due to the low group and task awareness of group members. Particularly, it is stated that, due to low levels of task and group awareness, the motivation of the group members can be decreased and the process of the transactive memory system, group cohesion and group atmosphere can be affected negatively (Engelmann et al., 2009; Fransen et al., 2013; Gijlers et al., 2013; Järvelä et al., 2015; Järvelä & Hadwin, 2013; Kirschner & Erkens, 2013; Malmberg, Järvelä, Järvenoja, & Panadero, 2015; Miller & Hadwin, 2015; Noroozi et al., 2013; Weinberger, 2011). *Transactive memory*, which is one of the factors indicating the sharing and use of individual cognition socially, refers to shared understanding of who knows what in the group and cognitive sharing of effort within group (Noroozi et al., 2013; Wegner, 1987). The term is referred to as transactive memory at individual level and as transactive memory system at group level and is defined as how actively group members use transactive memory in collaborative coding, storing and retrieval of information (Alsancak & Altun, 2011; Lewis, 2004). If the transactive memory system of a group is strong, the group members will be aware of who knows what in the group. *Group cohesion* is defined as the sense of belonging among members to the group or the degree of similarity between group members (Knight, Pearson, & Hunsinger, 2008). *Group atmosphere* is related to how the group environment is perceived by the group members (Kreijns, Kirschner, Jochems, & Van Buuren, 2004). Low level of task and group awareness among students could directly effect these concepts which are related to group collaboration. Kwon et al. (2013) emphasize the importance of offering group awareness tools and metacognitive support to solve aforementioned problems in CSCL processes. It is stated that the group awareness tools and scripts can be used in CSCL environments for improving the transactive memory system of the group, group cohesion and group atmosphere (Engelmann, Tergan, & Hesse, 2010; Schreiber & Engelmann, 2010). In addition to the group awareness tools and scripts, another way of providing metacognitive support to learners in online environments is benefitting from pedagogic agents. It is believed that the metacognitive support that will be provided through a pedagogic agent in CSCL environments

will improve the learning processes and results by enhancing the task and group awareness of group members. However, when the literature is reviewed, it is seen that there is a need for studies examining the pedagogic agent-mediated metacognitive support on learning processes and results in CSCL environments. From this point of view, the purpose of this study was to examine the metacognitive support that was provided for group members through a pedagogic agent in CSCL environments on students' motivations, metacognitive awareness and group processes (transactive memory system, group cohesion and group atmosphere). In line with this purpose, the hypotheses in the study are as given below. In addition, the opinions of students on the pedagogic agent support in the learning process were examined:

H1 *There is no significant difference in students' motivation between the experimental group (EG) and control group (CG).*
H2 *There is no significant difference in the metacognitive awareness of students between the EG and CG.*
H3 *There is no significant difference in the transactive memory systems of students between the EG and CG.*
H4 *There is no significant difference in group cohesions between the EG and CG.*
H5 *There is no significant difference in the group atmospheres between the EG and CG.*

3. Methods

3.1. Research model and participants

The study was designed as an experimental study with pretest-posttest control group and mixed research methods (quantitative data collection and analysis + qualitative data collection and analysis) were used. The study was carried out during Computing II course, with freshmen students who study at the Faculty of Economics and Administrative Sciences of a public university in Turkey. The participants were 50 freshmen students. Students were randomly assigned to EG and CG. As a result of the random assignment, 23 students participated in the EG in which the awareness support was provided through a pedagogic agent; and 27 students were assigned to the CG. 38% (f = 19) of the students who participated in the study were male and 62% (f = 31) were female.

The aforementioned students took the Computing I course which was delivered through a blended learning approach the previous semester (2015–2016 fall semester). Therefore, the students possess certain levels of motivation and metacognitive awareness towards the Computing course. In order to control the impact of this situation on the experimental process, the motivation and metacognitive awareness of students were measured with a pretest and posttest. Transactive memory, group cohesion and group atmosphere scales were used as posttest in order to compare the transactive memory system, group cohesion and group atmosphere levels of the students in the EG and CG at the end of the experimental process. The research process was summarized in Fig. 1.

As is seen in Fig. 1, at the beginning of the study, motivated strategies for learning questionnaire and metacognitive awareness scale were administered to both EG and CG students as a pretest. Following the 10-week collaborative learning process, motivated strategies for learning questionnaire and metacognitive awareness scale were re-administered to both groups of students as a posttest. Besides, in order to compare the group processes in EG and CG students, transactive memory scale, group cohesion scale and group atmosphere scale were administered as posttest. Finally, at the end of research process, student opinion form was used.

3.2. Data collection tools

3.2.1. Motivated strategies for learning questionnaire

In comparing motivation of the students, Motivated Strategies for Learning Questionnaire developed by Pintrich, Smith, Garcia and McKeachie (1991), and translated and adapted into Turkish by Buyukozturk, Akgun, Ozkahveci, and Demirel (2004) was used. The scale is a seven-point Likert type scale and consists of two main scales: the motivation scale and learning strategies scale. The motivation scale includes 31 items and six sub-scales which are intrinsic goal orientation, extrinsic goal orientation, task value, control beliefs about learning, self-efficacy for learning and performance and test anxiety. Researchers state that the motivated strategies for learning questionnaire has a modular structure and the sub-scales can be used independently depending on the research purpose (Buyukozturk et al., 2004). The Cronbach alpha values of the scales for this study are: motivation scale (0.92), intrinsic goal orientation sub-scale (0.85), extrinsic goal orientation sub-scale (0.85), task value sub-scale (0.88), control beliefs about learning sub-scale (0.75), self-efficacy for learning and performance sub-scale (0.95), and test anxiety sub-scale (0.71).

3.2.2. Metacognitive awareness inventory

The scale was developed by Schraw and Dennison (1994) was translated and adapted into Turkish by Akin, Abaci and Cetin (2007). The five-point Likert scale includes eight sub-factors which are declarative knowledge, procedural knowledge, conditional knowledge, planning, monitoring, evaluation, debugging, and information management and has 52 items in total. For this study, the Cronbach alpha values of the scale was found as (0.96) for the overall scale; and (0.81), for declarative knowledge (0.72) for procedural knowledge (0.71) for conditional knowledge, (0.77) for planning, (0.84) for monitoring, (0.77) for evaluation, (0.71) for debugging, and (0.75) for information management.

3.2.3. Transactive memory scale

The scale was developed by Lewis (2004) was translated and adapted into Turkish by Alsancak (2010). The scale consists of three factors which are specialization, credibility and coordination and has 12 items. For this study, the Cronbach alpha values of the scale were found as (0.87) for the overall scale and (0.70) for specialization, (0.79) for credibility, and (0.73) for coordination.

