Using Visualization to Motivate Student Participation in Collaborative Online Learning Environments

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ABSTRACT

Online participation in collaborative online learning environments is instrumental in motivating students to learn and promoting their learning satisfaction, but there has been little research on the technical supports for motivating students' online participation. The purpose of this study was to develop a visualization tool to motivate learners to participate actively in collaborative online learning communities and examine its effects on online participation, perceived learning, perceived satisfaction, team project performance, and usability. Two types of visualization tool were developed: the A-type for representing group participation and interaction between groups, and the B-type for representing group participation and individual participation. Undergraduate students (N = 118) were assigned randomly to one of three groups (A and B: experimental group, C: control group). The results showed that two types of visualization tool have significant effects on the perceived satisfaction, perceived learning, and team project performance. Regarding online participation, the B-type of visualization tool was found to be effective. The usability of the A and B groups was similar and many learners in both groups reported that the visualization tool motivated them to participate in online learning. Theoretical, empirical and practical discussions are provided based on the results.

Keywords

Visualization of participation, Online participation, Visual scaffolding, Visual feedback, Participation motivation

Introduction

Research has suggested that online participation, including social interactions in collaborative online learning environments, is instrumental in motivating the students to learn and promote their learning satisfaction (Cobb, 2009; Hrastinski, 2009). In face-to-face learning environments, learners can naturally know who is an active participant in learning and which group is more collaborating, and subsequently be motivated to participate more by them. On the other hand, engaging students to participate in online communities is not easy because many learners can be indolent and contribute very little (Barría, Scheihing, & Parra, 2014). Learners in collaborative online learning environments need participation information of individuals and groups (Gross, Stary, & Totter, 2005). Providing this participation information to learners can support online participation and learning outcomes (Nilsseon & Svensson, 2012). A few previous studies have reported that visualization tools for individual or group participation have potential effects on learning participation, collaborative activities, or group performance in online communities (Janssen, Erkens, & Kirschner, 2011; Hsiao et al., 2012; Sun & Vassileva, 2006). These studies suggested the applicability of a visualization tool on online participation; however, they had a limitation in that visualization tools were not properly designed based on theoretical backgrounds, and participation data for visualizing was used in a restricted manner. The aim of this study was to develop a visualization tool for participation information to motivate learners to participate actively in collaborative online learning environments. The effects of a visualization tool were also investigated in terms of online participation, perceived learning, perceived satisfaction, team project performance, and usability.

Online participation and visualization

In order to achieve the purpose of this study, online participation was defined and the limitation of the previous studies related to visualization of online participation was identified. A visualization of online participation can help learners aware their participation level, so the types of awareness information were reviewed and the useful guidelines for visualizing information were summarized.

Online participation

Hrastinski (2008, p. 1761) defined participation as "online participation is a process of learning by taking part and maintaining relations with others." Online participation involves many types of engaging activities, such as

talking, writing, reading, watching, or thinking. These online participation events can be collected and analyzed in collaborative online learning environments. Many studies have found empirically that online participation has positive effects on the learning satisfaction and retention as well as the learning outcomes (Alavi & Dufner, 2005; Morris, Finnegan, & Wu, 2005). After a survey targeting 1406 online learners, the State University of New York reported that the most important factors influencing the online learning effectiveness were (1) interaction with the teachers, (2) level of participation, and (3) interaction with classmates (Fredericksen et al., 2000). Morris et al. (2005) also proposed that online participation has a positive effect on the learning outcomes. Online participation in collaborative learning environments can be defined operationally as a process of learning by accessing a range of learning environments, maintaining relationships with peers and instructors, performing individual or group work, and sharing ideas or learning materials.

