# The effect of a group awareness tool in synchronous online discussions: studying participation, quality and balance

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## Abstract

Computer-supported collaborative learning (CSCL) seeks to improve students' learning with the support of technology. Although CSCL facilitates an enriching environment for cooperation, CSCL activities might be affected by asymmetrical participation. Group awareness tools have proven to enhance learners' interactions, balancing the levels of participation and increasing the learning outcomes. This study investigates the effect of a group awareness tool (GAT) on participation within synchronous CSCL activities in the context of extracurricular activities. We designed a quasi-experimental within-subject study (GAT exposure and control condition) and tested an ad hoc GAT in a web-based CSCL platform with high school students (N = 140). The measured variables included the effect of the GAT on students' participation and the quality of discussion. A complementary analysis evaluated students' perceptions of the tool. Results revealed that the implementation of a GAT encourages students to take part in CSCL discussions without explicitly hindering its quality. Even so, the balance of participation was not significantly affected. Students further reported that they found the GAT useful to regulate collaboration. The results from the study provide further knowledge of the functioning of group awareness tools in secondary education and share an insight into how students perceive them.

**Keywords:** CSCL, group awareness tool, participation regulation, collaborative learning, secondary education

## 1. Introduction

Collaborative learning constitutes an educational practice that involves the forming of groups to enhance learning by social interactions resulting from solving together a problem or task. The support of technology has given rise to evolved pedagogical practices that mediate social interaction allowing cooperation, coordination and knowledge-intensive discussions in virtual learning environments. The field of Computer Supported Collaborative Learning (CSCL) seeks to support, and often also guide, technology-mediated desired social interactions (Bernard & Bachu, 2015), benefiting students' teamwork skills, motivation, and learning outcomes (Chen et al. 2018).

To successfully achieve its goals, collaborative learning requires both the stimulation and balance of participation to guarantee communication, discussion, and argumentation in its practice (Laal &

Laal, 2012). Nonetheless, the presence of factors such as learners' lack of motivation (Blaskovich, 2008), low task awareness (Malmberg et al. 2015), poor social and self-regulation skills (Järvelä et al., 2014), and even the bad management of intercultural differences (Popov et al. 2019) can negatively affect participation in CSCL activities. Current research has targeted group awareness as a way to improve the experience of collaboration (Janssen et.al, 2011). The concept of group awareness can be defined as the understanding of the group's actions, goals, and contributions (Bodemer & Dehler, 2011), and is enabled through the display and monitoring of fellow participants' contributions (Schmidt, 2002). The lack of group awareness within CSCL can hinder students' engagement (Liu et al. 2018) and can potentially result in problematic interaction patterns (Strauß & Rummel, 2021b). Recent studies suggest that the implementation of group awareness tools in CSCL activities may regulate students' participation and learning (Laal & Laal, 2012; Janssen et. al, 2007; Yamada et. al, 2016); moreover, it may impact students' production while increasing group collaboration and their orientation to learning outputs (Lee, 2013; Lin, 2018).

With the importance of improving collaboration in CSCL platforms, research on group awareness tools has so far demonstrated a positive outcome toward collaboration processes. However, work investigating the use of such tools towards the quantity and quality of synchronous discussions in secondary education is scarce. Hence, this paper aims to explore the use of a group awareness tool (GAT) designed to promote discussion participation in a synchronous CSCL setting in secondary education. In particular, the study examines the implementation of an ad-hoc GAT in the context of Media Literacy interventions. The study has a twofold objective a) it examines the effect of the GAT on students' discussion participation and quality, and to further b) explore students' perceptions of the GAT as a stimulus to increase their collaboration. Based on the prior literature concerning the use of GATs in CSCL activities (Janssen et al. 2007; Janssen et al. 2011; Liu et al. 2018), this study foresees that the use of a visual GAT may increase students' participation in synchronous discussion as well as their quality of participation.