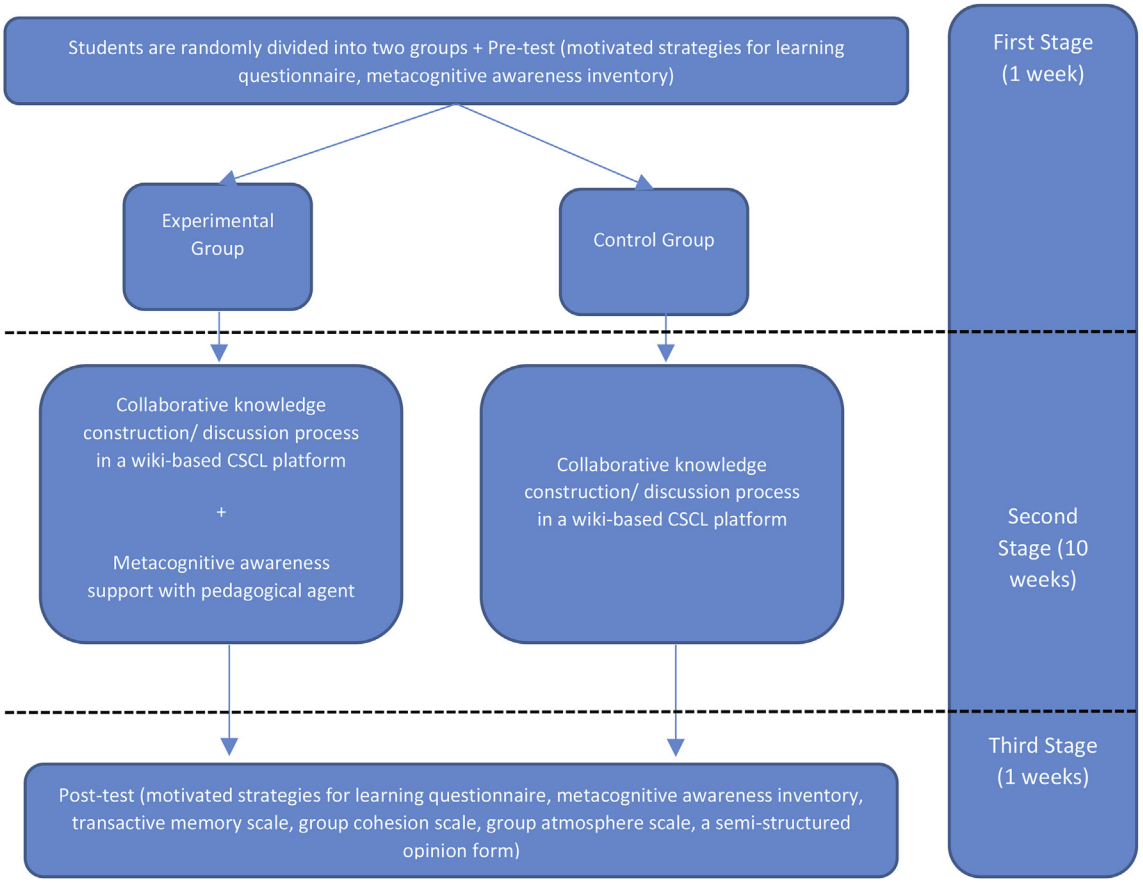

Fig. 1. Research model.

3.2.4. Group cohesion scale

The scale used to measure group cohesion level in CSCL was developed by Price and Mueller (1986) was translated and adapted into Turkish by Alsancak (2010). The five-point Likert scale includes five items and it has a single factor. For this study, the Cronbach alpha value of the scale was found as (0.77).

3.2.5. Group atmosphere scale

In CSCL, the scale which was developed by Fiedler (1967), translated and adapted into Turkish by Alsancak (2010) was used to determine the group atmospheres. The five-point Likert scale has a single factor and consists of six items. For this study, the Cronbach alpha value of the scale was found as (.79).

3.2.6. Student opinion form

This form consisting of semi-structured questions were generated by authors to identify students' opinions concerning CSCL environments. The questions in the form were formed towards identifying the opinions on the sub-dimensions of the scales that were employed in the study and used in the study by making the required arrangements after the review of the experts.

3.3. CSCL environments and procedure

In the study, Moodle mobile learning management system (LMS) was used as the CSCL environment and the pedagogic agent supported task and group awareness tool, integrated into Moodle mobile LMS via the, wiki tool in this system were used. Wiki environment was used to plan collaborative group work, share file and sources, share knowledge among group members, make discussions on group tasks and collaboration and construction of knowledge collaboratively. Pedagogical agent supported task and group awareness tool, on the other hand, was integrated into the Moodle and at the beginning and end of their weekly collaborative learning process, students used this tool. The purpose in using this tool was to offer metacognitive support towards increasing task and group awareness.

The study was carried out during Computing II course and lasted for 10 weeks. At the beginning of the study, the students in EG and CG were asked to form 3–5 person groups and were notified that they would carry out a group project during the semester. In the

first week of the research, the students in the EG and CG were informed after the formation of sub-groups, about the Moodle mobile environment and the operations they would perform. In this context, the students were asked to construct a topic related to digital citizenship (digital security, digital literacy etc.) which was determined by the relevant teacher each week in the wiki environment as a group. Accordingly, each group constructed the weekly topic and content given to them in the wiki environment. This collaborative knowledge construction process involved reviewing the resources on the weekly topic, evaluation of these resources by group members, deciding on the content and constructing this content systematically on wiki. Thus, at the end of weekly collaboration process, a wiki page, explaining the topic of the week, is designed by the group. It was explained that while preparing the content on wiki environment, students should not only use texts but also multimedia tools such as images and videos. While designing the wiki page on the given topic each week, students made collaborative discussions and decided on the content and elements to be added to the page. The discussions were carried out on the "comments" page on the wiki. Students can also see everyone's contribution in the process using the "history" page on wiki. At the beginning of the study, the researcher explained students that they should follow material design principles while constructing the topic and content, what they should do and what they should pay attention to.

The groups worked collaboratively during the information construction process. The teacher explained at the beginning of the semester that there were such roles in the sub-groups as group leader, resource researcher, arguer and summarizer and each member should take a role and contribute to the group work. In this context, the group leader was responsible for carrying out the planning of tasks and collaboration, resource researcher was responsible for reviewing the resources related to the topic and sharing it with group members, arguer was responsible for organizing the discussions to decide on which content and resources would be used and finally, summarizer was responsible for preparing the wiki page based on the agreed content. The role assignment was conducted in a similar way in the EG and CG. The students in the EG used the pedagogic agent supported task and group awareness tool. However, there was no pedagogical agent supported task and group awareness tool in the CSCL environment used by CG.