Visualization of online participation

A few studies have investigated the effects of visualizing individual or group online participation on learner participation or learning outcomes. Sun and Vassileva (2006) created motivational community visualizations with static and dynamic versions in peer-to-peer file-sharing networks and examined their effects on online participation and awareness of the online learning community. They did not find any evidence that the static visualization encouraged participation, however dynamic visualization effectively increased the learner's participation and awareness of the online learning community. Dynamic visualization could be viewed according to topic, number of original postings, number of shared files, login-frequency, and total participation. Janssen, Erkens, Kanselaar, and Jaspers (2006) examined the effects of learner participation visualization on the individual participation, awareness, collaborative activities, and group performance scores in an online chat room. The Participation-tool (PT) visualized the average length and the number of messages with spheres and lines, respectively. As a result, the PT increased the average length of the messages but had no effect on the awareness and group performance scores. This suggests that the size of a sphere, which indicates the average length of the messages sent by a student, makes the learner write longer messages. Janssen et al. (2011) examined again the effects of the PT on online collaboration and reported that the duration of PT use has a significantly effect on the group members' participation and equality of participation within the group, but they have no effect on the group performance. Stankiewicz (2015) also developed a visualization for students' writing and viewing behaviors in collaborative environments and examined its effects on the quantity of collaborative behaviors. He did not find sufficient evidence that the visualization led to more collaborative behaviors because the visualization might be unclear and ambiguous according to the student interview. Although the results of previous research related to visualization tools for online participation have been inconsistent, the potential effects of visualizing the online learning participation can be explained in terms of the awareness information.

Awareness information

Awareness is defined as "understanding of the activities of others, which provides a context for your own activity" (Dourish & Bellotti, 1992). Awareness information in collaborative online environments plays a role as making one's activity visible to others (Dourish, 1997). Nilsson and Svensson (2012) suggested that awareness information on participation can support participation and learning in online learning communities. Two types of awareness, group awareness and objective self-awareness, which were suggested by Gross, Stary and Totter (2005), can be considered when designing a visualization tool for online participation. Group awareness gives an overview of group members' roles, activities, movements and status in the collaborative process (Greenberg, Gutwin, & Cockburn, 1996). The following three types of group awareness can be considered as being crucial for effective collaborative learning: behavioral awareness provides information on the learners' activities in collaborative learning environments (e.g., Janssen et al., 2011); cognitive awareness reveals the knowledge level of the group members (e.g., Dehler, Bodemer, Buder, & Hesse, 2011); and social awareness reveals the functioning of the group, as perceived by the collaborators (e.g., Phielix, Prins, Kirschner, Erkens, & Jaspers, 2011). Objective self-awareness means the process of taking oneself as the focus of one's own attention, or becoming aware of oneself (Mullen & Goethals, 1987). This awareness addresses the individual performance, i.e., if one is sufficiently aware of oneself, one may come to recognize a discrepancy between one's present behavior and the standard of behavior. The individual attempts to reduce the discrepancy depending on his/her outcome expectancy (Mullen, Migdal & Rozell, 2003).

Information visualization

The general guidelines for visualizing an online community have been suggested in the field of information visualization. Erickson and Kellogg (2003) emphasized that the information shown in the visualization does not need to be detailed and precise. All learners should see the same thing so that they can feel responsible for their actions because they know that others will see the same things and be aware of what they do (Ericson, 2003). The choice of metaphor is also very important because the learners should not put their efforts in interpreting a visualization tool. A metaphor should be intuitive to use and not require cognitive overload for interpretation (Sun & Vassileva, 2006). Appropriate use of the location and color contraction of the visual components will also attract attention (Lamme, 2003).

Design directions for a visualization tool

The matrix shown in Table 1 organizes the design implications and directions for a visualization tool on online participation according to the theoretical foundations (i.e., concept of online participation, awareness information and information visualization).

Table 1. Design implications and directions for a visualization tool

Theoretical foundations	Design implications	Design directions
Online participation	Online participation includes - accessing to the learning environments - maintaining relations with peers and instructors - performing individual or group work - sharing ideas or learning materials	(1) Collect, analyze and visualize data to assess the level of online participation in a collaborative learning management system. - login frequency, number of original postings/responses & comments/read messages/votes, message lengths,
Awareness information	(Group awareness) Being informed about the specific aspects of group members strongly affects their collaboration	(2) Visualize the level of online participation of group members
	(Objective self-awareness) Recognizing a discrepancy between one's present behavior and the standard behavior make one try to reduce the discrepancy	(3) Visualize the relative status on online participation
Information visualization	The information shown in a visualization tool does not need to be precise	(4) Design to provide a general concept rather than detail information on online participation
	All should see the same thing	(5) Provide the same visualization tool to all the learners
	A metaphor should not require cognitive overload for interpretation	(6) Use an intuitive and understandable visual metaphor