This paper is structured in the following format: Section 2 explores related literature on the subjects of CSCL discussion participation and the effect of GATs. Section 3 presents our experimental design and describes the GAT utilized in this study. Section 4 presents the results from our study which are later discussed in section 5. Finally, in section 6 a set of possible limitations presented in the study are discussed and implications of the findings for educators are reported in section 7.

## 2. Theoretical background and related work

### 2.1 Discussion participation in CSCL environments

CSCL seeks to promote participation and cooperation among group members to achieve designed learning outcomes. The presence of discussion features such as online chats, forums, and instant messaging applications facilitate discussion in CSCL environments providing students with a medium to synchronously or asynchronously collaborate in specific practices (Oztok et al. 2013). An obvious advantage of using such features is to allow students to engage in conversations to define together a problem, orient a discussion, and ultimately develop a collaborative solution

(Kapur et al., 2005). The implementation of discussion features supports learners to have more active contributions, balance their participation, and enrich their learning practices (Miller & Hadwin, 2015).

The use of discussion features does not necessarily guarantee that students may engage in CSCL activities nor that the discussion produced will be effective. The quality of discussion in CSCL environments may be influenced by a variety of factors as in any other form of social interaction. While conducting online discussions, students can initiate humorous conversations as they commingle learning with humor (Vogler et al. 2019), engage in non-task-related interactions (Abedin et al. 2011), or act in silence as opposed to their peers' contributions (Panayirci, 2016). An effective discussion in CSCL environments would ideally see a large number of students contributing as the tasks require active participation (Guzdial & Turns, 2000). However, students' participation in CSCL can be negatively affected by factors such as students' characteristics (gender, personality traits, and competencies) (Prinsen et al. 2007; Reis et al. 2016; Lee, 2013), type of task, group size, and teacher orchestration (Amarasinghe et al. 2021). A less effective discussion can result in asymmetric participation where one or only a few students occupy central positions in the discussion while others adopt passive roles or careless attitudes. In their study about effective participation through computer-supported interaction, Lipponen et al. (2002) found out that even in intentional learning environments, isolated students can centralize discussion by taking leading roles when they respond to questions or add comments. Consistent with this, Amichai-Hamburger et al. (2016) suggest that most participants in online discussions are likely to remain silent as they doubt their abilities to contribute, taking instead a lurking role in others' interactions.

The lack of active participation between all participants in collaborative activities can in turn cause a negative effect on the group's cohesion and satisfaction with the overall work process (Monzani 2014; Strauß & Rummel, 2021a). CSCL platforms face the challenge of creating environments that imitate the essence of social presence that naturally exists in face-to-face interactions (Bali & Liu, 2018). This can cause the presence of problematic interaction patterns, such as the lack of participation and unbalanced contribution, which are not as easily confronted or eliminated in CSCL environments. The presence of these patterns can make participants feel dissatisfied with the collaborative process (Strauß & Rummel, 2021a), and further reduce participation (Strauß & Rummel, 2021b). The growing importance of collaboration in online educational environments has led researchers to investigate solutions that aim to improve students' participation during online discussions.

### 2.2 Enhancing participation in CSCL environments

The regulation of behavior and interaction processes of learners within social environments brings to light the importance of group awareness during collaboration (Schnaubert & Bodemer, 2022). The term group awareness refers to a behavioral, cognitive, and social understanding of the group's actions, goals, and contributions (Bodemer & Dehler, 2011) which assist in the dynamic maintenance of group information relevant to the learning process (Schnaubert & Bodemer, 2022). Group awareness can assist collaboration by raising awareness of other members' activities in the group (behavioral); of the beliefs or goals of the other members in the group (cognitive); and of what other members are doing by gathering continuous information about them and acting accordingly (social). It is an important aspect of collaboration, as learners need to be aware of their peers' interactions within a social environment (Schnaubert & Bodemer, 2022) to coordinate their behavior accordingly (Janssen & Bodemer, 2013).