The task and group awareness tool was implemented on students at the beginning of the relevant week before the students started to the group work and at the end of the week on each student individually. At the beginning of the week, the students were asked various questions supported with metacognitive guidance through the pedagogic agent by giving a link to Moodle mobile environment named "Let's Check before We Start to the Group Work" and students were asked to answer these questions. The purpose of these questions was to increase the awareness of the students in terms of the topic of the week, their tasks related to the topic and collaboration with the group. Examples of questions asked by the pedagogical agent include: "What kind of task and collaboration planning will you make to make the group work of this week more efficient?", "What kind of a strategy will you apply in order not to experience the same troubles you had in group work last week?"etc. After answering the questions in the pre-form, the groups started to the information construction process in the wiki environment. This process continued for a week. Subsequently, each group carried out a discussion by using the discussion panel of the wiki environment both on the material design principles and constructed topic contents by examining their wiki environments. These discussions continued for a week until students passed on the topic of the following week concerning digital citizenship. By implementing the pedagogic agent supported task and group awareness tool by clicking on the link named "Let's Evaluate the Group Work" in the Moodle mobile environment at the end of the week, the group awareness was tried to be increased by asking questions as in what extend group members fulfill their responsibilities, how is the group cohesion, the good and bad aspects, and solution suggestions towards these etc. After students in the EG answered the questions asked by the pedagogical agent regarding the evaluation of group work, they realized their mistakes and made the necessary amendments on wiki page. Examples of questions asked by the pedagogical agent include: "To what extent, do you think the group work was effective?", "Do you think there were mistakes and shortcomings in the product created, if you think so, how should they be fixed?", "What kind of group planning will you make to fix these mistakes and shortcomings?" etc. An example regarding the metacognitive support awareness provided by the pedagogic agent which is used for the purpose of increasing the task and group awareness was given in Fig. 2. In a similar way, the metacognitive support awareness implementation awareness provided through the pedagogic agent continued in the EG each week. This support was not included in the CSCL groups in CG.

The interfaces of the pedagogic agent employed in the CSCL environments were designed on the website named www.toondoo.com and on Photoshop program. Afterwards, CrazyTalk program was used to add gestures and mimics to the interfaces which were designed and animation. In addition, the voice records and thought balloons were added to the pedagogic agent. This way, the pedagogic agent could interact with students vocally and in a written form while asking the questions.

3.4. Data analysis

The Kolmogorov-Smirnov Test was used to test distribution of normality of the student scores from the scales. The test results indicated that the scores had a normal distribution ($p > .05$). For this reason, *t*-test and ANCOVA, which are parametric tests for data analysis were used. The comparison was made between the posttest scores in order to determine whether there was a significant difference by controlling the pretest motivation and metacognitive awareness scores of the students in the study groups. ANCOVA was used for this comparison. The analysis of ANCOVA was conducted by using the motivated strategies for learning questionnaire, metacognitive awareness inventory pretest scores as the covariant motivated strategies for learning questionnaire, metacognitive awareness inventory posttest scores as the dependent variable and CSCL platform as the independent variable in order to investigate whether the EG and CG showed significant differences in their motivated strategies for learning questionnaire, metacognitive awareness inventory skills by excluding the interaction effects of motivated strategies for learning questionnaire, metacognitive awareness inventory pretest. The *t*-test was used in the comparison of the transactive memory, group cohesion and group atmosphere scale scores of the study groups which were implemented as posttest. The analysis of the qualitative data collected by the student opinion form was done by the content analysis method. During the data analysis period, the data which had been coded by a

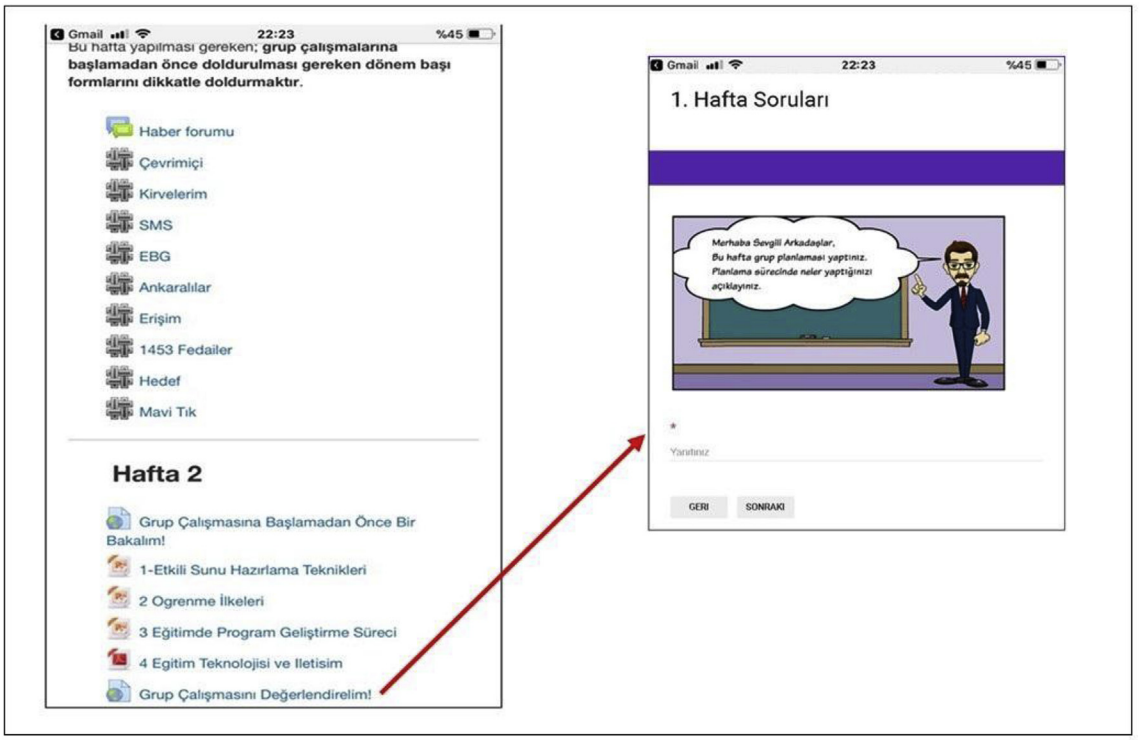

Fig. 2. An example of the metacognitive support awareness provided by the pedagogic agent.

researcher were coded again by a second coder for the reliability of the study. The reliability of the coding was obtained by dividing the number of common codes given by both coders to the total number of codes. The coding reliability percentage was found as 92% reliability = (consensus number)/(total consensus + number of disagreement) (Miles & Huberman, 1994). The researchers came together and agreed for the remaining 8% difference. As a result of the examination of the written answers given by the students, it was understood that this gap had appear from gathering certain answers under several sub-themes.