This study attempted to visualize the online participation with critical measures considering the concept of online participation in collaborative online learning communities, which was suggested in this study, to overcome the limitations of previous research. The quantitative data for visualizing the online learner participation was only designed to make a visualization tool easily reusable in similar situations. The qualitative data was mostly analyzed manually because there has been little research on the implementation of analysis tools of qualitative data in a learning management system. The following units of online participation analysis were initially selected: login frequency, number of original postings, number of responses and comments, message lengths, read messages, and time spent. Expert reviews were conducted to validate the six types of online participation behaviors. Five experts participated in two expert reviews; they had a PhD. in educational technology and had more than five years' experience in studying and teaching online courses. The purpose of this study was introduced to the experts by telephone and an expert review instrument was provided and collected by e-mail. The instrument for the expert review was designed to evaluate the appropriateness of the selected units for online learner participation using a four-point Likert-type scale. The instrument was composed of the following 7 items: six for the appropriateness of the selected analysis units and one asking for any comments on the units. The validity of the expert responses was analyzed using the content validity index (CVI) and the inter-relater agreement (IRA) adopted in Jin (2013). According to the results of the first expert review, all

CVI and IRA values for the five types of analysis units exceeded 0.8 except for the "time spent" unit. Two experts reported that the time spent unit could be biased in many cases. Three experts suggested adding the unit of the voting number to the participation and interaction value.

Therefore, a second expert review was conducted to validate the revised units of the analysis and explore their weighted value using the same method as the first expert review. The instrument was composed of 7 items: six for the appropriateness of the revised analysis units and one for asking to write the weighted values in each unit. All CVI and IRA values for the six types of analysis units exceeded 0.8, suggesting that all units were valid and highly reliable. The weighted value of each unit was first yielded according to the mean value of the experts' opinions and were determined as follows by another experts review: 1 for the login frequency, 3 for the number of original postings, 2 for the number of responses and comments, 2 for the message lengths, 1 for the read messages, and 1 for number of votes.

Referring to the design implications based on the awareness information, a visualization tool should represent the group participation as well as the individual participation. Moreover, it should represent the relative status of online participation. Therefore it is intended for the learner to make efforts to improve the individual or group participation.

Representing the overall information on online participation is sufficient in designing a visualization tool. Learners just need to be provided with a general concept for their participation. Erickson and Kellogg (2000) related the concept of social translucence; they addressed 'accountability' in collaborative online communities. Accountability is related to the fact that they also know about you, as you know about others in a socially translucent system. Therefore, all the learners should be provided with the same visualization tool. Lastly, a visual metaphor following these design directions is important. A method to represent general social networks can be applicable and useful.

A visualization tool on online participation

A visualization tool represents the individual participation, group participation and the interaction among individuals or groups considering the characteristics of collaborative online learning. Representing the individual participation and interaction was intended to provide information on the learner's objective self-awareness. Representing the group participation and interaction was intended to inform learner group awareness. To determine which information is critical for online learning, two types of visualization tools were developed to reflect the characteristics of the awareness information represented. The A-type represents the group participation and the interaction between groups that identify the group awareness information, and the B-type represents the group participation and individual participation that identifies the group and objective self-awareness information. The online participation data is displayed with circles, squares and lines referring to the representation method of various social networks.