Group awareness is easily noticeable in face-to-face interactions, and even so, technological support has been shown to benefit it by encouraging balanced discussion between participants (Bachour et al. 2010) and supporting joint regulation (Schnaubert & Bodemer, 2019). Considering that awareness is enabled through the display and monitoring of fellow participants' contributions (Schmidt, 2002), CSCL platforms have to implement features that visualize learners' contributions to increase awareness of their own learning and that of others (Järvelä et al. 2014). Such implementation does not only encourage positive attitudes toward online collaborative learning (Yılmaz & Karaoğlan Yılmaz, 2020) but also improves knowledge construction (Li et al. 2021).

Considering that group awareness consists of three different types of awareness (behavioral, cognitive, and social), studies have focused on the implementation of GATs that target them respectively. For instance, to target cognitive awareness, visual representations of prior knowledge levels have been utilized (Sanghin et al. 2011); on its part, social awareness has been represented by interactive maps to visualize the group's interactions (Ma et al. 2020) while behavioral awareness has been visualized by means of participation levels (Strauß & Rummel, 2021a). Eventually, research combining these features has reported improved quality of interactions, balanced students' motivation, a reduction of the sense of loneliness (Ma et al. 2020), and a decrease in the free-rider effect (Lin, 2018).

In order to deal with problematic interaction patterns such as unequal participation causing learners to feel dissatisfied with the collaborative process (Strauß & Rummel, 2021a), CSCL platforms with a focus on discussion and collaborative writing, may use the implementation of GATs that visualize students' behavioral awareness based on their participation. This results in an increase in student participation and messages being sent during the activity (Janssen et al. 2007) and an increase in behavioral engagement amongst students (Liu et al. 2018; Peng et al. 2022). However, an increase in participation does not explicitly mean that students engage in fruitful collaboration as students tend to engage in non-task-related conversations during CSCL (Abedin et al. 2011; Vogler et al. 2019). Even so, an increase in participation solely depends on students utilizing the tools correctly (Janssen et al. 2011) and unequal participation can still be present even with the use of GATs (Strauß & Rummel, 2021a).

With the importance of improving collaboration in CSCL platforms and reducing the effects of unequal participation, research on behavioral GATs has so far demonstrated a positive outcome toward collaboration processes. However, research that explores the effect of GATs on the quality of discussions being produced is limited as the current focus of research tends to be on participation and engagement (Liu et al. 2018; Strauß & Rummel, 2021a), self and group regulation (Lin, 2018; Yılmaz & Karaoğlan Yılmaz, 2020; Rojas et al. 2022) and learning outcomes (Sanghin et al. 2011; Ollesch et al. 2021). The type of discussions occurring in collaborative activities can help to produce better learning outcomes (Fischer et al. 2013; Noroozi et al. 2013) and should be taken as an important factor when evaluating a GAT. A higher participation rate in CSCL does not always signify a better collaboration among participants (Velamazán et al. 2022) and GATs have been shown to influence how students discuss during collaboration (Janssen et al. 2007). It is therefore important to not only measure students' participation and equality during discussion, but also to evaluate if the use of a GAT can hinder or enhance the quality of discussion.

### 2.3. The present study

Building on this literature, the present study aims to evaluate the use of a GAT within a synchronous CSCL platform by measuring both the discussion participation and quality of discussion. While research has tested GATs in real teaching environments (Ma et. al, 2020; Li et. al, 2021; Liu et. al, 2018), researchers have been limited to explore their efficacy in secondary education. Recent work has shown that frequent use of GATs in secondary education can help students regulate their collaboration process (Hu et.al, 2022) and positively affect their collaboration attitudes (Rojas et al., 2022). However, work investigating the effect of GATs on participation and quality of discussion in secondary education is limited. To fill this gap we propose the design of a study aimed at high school students. Likewise, scarce work has seen the use of within-subject experimental designs to investigate GATs. A within-subject experimental design could potentially help to minimize any underlying external variables such as students' characteristics that could have an impact on the findings. Ultimately, existing research has tested tools for asynchronous and synchronous communication which potentially enables our comprehension of awareness features in online educational platforms. Still, the exploration of such tools for synchronous extracurricular activities is a matter of discussion to better understand their need and efficacy. Hence, to explore the effect of an ad hoc designed GAT as part of a high school extracurricular activity, the following research questions (RQ) were formulated.