4. Findings

4.1. Findings on motivation

In order to test the first hypothesis, an answer was sought for the question of whether there was a significant difference between the motivated strategies for learning questionnaire scores of EG and CG. When the pretest scores that the students in the EG and CG obtained from the motivated strategies for learning questionnaire were controlled, the existence of a significant difference between the motivated strategies for learning questionnaire posttest scores were tested by employing ANCOVA. The assumptions were met ($F = 2.222$; $p > .05$), before covariance analysis.

The adjusted motivated strategies for learning questionnaire posttest scores were found as ($\bar{x} = 181.78$) for EG and as ($\bar{x} = 152.96$) for CG. The covariance analysis results, which was performed to test whether the difference occurred between the motivated strategies for learning questionnaire posttest scores of the EG and CG were significant or not, is presented in Table 1.

When the pretest scores of the EG and CG were controlled (Table 1); the difference between the adjusted posttest scores were significant [$F_{(1,47)}$: 18.776; $p < .05$]. In an other saying, it was found that motivated strategies for learning questionnaire posttest scores of the EG ($\bar{x} = 181.78$) were significantly higher than motivated strategies for learning questionnaire posttest scores of CG ($\bar{x}$

Table 1
The results of covariance analysis of the posttest scores of the students in experimental group and control group when their motivated strategies for learning questionnaire pretest scores are taken under control.

Source	Sum of Squares	df	Mean Square	F	p
Pre-test	89.526	1	89.526	.164	.687
Group	10258.520	1	10258.520	18.776	.000
Error	26840.241	47	571.069		
Total	1417539.000	50			

Table 2
The results of covariance analysis of the posttest scores of the students in experimental group and control group when their metacognition awareness scale pretest scores are taken under control.

Source	Sum of Squares	df	Mean Square	F	p
Pre-test	445.279	1	445.279	.761	.596
Group	29806.864	1	29806.864	50.962	.000
Error	27489.674	47	584.887		
Total	2486289.000	50			

= 152.96). Table 1 summarizes, the motivated strategies for learning questionnaire pretest scores of the study groups were assigned as a covariate variable, grouping main effect was significant in terms of motivated strategies for learning questionnaire scores with a medium effect size, [$F_{(1,47)}$: 18.776; p = .000 < 0.05; Cohen's f = 0.28] (Cohen, 1988).

4.2. Findings on metacognitive awareness

In order to test the second hypothesis, an answer was sought for the question of whether there was a significant difference between the metacognitive awareness inventory scores of the EG and CG. When the pretest scores that the students in the EG and CG obtained from the metacognitive awareness inventory were controlled, the existence of a significant difference between the posttest scores were tested by employing ANCOVA. The assumptions were met (F = 0.499; p > .05), before covariance analysis.

The adjusted metacognitive awareness inventory posttest scores were found as ($\bar{x}$ = 247.26) for EG and ($\bar{x}$ = 197.41) for CG. The covariance analysis results, which was performed to test whether the difference occurred between the posttest scores of the groups is significant or not, is presented in Table 2.

When the pretest scores of the EG and CG were controlled (Table 2); the difference between the adjusted posttest scores were significant [$F_{(1,47)}$: 50.962; p < .05]. In an other saying, it was found that metacognitive awareness inventory posttest scores of EG ($\bar{x}$ = 247.26) were significantly higher than metacognitive awareness inventory posttest scores of CG ($\bar{x}$ = 197.41). Table 2 summarizes, the metacognitive awareness inventory pretest scores of the study groups were assigned as a covariate variable, grouping main effect was significant in terms of metacognitive awareness inventory scores with a large effect size, [$F_{(1,47)}$: 50.962; p = .000 < 0.05; Cohen's f = 0.52] (Cohen, 1988).

4.3. Findings on transactive memory system

In order to test the third hypothesis, an answer was sought for the question of whether there is a significant difference between the transactive memory scale posttest scores of EG and CG. The *t*-test analysis results, which was performed to test whether there was a significant difference between the transactive memory scale posttest scores that EG and CG, are presented in Table 3.

The difference between the posttest transactive memory scale scores (Table 3) of EG and CG was significant (p < .05). In an other saying, it was seen that the transactive memory scale posttest scores of EG ($\bar{x}$ = 51.22) were significantly higher than the transactive memory scale posttest scores of CG ($\bar{x}$ = 44.67). When the effect size was analyzed, Cohen's was found as d = 0.15; in other words, it was determined that the effect size was small (Cohen, 1992).

4.4. Findings on group cohesion

In order to test the fourth hypothesis, an answer was sought for the question of whether there was a significant difference between the group cohesion scale scores of EG and CG. The *t*-test analysis results, which was performed to test whether there was a significant difference between the group cohesion scale posttest scores that EG and CG, are presented in Table 4.

The difference between the posttest group cohesion scale scores (Table 4) of EG and CG was significant (p < .05). In an other saying, it was seen that the group cohesion scale posttest scores of EG ($\bar{x}$ = 22.78) were significantly higher than the group cohesion scale posttest scores of CG ($\bar{x}$ = 19.11). When the effect size was analyzed, Cohen's was found as d = .63; in other words, it was determined that the effect size was medium (Cohen, 1992).

4.5. Findings on group atmosphere

In order to test the fifth hypothesis, an answer was sought for the question of whether there was a significant difference between

Table 3
T-test results of the groups' transactive memory scale posttest scores.

Groups	N	$\bar{x}$	df	t	p
Experimental Group	23	51.22	4.14	3.446	.00
Control Group	27	44.67	8.26		

Table 4
T-test results of the groups' group cohesion scale posttest scores.

Groups	N	$\bar{x}$	df	t	p
Experimental Group	23	22.78	2.04	5.277	.00
Control Group	27	19.11	2.75		

the group atmosphere scale scores of EG and CG. The *t*-test analysis results, which was performed to test whether there was a significant difference between the group atmosphere scale posttest scores that EG and CG, are presented in Table 5.

The difference between the posttest group atmosphere scale scores (Table 5) of the EG and CG was significant ($p < .05$). In an other saying, it was seen that the group atmosphere scale posttest scores of EG ($\bar{x} = 27.35$) were significantly higher than the group atmosphere scale posttest scores of CG ($\bar{x} = 23.59$). When the effect size was analyzed, Cohen's was found as $d = .41$; in other words, it was determined that the effect size was medium (Cohen, 1992).