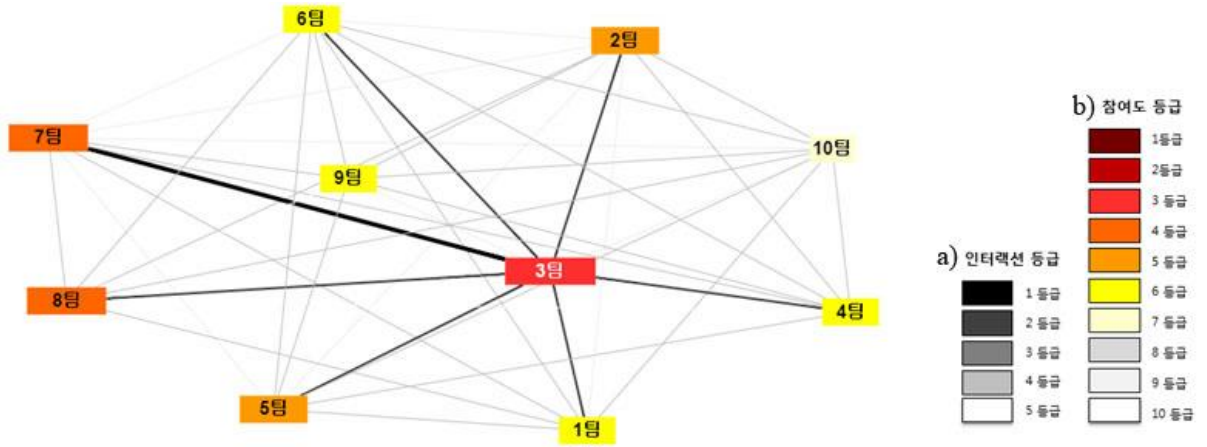

Figure 1. Screenshot from the A-type of visualization tool: (a) group interaction levels; (b) group participation levels

Figure 1 presents a screenshot of the A-type of visualization tool representing the group participation and group interaction. The color and size of each square represents the level of group participation. The group participation

value was calculated from six analysis datasets (login-frequency, number of original posts, number of follow-up posts, number of reading, message lengths, and the number of votes) of the group members and their weighting values. The thickness and color of the lines between the squares indicate the level of group interaction. The group interaction value was calculated from the number of follow-up posts, number of reading posts, and number of votes on the posts among the members of the two groups. The interaction value also reflects the weights of the target analysis units. Ten different color codes for the group participation level and five different color codes for the group interaction level were used.

Figure 2 presents a screenshot of the B-type of visualization tool representing the group and individual participation. The color and size of the circles represent the level of individual participation, so the learner's name is presented in each circle. The color and size of the squares in the middle of each group represent the level of group participation. The individual participation value was calculated using the data from six analyses and their weighted values. The group participation value was produced using the same method applied in the A-type of visualization tool. The interaction value was not represented in this visualization tool. Ten different color codes for the individual and group participation level were used.

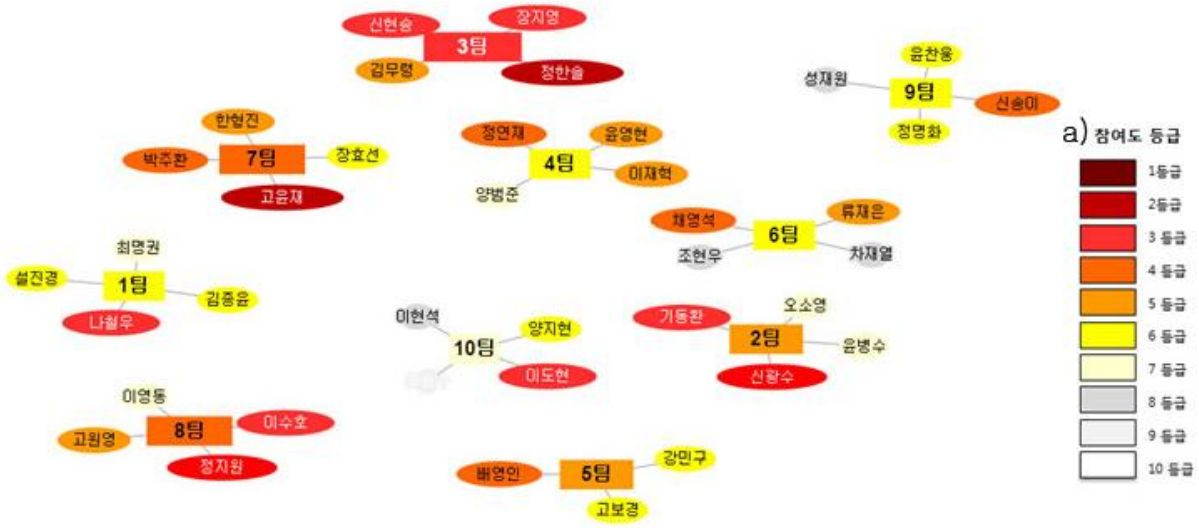

Figure 2. Screenshot from the B-type of visualization tool: (a) group or individual participation levels

An expert validation test was conducted to determine if the individual participation, group participation, and group interaction were represented appropriately in the developed visualization tool. The same experts who took part in the former expert review for the analysis units selection participated. Using a four-point Likert-type scale (strongly disagree/strongly agree), the five experts were asked about the implementation appropriateness on the individual participation, group participation and group interaction. As a result, all experts responded with at least three points.