RQ1: What is the effect of a GAT on high school students' discussion participation?

Based on the prior literature concerning the use of GATs in CSCL activities (Janssen et al. 2007; Bachour et al. 2010; Janssen et al. 2011; Liu et al. 2018), we hypothesize that the use of a behavioral GAT will increase students’ participation in synchronous discussion (H1) and will balance participation among students (H2).

RQ2: What is the effect of a GAT on high school students' discussion quality?

As previous work has shown an effect of GATs on discussion orientation (Janssen et al. 2007) we hypothesize that the quality of discussion will improve with higher coordination interactions among students (H3).

RQ3: Do students perceive the use of GAT as an effective way to regulate collaboration?

Finally, we expect that students will perceive the GAT as a helpful tool to regulate collaboration.

## 3. Methodology

### 3.1 Study design and participants

A quasi-experimental within-subject study (GAT tool and control condition) was designed. The study took part in the context of a three-session media literacy workshop conducted in junior and senior high schools. A total of 162 students participated in the study; of the participants, 78.0% were males and the mean age was 18.7 years old (SD = 2.47). The proportion of males to females in this sample was affected by the technical focus of one of the schools. From the overall sample, only 140 students completed the necessary activities for this study. Further demographic data can be observed in Table 1. In compliance with the university ethical board, all participants were informed about the research objectives of the workshop and consented to their participation by signing an electronic form. In the case of underage students, a parental consent form was also required.

**Table 1.** Demographic data of participants

| | | |
|---|---|---|
| *Sex* | **Male** | 127 (78%) |
| | **Female** | 35 (22%) |
| *Educational Level* | **Junior High School** | 54 (33,3%) |
| | **Senior High School** | 108 (66,6%) |
| *Country of origin* | **Spain** | 129 (80%) |
| | **Brazil** | 33 (20%) |

The workshops took place in already-formed groups during school hours in the first semester of 2022. As part of the research protocol, students were placed in their assigned classrooms, welcomed by the instructors, and oriented to the workshop practice. In total, 10 groups formed the study. The groups were exposed to the GAT feature randomly to minimize any possible effect of students being trained to participate more in the discussion. To ensure the results would not be affected due to students' familiarity with the CSCL activities, an introductory activity using the CSCL learning environment was conducted before the study took place. In summary, all groups participated in three CSCL activities: an introductory activity at the start of session 2; an activity with the GAT activated (experimental); and an activity with the GAT disabled (Control). This resulted in 10 CSCL activities with the feature and 10 CSCL activities without the feature.

### 3.2 Materials

An ad hoc GAT was implemented within the online collaborative tool PyramidApp (Manathunga, K., & Hernández-Leo, 2018). The PyramidApp is a web-based CSCL tool that follows the pyramid collaborative learning flow pattern and allows students to synchronously construct improved answers through a chat. The PyramidApp divides collaboration into several phases allowing students to provide answers to a problem through collaborative interaction. In the *initial* *phase*, students are assigned a task to which they need to provide an individual answer. Once all students have submitted an answer, the system allocates them into small groups where they can see each other's answers and rate them. In the next stage, also known as the *answer-improving stage*, students are asked to discuss with the aim of providing an improved answer collectively. After this phase, the system allocates the students into bigger groups where they can further engage in discussions and vote for the best answers to reach a consensus at the end of the activity. The PyramidApp has been designed to be used for both mobile and desktop screens to allow students to participate from their own devices. Due to screen size constraints, a responsive design was implemented to not hinder the different features of the PyramidApp including the one of GAT (see Figure 1).