4.6. Student opinions on pedagogic agent use

When the answers given by students on the issue pedagogic agent use in the process of collaborative learning, it was found that positive and negative sub-themes appeared as a result of the content analysis. These themes were evaluated in general below.

Table 6 summarizes the opinions of the students in the EG about the contributions of providing pedagogic agent support in CSCL environment to individual learning processes.

When the contributions of pedagogic agent use to the individual learning processes of the students were examined, the students stated respectively that pedagogic agent use mostly helps them to: enables learners to evaluate themselves during learning process (f = 5), enables learners to have a comprehensive understanding on the topic (f = 5), increases motivation and concentration of learners through gestures and mimics (f = 5), drives learners to think elaborately (f = 4), enables learners to notice missing or wrong learnings (f = 4) and enables learners to reinforce learnings (f = 3). In addition, some of the students stated that pedagogic agent use: drives learners to search for (f = 2), enables learners to question what is learned (f = 1), accelerates learning (f = 1) and enables learners to grasp the importance of the topic (f = 1). On the other hand, one student stated as a negative opinion that the pedagogic agent in the form of a virtual character was more appropriate for children and therefore did not contribute to the individual learning process. Some of the answers given by the students about the individual learning process are given below.

S1: *"It helped me to question what I learned."*
S2: *"It helped me see my inadequacies and improve them."*
S3: *"It helped me to revise what I did."*
S4: *"It gave me the opportunity to question myself."*

Table 7 summarizes the opinions of the students in the EG about the contributions of providing pedagogic agent support in CSCL environment to group cooperation processes.

When the contributions of pedagogic agent use to the group work processes of the students were examined, the students stated respectively that pedagogic agent use mostly: enables learners to make individual evaluation relating to cohesion with group members (f = 6), contributes to development of group cohesion (f = 5), enables learners to make evaluation about the group (f = 4), allows to involve in group works in a planned manner (f = 3), facilitates group works, by guiding (f = 3). In addition, some of the students stated that pedagogic agent use increases mastery on the topic and tasks (f = 2) enables learners to achieve individual responsibilities more attentively and comprehensively for the sake of group tasks (f = 2), enables learners to become aware of mistakes (f = 1), and facilitates knowledge sharing among group members (f = 1). On the other hand, three students stated that pedagogic agent use did not contribute to the group work process extensively. Some of the answers given by the students about the group work processes are given below.

S1: *"It helped us to make an evaluation of the group."*
S2: *"It helped us to understand how good we worked with our team mates."*
S3: *"Since we answer questions related to group work every week, we paid more attention to doing group tasks in a more planned and organized manner."*
S4: *"It enabled us to see how to work on a topic together."*

Table 5
T-test results of the groups' group atmosphere scale posttest scores.

Groups	N	$\bar{x}$	df	t	p
Experimental Group	23	27.35	2.79	4.324	.00
Control Group	27	23.59	3.27		

Table 6
Contributions of providing pedagogic agent support in CSCL environment to individual learning processes.

Sub-themes	f
Enables learners to evaluate themselves during learning process	5
Enables learners to have a comprehensive understanding on the topic	5
Increases motivation and concentration of learners through gestures and mimics	5
Drives learners to think elaborately	4
Enables learners to notice missing or wrong learnings	4
Enables learners to reinforce learnings	3
Drives learners to search for	2
Enables learners to question what is learned	1
Accelerates learning	1
Enables learners to grasp the importance of the topic	1

Table 7
Contributions of providing pedagogic agent support in CSCL environment to group cooperation processes.

Sub-themes	f
Enables learners to make individual evaluation relating to cohesion with group members	6
Contributes to development of group cohesion	5
Enables learners to make evaluation about the group	4
Allows to involve in group works in a planned manner	3
Facilitates group works, by guiding	3
Increases mastery on the topic and tasks	2
Enables learners to achieve individual responsibilities more attentively and comprehensively for the sake of group tasks	2
Enables learners to become aware of mistakes	1
Facilitates knowledge sharing among group members	1

Table 8 summarizes the opinions of the students in the EG about advantages and disadvantages of using pedagogic agent in CSCL environment in general.

When the students were asked about the advantages of pedagogic agent use in general, they stated that it allows learners to notice mistakes/missing points, by enabling them to complete the shortcomings related to tasks (f = 5), raised awareness on the tasks and group (f = 3), enables learners to revise themselves (f = 3) and enables learners to achieve new learnings (f = 3). In addition, it was stated that: facilitates to understanding (f = 1), enables learners to reinforce learnings (f = 1), enables learners to achieve the tasks more regularly (f = 1), develops concentration on task and cooperation (f = 1), and enables learners to act in a planned manner (f = 1). When the students were asked about the disadvantages of pedagogic agent use in general, 16 students stated that it did not pose any disadvantages. On the other hand: answering the questions of the pedagogic agent each week was boring (f = 4) and answering the questions took a long time (f = 3) were some of the disadvantages. Some of the answers given by the students were presented as follows.

S1: *"The pedagogic agent enabled us to see how we should perform a subject and how we can accomplish the mission together."*
S2: *"The pedagogic agent made us question who are fulfilling their tasks in the study and whether we are happy or not."*
S3: *"The convenient aspects of the questions asked by the pedagogic agent made us think like what we can do to perform a better performance as a group by seeing our mistakes and shortcomings."*

Table 8
Advantages and disadvantages of using pedagogic agent in CSCL environment.

Sub-themes	f
Advantages	
Allows learners to notice mistakes/missing points, by enabling them to complete the shortcomings related to tasks	5
Raised awareness on tasks and group	3
Enables learners to revise themselves	3
Enables learners to achieve new learnings	3
Facilitates to understanding	1
Enables learners to reinforce learnings	1
Enables learners to achieve the tasks more regularly	1
Develops concentration on task and cooperation	1
Enables learners to act in a planned manner	1
Disadvantages	
Answering the questions of the pedagogic agent each week was boring	4
Answering the questions took a long time	3

S4: *"It took some time to answer the questions. Repetition of similar questions was a little boring."*
S5: *"The questions were not unnecessary but boring."*

5. Discussion

This study examined the impact of the metacognitive support provided to increase the task and group awareness in the CSCL process on students' motivations, metacognitive awareness, transactive memory, group cohesion and group atmosphere. The research findings indicated that providing metacognitive support to the group members increased students' motivations and metacognitive awareness and improved the transactive memory, group cohesion and group atmosphere in a positive way. The qualitative data analysis results also support the findings obtained from the quantitative data.