Research method

The visualization tools were validated by controlled testing based on a development research methodology. An experimental study was carried out determine the effects of the visualization tool on online learning. The specific research questions were as follows:

- To what extent do the visualization tools influence the learner's online participation?
- To what extent do the visualization tools influence the learner's perceived learning, perceived satisfaction, and team project performance?
- Are there any differences in usability between the groups that received an A-type or B-type of visualization tool?
- What do the learners think when they look at the visualization tools?

Participants and design

The participants were 118 undergraduate students (91 males, 27 females) enrolled in a "Creative Thinking" course at a university in South Korea. All students came from an engineering college and were assigned

randomly to one of three groups. Forty three students (30 males and 13 females) were included in the first experimental group, which received the A-type of visualization tool representing the group participation and group interaction. Forty students (32 males, 8 females) were assigned to the second experimental group, which received the B-type of visualization representing the group participation and individual participation. Thirty five students (29 males, 6 females) were included in the control group, which used the same online learning community as the experimental group learners but they did not receive any type of visualization tool. The experiment was carried out as part of the student's regular coursework. Six units of online participation analysis were not explained to groups A or B. Thus, the learners in both groups sometimes asked the teachers how to yield the participation or interaction levels, and the teachers always answered that the visualization tool represented synthetically their online participation.

e-Learning activities in the "Creative Thinking" course

The course, "Creative Thinking," was designed to enhance the divergent thinking ability of engineering students. This course provides various team-based activities for the learner to explore and develop his/her creative thinking. This course is normally operated by blended learning. For in-class activities, a range of creative thinking methods are explained and the learners apply the learned methods to solve problems. For online activities, the teacher gives the learners a real-world problem to solve with the acquired creative thinking methods each week. The grades are determined by the in-class and online activities. A new online learning community was created for this study. The students did not provided a visualization tool for the initial eight weeks to allow them to become accustomed to using the new online learning community. The results of examining the homogeneity among groups showed no significant differences in the levels of online participation (Group A: M = 30.17, SD = 16.27, Group B: M = 33.56, SD = 11.48, Group C: M = 33.71, SD = 18.14) and interaction (Group A: M = 51.39, SD = 26.64, Group B: M = 45.72, SD = 32.17, Group C: M = 66.91, SD = 47.64). The experiment study was then performed over a seven week period. The students had to perform the team-based project activities and submit the outputs of each process every week through a design thinking process in the online community. Any teaching strategy to support collaborative activities did not applied, because the strategies can be biased to examine the effects of the visualization tools. Two teachers taught three classes with the same learning materials and evaluation plans. One taught the first experimental group and the other taught the second experimental group and control group.

Measures

The measures for this study consisted of online participation, perceived learning, perceived satisfaction, usability test, students' opinions and team project score. The online participation was examined with six analysis units (login frequency, number of original postings, number of responses and comments, message lengths, read messages, and number of votes) and an influence test of the visualization tools. The data from six analysis units was collected from web-log data. The influence test (a = 0.81) of the visualization tools was intended to measure how much the visualization tools influenced the learner's online participation, such as login to the system, writing original posts, writing follow-up posts, facilitating group members' online participation, and accessing the visualization tool. The perceived learning test and perceived satisfaction test items were developed by referring to Eom, Wen, and Ashill (2006) and Kang and Park (2010) to measure the degree of students' perceived learning and satisfaction through their online learning activities. The perceived learning test consisted of four items (a = 0.81), and the sample item was "I feel that I have learned a lot from this online learning activities." The perceived satisfaction items (a = 0.85) were three and the sample item included "I would recommend this course to other students." The usability test was developed by referring to the items suggested by Nokelainen (2006) and was assessed using the following three measuring scales: learnability (2 items; a = 0.78), effectiveness (2 items; a = 0.76), and satisfaction (3 items; a = 0.84). An open-ended question was provided to the students in the two experimental groups to identify the students' opinions on the visualization tool. The validity of all test items was examined by two of the five experts who participated in the previous two experts' reviews. Lastly, the team project scores were then yielded using an evaluation rubric for assessing the engineering design activities. Two teachers evaluated all team project reports of the three groups and the team project score in each team was the mean value between teachers. All tests was performed in a classroom under a teaching assistant's guidance after completing the course.