The GAT consists of a bar that visualizes the participation level of each student and appears under their name (see Figure 1). The participation level is updated every 5 seconds and allows students to compare their participation to others in their group, raising behavioral awareness among the participants. It is calculated by the number of characters sent, edited, or deleted from the chat and the collaborative writing editor. To promote equal participation, the bar changes colors depending on the level of participation; if the student contributes to the discussion sufficiently the bar is green, if the student is contributing quite less or more than the average the bar turns orange, if the student monotonized the discussion or is not participating sufficiently the bar turns red.

During the workshops, the students were able to access the PyramidApp activity from both desktop and handheld devices. The employed devices did not affect the experimental setting as the participants using a computer and handheld device showed high awareness of the bar tool.

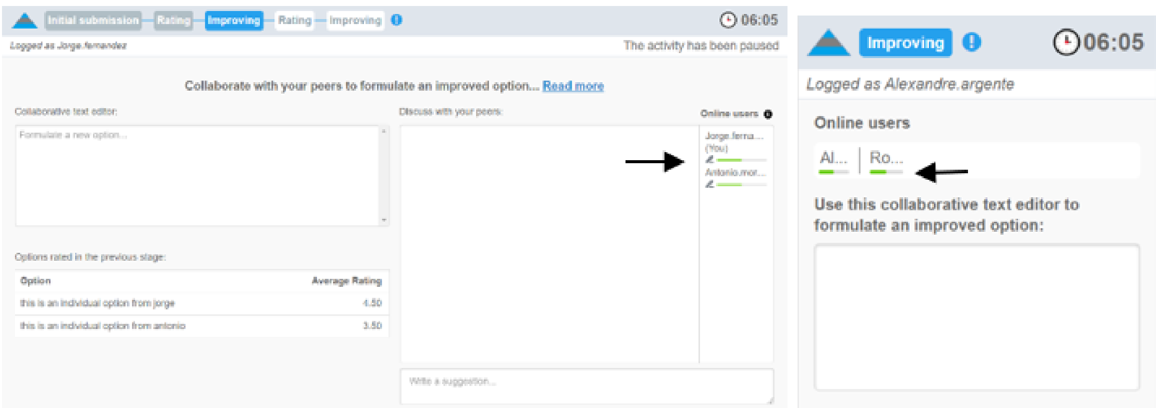


**Figure 1.** The *answer-improving stage* of the PyramidApp. In the web GUI (left) the GAT appears under the username of each online user. In the responsive design GUI (right) the GAT appears on top of the chat, under the users' initials.

### 3.3. Procedure

The study was part of a three-session media literacy workshop conducted on different days of the school calendar during the second semester of 2022. The main topic of the workshops was a short training to know more about the risks and threats of social media. During the first session, the students were given introductory information about the workshop, completed a questionnaire to collect their demographic data, and raised their doubts and questions about the workshop. During the second session, the students participated in two CSCL activities: the first activity acted as an introduction for the students to become familiar with the PyramidApp platform. The activity was set to only two levels (an option submission level and an answer improving level), lasted 11 minutes, and the GAT was disabled for all groups. During the activity, the teacher explained the PyramidApp participation process step by step. This trial prepared participants for the final activity.

Not until the second PyramidApp activity, did the experiment commence. By formulating a group question, the students were asked to collaboratively form a piece of advice about how different social media use can affect users' well-being. The task was set to three levels (option submission level, first answer improving level, second answer improving level) and it lasted 18 minutes. During the third session, the students completed the second experiment. This CSCL activity was focused on an open-ended question to discuss the effects of social media on body image. The activity was set to three levels (option submission level, answer improving level, the second answer improving level) and it lasted 16 minutes, 2 minutes were removed from the rating phase as it was found redundant. The procedure of the study can be seen in figure 2.