When the findings of the study on motivations are compared to the existing literature, it is seen that the results support the literature. Janssen et al. (2011) found that the increase in the awareness of students on the knowledge in the CSCL environment had a positive effect on students' collaborative behavior and motivations. Malmberg et al. (2015) indicated that awareness of socially shared regulation of learning in CSCL improved motivation. Zumbach, Hillers, and Reimann (2004) concluded that the use of a group awareness tool in CSCL affected students' learning processes, group performances and motivations positively. The findings of this study indicated that the task and group awareness support provided through a pedagogic agent improved the transactive memory, group cohesion and group atmosphere. This result can be interpreted in two different ways. First of all, the pedagogic agent support might influence student motivation directly. Similarly, in other studies, it was stated that the pedagogic agent support can be effective on student motivation (Duffy & Azevedo, 2015; Meij, Meij, & Harmsen, 2015; Schroeder & Adesope, 2014). On the other hand, it was seen that the transactive memory system, group cohesion and group atmosphere were improved more in the CSCL groups which receive a pedagogic agent support in comparison to the CSCL groups which do not receive a pedagogic agent support. It can be considered that this positive improvement in the group processes and structures also increases the student motivation. In other words, the pedagogic agent support might affect student motivation indirectly. Thus, the research results demonstrate that the pedagogic agent support improves the transactive memory system, group cohesion and group atmosphere of the group. In the future research studies, research designs can be planned towards determining the direct and indirect impact of a pedagogic agent on motivation.

When the findings of the study on metacognitive awareness are compared with the literature, it is found that the results support the literature. In the study conducted by Pifarré et al. (2014), it was concluded that the students in the EG, who used a group awareness tool during the CSCL process, attained more significant results in terms of participation in the CSCL processes, cognitive and metacognitive activities and task performances, in comparison to the students in the CG. Janssen et al. (2011) found that using a group awareness tool in the CSCL environment affected the group awareness partially. Kimmerle and Cress (2008) drew the conclusion that the use of a group awareness tool increases the awareness in terms of providing an individual contribution and provides an opportunity to individuals for knowing themselves. Based on these results, it can be stated that the metacognitive awareness support provided in the CSCL process through a pedagogic agent enables students to evaluate themselves on individual participation and participation in group processes and accordingly improves the task and group awareness.

The research results on the transactive memory system, group cohesion and group atmosphere show consistency with the literature in general. Pifarré et al. (2014) concluded that using a group awareness tool during the CSCL process increased the participation of students in collaborative learning by improving their group processes. Kirschner et al. (2015) drew the conclusion that the use of Radar and Reflector tools in the CSCL environment supported group development in terms of cognitive, social and socio-emotional aspects, encourages interaction and group processes and leads to a decrease in contradiction levels between the group members by increasing the group saturation. Gijlers et al. (2013) indicated that providing an awareness support in the collaborative learning process improved consensus reaching activities and increases the activities regarding task and coordination. Buder and Bodemer (2008) remarked that the use of a group awareness tool supports group cooperation in the group decision dimension. Kimmerle and Cress (2008) concluded that the use of a group awareness tool in the CSCL processes increased the awareness in terms of making individual contributions to the group processes and enable individuals to know themselves. Phielix et al. (2011) reached the conclusion that the use of a peer feedback and reflection tool in the CSCL environment increases group process satisfaction and social performance of the groups. Schreiber and Engelmann (2010) examined the impact of the use of knowledge and information awareness tool on transactive memory system processes. The results showed that the tool has a potential to launch a transactive memory system processes and improves knowledge sharing among the group members. Dehler et al. (2011) determined that the use of a group knowledge awareness tool direct students towards collaboration and improves students' communicational behaviors. Phielix, Prins, and Kirschner (2010) found that the use of a peer feedback tool (Radar) and a reflection tool (Reflector) in the CSCL environment contributes to the group development, reduces the contradiction/conflict levels between the group members and improves the positive attitude towards collaboration. Kwon et al. (2013) found that the use of an awareness tool based on the metacognitive scaffolding principles improved the loyalty of students to their groups, enhances collaboration and group processes. When the results are evaluated generally, providing a task and group awareness support in the CSCL processes promotes individual awareness development of the group members at first, and this improves the transactive memory system, group cohesion and group atmosphere of the group.

The following suggestions can be made for the design of the CSCL environments based on the research results: A metacognitive support can be provided through a pedagogic agent in CSCL environments at the beginning and end of the weekly learning processes to increase task and group awareness of the student. This way, a contribution can be made for the solution of the problems that occur in terms of student's motivation, metacognitive awareness situation, development of the transactive memory system of the group, group cohesion and group atmosphere, which are among the problematic issues seen in the CSCL environments and processes. It is

important to add gesture and mimic features to the agent and add a visual and aural dimension to the agent messages besides texts in order to increase the effectiveness of the messages in the process of the pedagogic agent support provision. Thus, in the qualitative data analysis findings, students emphasize the importance of the gesture and mimic features of the pedagogic agent and its ability to establish an interaction vocally in addition to the texts.

In this study, the answers given by the students to the pedagogic agent are asynchronous-based and based on the self-evaluation of the students. In the future studies, the impact of the pedagogic agent support can be examined by providing a simultaneous interface agent supported ChatBot system integration. Nevertheless, a feedback could not be provided by the pedagogic agent for the students, after the responses given by the students to the agent. In the future studies, the effectiveness of an awareness tool, which provides a feedback for students in line with students' responses to the questions asked by the pedagogic agent, can be tested. The study was conducted on university students. A similar study can be repeated on younger students who might need more external support in the learning process and the impact of the pedagogic agent support can be examined.

6. Conclusion

This study evaluated the efficiency of metacognitive support offered through pedagogical agent in order to increase task and group awareness in CSCL environment. Existing studies indicate that using such tools as radar and reflector and scripts in CSCL environments to increase task and group awareness is useful. Different from existing studies, current study shows that offering metacognitive support through a pedagogic agent in CSCL to increase task and group awareness has significant effect on student motivation, metacognitive awareness and group processes (transactive memory system, group cohesion, group atmosphere). In this sense, it seems possible to develop task and group awareness of students through external support such as pedagogic agent provided to group members in CSCL processes. The development of task and awareness of students, on the other hand, will yield efficient results in terms of increasing motivations of students during cooperative learning and developing metacognitive awareness of students. Hence, students can be more actively involved in CSCL process thanks to increased motivation, task and group awareness. Additionally, it would be possible to develop transactive memory system, group cohesion and group atmosphere in a positive way, depending on development of task and group awareness through pedagogic agent that is an external support provided individually to the students. As a result of this, interdependence among group members, coordination and cooperation will have improved. This will contribute to a more efficient and effective CSCL process. These make this study innovative and original and we expect that these results will guide practitioners and researchers.

Conflicts of interest

The authors declare that they have no conflict of interest.