Data analysis

Multivariate analysis of the variance was conducted to determine the effects of two types of visualization tool on the learner's online participation, perceived learning, perceived satisfaction, and usability. The data was examined for normality, presence of outliers, and homogeneity of the variances before performing MANOVA. The partial eta-squared (η^2) and Cohen's *d* were calculated to determine the effect size if a significant multivariate result was found. The partial eta-squared values of approximately 0.01, 0.06, and 0.14 indicated small, medium, and large effects, respectively (Richardson, 2011). Cohen's *d* can be interpreted as follows: small < 0.2, medium ~ 0.5, and large > 0.8 (Cohen, 1988). The mean values of the team project performance were compared among the groups due to the insufficient number of teams. The learners' responses of an open-ended question were analyzed using a content analysis method (Krippendorff, 2004). Each response was reviewed on a line-by-line basis, and the units of meaning were identified. The units consisted of words, phrases and/or sentences that contained meaningful information about the learner's thoughts on the visualization tool. The units were coded and grouped into three categories: affective, cognitive and aesthetic opinions. The results of content analysis were cross-checked for validity by two PhD qualified educational technologists. A cross validation check revealed a proportional agreement of 0.92 between the analysts. Disagreements were resolved through discussion. Frequency analysis was conducted to compare the learners' responses based on the units analyzed among the groups.

Results

Does the visualization tool encourage learner online participation?

Two types of data analysis were conducted to determine if the visualization tools encourage learner online participation. First, six sets of analysis data from the web-log database were extracted and the questionnaire data on the influence test of the visualization tool was then assessed. Table 2 lists the means and standard deviations of the three groups regarding the online participation (individual participations, peer interactions, and six type of participations data). The mean values of the dependent variables related to online participation of the two groups that received the A- or B-type of visualization tool were higher than those of group C, which did not receive any type of visualization tool. MANOVA revealed significant effects for the B-type of visualization tool on individual participation ($F(2, 115) = 13.877$, $p = .000$, $\eta^2 = .209$) and peer interactions ($F(2, 115) = 18.653$, $p = .000$, $\eta^2 = .262$). On the other hand, no significant effect was observed for the A-type of visualization tool, which represented the group participation and interaction. In particular, the B-type of visualization tool had positive effects on the login-frequency ($F(2, 115) = 4.836$, $p = .010$, $\eta^2 = .084$), number of follow-up posts ($F(2, 115) = 22.073$, $p = .000$, $\eta^2 = .296$), and message length ($F(2, 115) = 14.345$, $p = .000$, $\eta^2 = .215$) compared to those of the other two groups. Regarding the number of reading messages, a significant effect was observed for the two types of visualization tools ($F(2, 115) = 9.096$, $p = .000$, $\eta^2 = .148$).

Table 2. Comparison of the online participation among the three groups

Online participation	Group A		Group B		Group C		*F* value *P* value	Post hoc test (*d*)
	A-type of visualization tool (*n* = 43)		B-type of visualization tool (*n* = 40)		Control group (*n* = 35)			
	M	*SD*	*M*	*SD*	*M*	*SD*		
Participations	40.13	20.87	56.16	19.85	33.86	12.81	13.877 .000	B > A(0.76) B > C(1.74)
Interactions	87.65	46.41	228.76	184.04	77.74	64.25	18.653 .000	B > A(3.04) B > C(2.35)
login frequency	44.07	24.46	59.41	35.17	40.67	18.14	4.836 .010	B > A(0.62) B > C(1.03)
num.original posts	8.44	4.51	8.61	2.45	8.29	3.12	.076 .927	-
num.follow-up posts	5.31	4.27	30.59	32.26	3.26	4.56	22.073 .000	B > A(5.92) B > C(5.99)
message lengths	1324.68	1057.80	2308.00	1164.36	1178.58	540.03	14.345 .000	B > A(0.92) B > C(2.09)

num.votes	2.81	4.20	5.89	20.50	1.67	2.61	1.072 .346	-
read messages	70.36	33.06	78.12	34.08	47.35	22.12	9.096 .000	A > C(1.04) B > C(1.39)
Visualization tool's Influence	2.95	.77	3.76	.73	-	-	20.839 .000	(.227)
Login to system	2.85	1.07	3.87	.89	-	-	19.509 .000	(.216)
Writing original posts	2.82	1.05	3.79	1.05	-	-	15.344 000	(.178)
Writing follow-up posts	2.88	1.03	3.94	1.02	-	-	19.443 .000	(.215)
Access to the visualization tool	3.20	1.09	4.05	.99	-	-	11.900 .001	(.144)
Facilitate group member	3.02	1.11	3.15	1.11	-	-	.227 .635	-