As the GAT was implemented in the *improvement stage* of the PyramidApp, the study focused on the data produced during this stage. The messages posted during the discussions were saved as individual entries in a database and were identified by the students' IDs and group IDs.

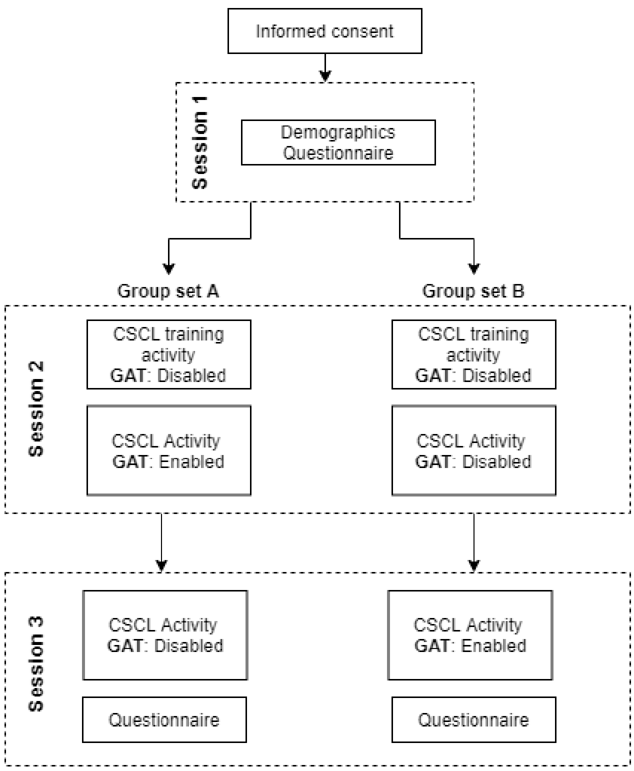


**Figure 2.** The procedure of the study. Group set A: G2, G3, G5, G6, G7, G8, G10, and the group set B: G1, G4, G9

### 3.5 Measurement

To measure the effect of the GAT we worked on the following variables and instruments:

*Discussion participation.* This variable was defined as active participation: students logging into the activity and properly contributing to the discussion (Amichai-Hamburger et al. 2016). Participation was therefore measured by counting the number of contributions and analyzing its effectiveness to balance discussion. The analyzed data was extracted from the chat transcript, allowing us to identify how many participants were in each group and how many of them had active participation. To calculate the discussion participation of each group, we divided the group members that participated in the discussion by the total number of participants in the group. Complementary, the balance of participation in groups was measured and compared using the Gini coefficient. Similar to previous work analyzing the balance of participation in CSCL, we measured students' contributions as the number of words to find the deviation of the group's messages from equal participation (Janssen et al, 2011; Strauß & Rummel, 2021).

*Quality of discussion*. This variable approached whether the discussion produced by participants was caused by task collaboration or occurred due to other conversational outlets. Since the CSCL tool provided us with the raw messages sent by the participants, a quantitative content analysis was used to code each message. In particular, we used the Functional Category System (FCS) coding scheme (Poole & Holmes, 1995) to code the messages that were sent. The FCS coding scheme has been developed to study small-group collaborative interactions and has previously been used to code interactions within CSCL scripts (Kapur & Kinzer, 2007). Each message that was posted during the answer-improving stage was coded into one of the seven categories proposed by the FCS which can be seen in Table 2. An analysis was then conducted to measure the quality of discussion between the two conditions. The quality of discussion was treated based on the level of the conditions and not on the group's level. The first author of this paper and two trained research assistants (undergraduate students who are familiar with the tasks and have user experience with the CSCL tool) independently coded the messages sent during the CSCL activity using the FCS coding scheme. The research assistants were trained to learn the coding scheme, the coding procedure, and a set of examples prior to the final coding. To measure the inter-rater reliability of the coding, the calculation of Cronbach's Alpha was used and returned an average value of 0.74.