Notes on contributors

Fatma Gizem Karaoglan Yilmaz is an associate professor in the Department of Computer Education & Instructional Technology at Bartin University in Turkey. She is interested in distance education, interactive learning environments and human-computer interaction.

Ramazan Yilmaz is an associate professor in the Department of Computer Education & Instructional Technology at Bartin University in Turkey. He is interested in instructional design, online learning, technology enhanced learning and smart learning environments.

Funding information

The authors declare that they have no funding of this study.

References

Akin, A., Abaci, R., & Çetin, B. (2007). The validity and reliability of the Turkish version of the metacognitive awareness inventory. *Educational Sciences: Theory & Practice, 7*(2), 671–678.

Alsancak, D. (2010). *The investigation of the relationship between transactive memory with group cohesion, group atmosphere and performance in computer supported collaboration learning environments*Doctoral Dissertation. Ankara, Turkey: Hacettepe University.

Alsancak, D., & Altun, A. (2011). The relationship between transactive memory and group cohesion, group atmosphere and performance in computer supported collaboration learning environments. *Educational Technology Theory and Practice, 1*(2), 1–16.

Azevedo, R., & Hadwin, A. F. (2005). Scaffolding self-regulated learning and metacognition – implications for the design of computer-based scaffolds. *Instructional Science, 33*(5), 367–379.

Blakey, E., & Spence, S. (1990). *Developing metacognition.* Syracuse, NY: Clearinghouse on Information Resources ERIC Document Reproduction Service No. ED 327 218.

Bodemer, D., & Dehler, J. (2011). Group awareness in CSCL environments. *Computers in Human Behavior, 27*(3), 1043–1045.

Brown, A. L. (1987). Metacognition, executive control, self-regulation, and other more mysterious mechanisms. In F. E. Weinert, & R. H. Kluwe (Eds.). *Metacognition, motivation, and understanding (65-116)*. Hillsdale, New Jersey: Lawrence Erlbaum Associates.

Buder, J., & Bodemer, D. (2008). Supporting controversial CSCL discussions with augmented group awareness tools. *International Journal of Computer-Supported Collaborative Learning, 3*(2), 123–139.

Butler, D. L., & Winne, P. H. (1995). Feedback and self-regulated learning: A theoretical synthesis. *Review of Educational Research, 65*(3), 245–281.