MANOVA also revealed significant effects of the B-type of visualization tool on the influence ratings and each of the four influence scales: login to the system, $F(2, 115) = 19.509$, $p = .000$, $\eta^2 = .216$; writing original posts, $F(2, 115) = 15.344$, $p = .000$, $\eta^2 = .178$; writing follow-up posts, $F(2, 115) = 19.443$, $p = .000$, $\eta^2 = .215$; and access to the visualization tool, $F(2, 115) = 11.900$, $p = .001$, $\eta^2 = .144$. These results mean that the learners in group B login to the system more, and write more original and follow-up posts after receiving the visualization tool than those in group A.

Does the visualization tool enhance the learner's perceived learning, perceived satisfaction and team project performance?

The effects of the visualization tool were significant on the learners' perceived learning ($F(2, 115) = 6.206$, $p = .003$, $\eta^2 = .109$), and perceived satisfaction ($F(2, 115) = 3.998$, $p = .021$, $\eta^2 = .073$). Regarding the team project performance, MANOVA could not be conducted because of the insufficient number of teams but the results showed that the mean values of groups A and B, which received the visualization tools, were higher than those of group C, which did not receive a visualization tool.

Are there any differences in usability between groups which received A-type or B-type of visualization tool?

As shown in Table 3, the mean ratings of group B were higher on the usability tests than those of group A. MANOVA showed that the usability test and its sub-scales had no significant effect except for the effectiveness between the two types of visualization tool. The effect of the B-type of visualization tool reached statistical significance for the effectiveness scales ($F(2, 115) = 6.662$, $p = .012$, $\eta^2 = .092$).

Table 3. Mean score and standard deviation of the three groups on the dependent variables

Dependent variables	Group A A-type of visualization tool (n = 43)		Group B B-type of visualization tool (n = 40)		Group C Control group (n = 35)		*F* value *P* value	Post hoc test (effect size)
	M	*SD*	*M*	*SD*	*M*	*SD*		
Perceived learning	4.11	.64	4.00	.61	3.54	.80	6.206 .003	A > C(0.71) B > C(0.57)
Perceived satisfaction	4.04	.77	4.03	.79	3.54	.87	3.998 .021	A > C(0.57) B > C(0.56)
Team project performance (teams)	14.45 (11)	-	15.4 (10)	-	12.3 (9)	-	-	-

Usability	3.77	.63	4.01	.49	-	-	3.202 .078	-
Learnability	3.94	.81	4.27	.75	-	-	2.900 .093	-
Efficiency	4.03	.99	4.12	.69	-	-	.180 .673	-
Effectiveness	3.38	.79	3.85	.71	-	-	6.662 .012	(.092)
Satisfaction	3.73	.83	3.83	.67	-	-	.287 .594	-

What do learners think when they look at the visualization tool?

The learners' thoughts that come to mind when they look at the visualization tool can be categorized into affective, cognitive and aesthetic opinions (See Table 4). Most learners in Groups A and B thought that the visualization tool motivated them to participate in online learning through a competitive comparison. The number of learners in Group B who reported the visualization tool's motivation effect was higher than that in Group A (Group A: 13 vs. Group B: 27). This concurs with the result of research problem one in this study (See Section *Does the visualization tool encourage learner online participation?*). In addition, the B-type of visualization tool motivates the learners to participate in online learning better than the A-type. Regarding the cognitive aspect, the learners gave their opinions that the visualization tool helped them understand their online participation degree intuitively and made them self-reflect their online learning. The number of learners in Group A, who reported they felt unpleasant when they looked at the visualization, was higher than those in Group B. On the other hand, group B had more learners with negative feelings than Group A. Finally, a few learners in both groups reported that the visualization tool provided was fresh and interesting.