Buyukozturk, S., Akgun, O. E., Ozkahveci, O., & Demirel, F. (2004). The validity and reliability study of the Turkish version of the motivated strategies for learning questionnaire. *Educational Sciences: Theory & Practice, 4*(2), 231–239.
Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Hillsdale, NJ: Erlbaum.
Cohen, J. (1992). Statistical power analysis current directions. *Psychological Science, 1*(3), 98–101.
Dehler, J., Bodemer, D., Buder, J., & Hesse, F. W. (2011). Guiding knowledge communication in CSCL via group knowledge awareness. *Computers in Human Behavior, 27*, 1068–1078.
Dincer, S., & Doganay, A. (2017). The effects of multiple-pedagogical agents on learners' academic success, motivation, and cognitive load. *Computers & Education, 111*, 74–100.
Duffy, M. C., & Azevedo, R. (2015). Motivation matters: Interactions between achievement goals and agent scaffolding for self-regulated learning within an intelligent tutoring system. *Computers in Human Behavior, 52*, 338–348.
Engelmann, T., Dehler, J., Bodemer, D., & Buder, J. (2009). Knowledge awareness in CSCL: A psychological perspective. *Computers in Human Behavior, 25*(4), 949–960.
Engelmann, T., Tergan, S. O., & Hesse, F. W. (2010). Evoking knowledge and information awareness for enhancing computer-supported collaborative problem solving. *The Journal of Experimental Education, 78*, 1–20.
Fiedler, F. E. (1967). *A theory of leadership effectiveness.* New York: McGraw-Hill.
Fransen, J., Kirschner, P. A., & Erkens, G. (2011). Mediating team effectiveness in the context of collaborative learning: The importance of team and task awareness. *Computers in Human Behavior, 27*(3), 1103–1113.
Fransen, J., Weinberger, A., & Kirschner, P. A. (2013). Team effectiveness and team development in CSCL. *Educational Psychologist, 48*(1), 9–24.
Gijlers, H., Weinberger, A., Van Dijk, A. M., Bollen, L., & Van Joolingen, W. (2013). Collaborative drawing on a shared digital canvas in elementary science education: The effects of script and task awareness support. *International Journal of Computer-Supported Collaborative Learning, 8*(4), 427–453.
Guo, Y. R., & Goh, D. H. L. (2016). Evaluation of affective embodied agents in an information literacy game. *Computers & Education, 103*, 59–75.
International Society for Technology in Education (ISTE) (2017). *ISTE standards for students.* Available at: https://www.iste.org/standards/standards/for-students, Accessed date: 6 July 2017.
Janssen, J., & Bodemer, D. (2013). Coordinated computer-supported collaborative learning: Awareness and awareness tools. *Educational Psychologist, 48*(1), 40–55.
Janssen, J., Erkens, G., Kanselaar, G., & Jaspers, J. (2007). Visualization of participation: Does it contribute to successful computer-supported collaborative learning? *Computers & Education, 49*, 1037–1065.
Janssen, J., Erkens, G., & Kirschner, P. A. (2011). Group awareness tools: It's what you do with it that matters. *Computers in Human Behavior, 27*(3), 1046–1058.
Järvelä, S., & Hadwin, A. F. (2013). New frontiers: Regulating learning in CSCL. *Educational Psychologist, 48*(1), 25–39.
Järvelä, S., Kirschner, P. A., Panadero, E., Malmberg, J., Phielix, C., Jaspers, J., et al. (2015). Enhancing socially shared regulation in collaborative learning groups: Designing for CSCL regulation tools. *Educational Technology Research and Development, 63*(1), 125–142.
Karaoglan Yilmaz, F. G., Olpak, Y. Z., & Yilmaz, R. (2018). The effect of the metacognitive support via pedagogical agent on self-regulation skills. *Journal of Educational Computing Research, 56*(2), 159–180.
Kimmerle, J., & Cress, U. (2008). Group awareness and self-presentation in computer-supported information exchange. *International Journal of Computer-Supported Collaborative Learning, 3*(1), 85–97.
Kirschner, P. A., & Erkens, G. (2013). Toward a framework for CSCL research. *Educational Psychologist, 48*(1), 1–8.
Kirschner, P. A., & Kreijns, K. (2003). The sociability of computer-mediated collaborative learning environments: Pitfalls of social interaction and how to avoid them. In R. Bromme, F. Hesse, & H. Spada (Eds.). *Barriers and biases in computer-mediated knowledge communication and how they may be overcome* (pp. 169–192). Dordrecht, Netherlands: Kluwer.
Kirschner, P. A., Kreijns, K., Phielix, C., & Fransen, J. (2015). Awareness of cognitive and social behaviour in a CSCL environment. *Journal of Computer Assisted Learning, 31*(1), 59–77.
Knight, M. B., Pearson, J. M., & Hunsinger, D. S. (2008). The role of media richness in information technology-supported communication in group cohesion, agreeability, and performance. *Journal of Organizational and End User Computing (JOEUC), 20*(4), 23–44.
Kreijns, K., Kirschner, P. A., Jochems, W., & Van Buuren, H. (2004). Measuring perceived quality of social space in distributed learning groups. *Computers in Human Behavior, 20*(5), 607–632.
Kreijns, K., Kirschner, P. A., Jochems, W., & Van Buuren, H. (2007). Measuring perceived sociability of computer-supported collaborative learning environments. *Computers & Education, 49*(2), 176–192.
Kwon, K., Hong, R. Y., & Laffey, J. M. (2013). The educational impact of metacognitive group coordination in computer-supported collaborative learning. *Computers in Human Behavior, 29*(4), 1271–1281.
Lewis, K. (2004). Knowledge and performance in knowledge-worker teams: A longitudinal study of transactive memory systems. *Management Science, 50*, 1519–1533.
Liccardi, I., Davis, H. C., & White, S. (2007). CAWS: A wiki system to improve workspace awareness to advance effectiveness of co-authoring activities. *CHI'07 extended abstracts on human factors in computing systems* (pp. 2555–2560). .
Malmberg, J., Järvelä, S., Järvenoja, H., & Panadero, E. (2015). Promoting socially shared regulation of learning in CSCL: Progress of socially shared regulation among high-and low-performing groups. *Computers in Human Behavior, 52*, 562–572.
Meij, H., Meij, J., & Harmsen, R. (2015). Animated pedagogical agents effects on enhancing student motivation and learning in a science inquiry learning environment. *Educational Technology Research and Development, 63*(3), 381–403.
Miles, M. B., & Huberman, A. M. (1994). *Qualitative data analysis: An expanded sourcebook.* Sage Publications.
Miller, M., & Hadwin, A. (2015). Scripting and awareness tools for regulating collaborative learning: Changing the landscape of support in CSCL. *Computers in Human Behavior, 52*, 573–588.
Noroozi, O., Biemans, H. J., Weinberger, A., Mulder, M., & Chizari, M. (2013). Scripting for construction of a transactive memory system in multidisciplinary CSCL environments. *Learning and Instruction, 25*, 1–12.
Noroozi, O., Weinberger, A., Biemans, H. J., Mulder, M., & Chizari, M. (2012). Argumentation-based computer supported collaborative learning (ABCSCL): A synthesis of 15 years of research. *Educational Research Review, 7*(2), 79–106.
Phielix, C., Prins, F. J., & Kirschner, P. A. (2010). Awareness of group performance in a CSCL-environment: Effects of peer feedback and reflection. *Computers in Human Behavior, 26*(2), 151–161.
Phielix, C., Prins, F. J., Kirschner, P. A., Erkens, G., & Jaspers, J. (2011). Group awareness of social and cognitive performance in a CSCL environment: Effects of a peer feedback and reflection tool. *Computers in Human Behavior, 27*(3), 1087–1102.
Pifarré, M., Cobos, R., & Argelagós, E. (2014). Incidence of group awareness information on students' collaborative learning processes. *Journal of Computer Assisted Learning, 30*(4), 300–317.
Pintrich, P. R., Smith, D. A. F., Garcia, T., & McKeachie, W. J. (1991). *A manual for the use of the motivated strategies for learning.* Michigan: School of Education Building, the University of Michigan (ERIC Document Reproduction Service No. ED338122).
Price, J. L., & Mueller, C. W. (1986). *Handbook of organizational measurement.* Marshfield, MA: Pitman.
Sangin, M., Molinari, G., Nüssli, M. A., & Dillenbourg, P. (2011). Facilitating peer knowledge modeling: Effects of a knowledge awareness tool on collaborative learning outcomes and processes. *Computers in Human Behavior, 27*(3), 1059–1067.
Schraw, G., & Dennison, R. S. (1994). Assessing metacognitive awareness. *Contemporary Educational Psychology, 19*, 460–470.
Schreiber, M., & Engelmann, T. (2010). Knowledge and information awareness for initiating transactive memory system processes of computer-supported collaborating ad hoc groups. *Computers in Human Behavior, 26*(6), 1701–1709.
Schroeder, N. L., & Adesope, O. O. (2014). A systematic review of pedagogical agents' persona, motivation, and cognitive load implications for learners. *Journal of Research on Technology in Education, 46*(3), 229–251.
Wegner, D. M. (1987). Transactive memory: A contemporary analysis of the group mind. *Theories of group behavior* (pp. 185–208). New York: Springer.
Weinberger, A. (2011). Principles of transactive computer-supported collaboration scripts. *Nordic Journal of Digital Literacy, 6*(3), 189–202.

Weinberger, A., Ertl, B., Fischer, F., & Mandl, H. (2005). Epistemic and social scripts in computer supported collaborative learning. *Instructional Science, 33*(1), 1–30.
Weinberger, A., & Fischer, F. (2006). A framework to analyze argumentative knowledge construction in computer-supported collaborative learning. *Computers & Education, 46*(1), 71–95.
Weinberger, A., Stegmann, K., & Fischer, F. (2007). Knowledge convergence in collaborative learning: Concepts and assessment. *Learning and Instruction, 17*(4), 416–426.
Winne, P. H. (2015). What is the state of the art in self-, co-and socially shared regulation in CSCL? *Computers in Human Behavior, 52*, 628–631.
Yilmaz, R., & Keser, H. (2017). The impact of interactive environment and metacognitive support on academic achievement and transactional distance in online learning. *Journal of Educational Computing Research, 55*(1), 95–122.
Yilmaz, R., & Kilic-Cakmak, E. (2012). Educational interface agents as social models to influence learner achievement, attitude and retention of learning. *Computers & Education, 59*(2), 828–838.
Zimmerman, B. J. (1995). Self-regulation involves more than metacognition: A social cognitive perspective. *Educational Psychologist, 30*(4), 217–221.
Zumbach, J., Hillers, A., & Reimann, P. (2004). Distributed problem-based learning: The use of feedback mechanisms in online learning. In T. S. Roberts (Ed.). *Online collaborative learning: Theory and practice* (pp. 86–102). Hershey, PA: Idea Group Inc.