Table 4. Learners' opinions on the visualization tool

	Opinions	Frequency	
		Group A	Group B
		A-type of visualization tool (n = 43)	B-type of visualization tool (n = 40)
Affective	Motivate to participate in online learning due to comparison	13	27
	Positive feeling: great and pride	2	2
	Unpleasant feeling: envy, regrettable, sad, sorry	5	-
	Negative feeling: bad, inferior, and unease	3	5
	Subtotal	*23*	*32*
Cognitive	Easy of understanding of the degree of online learning participation at a glance	6	10
	Self-reflection on his/her own online learning	4	8
	Effective method for facilitating online participation	3	-
	Effective for upper and middle groups but negative for lower groups	1	2
	Subtotal	*14*	*20*
Aesthetic	Fresh and interesting	3	2

Discussion

Theoretical implications

The instructional effects of the visualization tool on online participation can be explained theoretically in terms of the awareness information, visual feedback, and social comparison. Schmidt (2002) suggested two types of

important activities, displaying and monitoring, for being aware group or oneself in collaborative online learning environments. The visualization tool may help the learners objectively monitor their status of on online participation by displaying their online participation. Although the learners perform team-based activities, they are motivated by the level of individual participation more than the level of group participation. Namely, this study found that objective self-awareness information has a more positive effect on individual participation than group awareness information. These results are also supported by Janssen's et al. (2006) study, who suggested that the visualization of participation can affect participation through feedback processes. The learners want to receive comments or feedback on what they have done. The visualization tool makes the learners aware and monitors their online participation by providing visual feedback as to what degree they participate in online learning. The visual feedback helps the learners self-evaluate their online learning and makes them compare their participation levels with others. As a result, visual feedback and social comparison motivate the learners to participate more actively. Festinger's (1954) theory of social comparison states that an upward comparison process refers to viewing others performing marginally better than themselves. This might encourage the learners to set higher personal standards that can motivate them to improve themselves. The visualization tool may help learners make an upward comparison, so learners may be motivated to increase their participation.

The effects of the visualization tool on online participation were similar to the results reported by Sun and Vassileva (2006), and the effects on the learning outcomes were consistent with Michinov and Primois (2005). Janssen et al. (2006) visualized the learner participation and reported that the participation tool increased the message length but did not affect the other dependent variables. The results reported by Janssen et al. (2006) may have been affected by the size of the sphere in the visualization tool determined from the average length of the learner's messages. Therefore, the visualization tool in this study was designed with various learner's participation data and the learners were not given a specific explanation. These uncertainties on the visualization tool may have a positive effect on their online participation.

Design implications

The differences between the current implementation and the previous participation visualizations in collaborative learning environments can be discussed in three aspects: using various participation data according to the concept of online participation, designing the visualization tools based on theoretical backgrounds, and using visual metaphor for learners to understand easily. This study provides an effective design strategy that makes the learners self-reflect and promotes online participation. In addition, it makes the teachers understand the learners' online participation and become aware of who requires the teachers' support. More importantly, the visualization tool suggested in this study is easy to understand. Table 1 lists the specific design guidelines for visualizing the student's participation in collaborative online learning environments.

Limitation and future directions

This study examined the effects of a visualization tool on online participation, perceived learning, perceived satisfaction, and team project performance. The levels of online participation were determined from quantitative online participation data, such as the login frequency, number of original postings, number of responses and comments, message lengths, messages read, and number of votes. As suggested by Richards (2011), in that the learner's engagement cannot be explained fully by a small amount of quantitative data, future research will be needed to represent the learner's qualitative online participation and examine its effects on online learning. Moreover, the effects of the visualization tool may differ according to the learner's characteristics. In particular, future research will be needed to determine if there are differences in the effects of the visualization tool according to the learners' social comparison motive. To understand the effects of the visualization tool in more detail, the learner's thoughts or feelings on the visualization tool need to be analyzed using a qualitative research methodology, and the learner's attention or eye movement needs to be analyzed using an eye tracking method. In addition, the visualization tool initially attempted to represent the individual interactions and individual contributions to the group participation, however it could not be represented due to technical limitations. Therefore, future research will be needed to develop a visualization tool representing the individual interactions and individual contributions to the group participation, and examine its effects.

Conclusions

These results show that the visualization tool on online participation can enhance their online participation. In particular, the visualization of individual participation has greater effects on the online participation than the visualization of group participation despite the collaborative learning community. These findings will help guide the design of collaborative online learning communities to motivate learners to participate by making them reflect on their online learning participation themselves without the need for coaching or guiding of teachers or tutors. Moreover, the visualization tool can be adapted easily to collaborative online learning environments because of the ease of development.

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