**Functional Category System (FCS)**

1. **Problem Definition (PD)**
   1a. *Problem Analysis*: Statements that define or state the causes behind a problem
   1b. *Problem Critique*: Statements that evaluate problem analysis statements

2. **Orientation (OO)**
   2a. *Orientation*: Statements that attempt to orient or guide the group's process.
   2b. *Process Reflection*: Statements that reflect on or evaluate the group's process or progress.

3. **Solution Development (SD)**
   3a. *Solution analysis*: Statements that concern criteria for decision making or general parameters for solution
   3b. *Solution Suggestion*: Suggestions of alternatives

3c. *Solution Elaboration*: Statements that provide details or elaborate on a previously stated alternative
3d. *Solution Evaluation*: Statements that evaluate alternatives and give reasons, explicit or implicit, for the evaluations
3e. *Solution Confirmation*: Statements that state the decision in its final form or ask for final group confirmation of the decision.

4. **Non-Task (NT)**
   Statements that do not have anything to do with the decision task. They include off-topic jokes and tangents.

5. **Simple Agreement (SA)**

6. **Simple Disagreement (SDA)**

**Table 2.** Functional Category System (FCS) (Derived from Kapur et al. 2005)

In order to know the students' perception of the GAT, a descriptive analysis was conducted. This analysis substantially focused on a questionnaire to investigate students' experience and evaluation of the tool. Based on similar analyses (Strauß & Rummel, 2021a), we designed an ad hoc questionnaire and applied it at the end of the workshop. This instrument consisted of a battery of nine questions classified under four categories: 1) technical aspects; 2) visibility of the feature; 3) experience with the feature; and 4) assessment of the feature. The structure of the questionnaire first introduced a binary question related to the visibility of the feature and acted as a verification that students noticed the tool. The question asked if participants had noticed the GAT. To ensure participants understood the question, a small description of the feature was added underneath the question. Results showed that 72% (N = 98) of respondents had seen the feature. The next two questions collected the assessment of the tool. A 5-point Likert scale (1 =definitely disagree to 5=definitely agree) was applied to evaluate this purpose. In the third section, a set of five questions evaluated students' experience with the GAT. These questions were formulated as a self-assessment Likert scale and were rated on a scale from 1 (definitely disagree) to 5 (definitely agree). An example of this set of questions is "On occasions, I felt that the bar caused me stress". Finally, a question to identify the device participants used to access the platform was added. This item helped to detect if the type of device had an effect on the visibility of the feature.

### 3.6 Data Analysis

As the experimental design saw a random assignment of control and experimental condition to the same groups, the first analysis was made to examine if the order of the CSCL activity could have influenced the results. A Levene's test was conducted to analyze if the activities that were conducted second, without considering the GAT, had more or less participation. This showed that the order of experimental conditions did not have any significant differences with a *p-value* of 0,817, which indicates that students that received the GAT first did not become influenced by it in the 2nd CSCL activity.

To prevent students who did not see the GAT during the online discussion influence the final results, groups where the majority of students reported not seeing the GAT, were excluded from the analysis. This resulted in three groups being removed from the final analysis as more than 45% of the group members reported not seeing the GAT during the discussion. The rest of the group kept acceptable levels for tool visibility (a rank of 77,0% to 95% ).

For all hypotheses, the first level of analysis included the descriptive statistical analysis for discussion participation and quality discussion as a result of the use of the GAT tool. Percentages, mean values, and standard deviations were calculated and compared for GAT and control conditions. The analysis also included normality tests to observe variable distribution. The second level of analysis included the Mann-Whitney and T-student tests to observe statistically significant differences in the discussion participation, the balance of participation, and the quality of discussion of tested conditions. Additionally for h2, the Gini coefficient was calculated to measure the effect of the GAT on the balance of participation in both conditions. A low Gini coefficient would indicate more equal participation while a higher coefficient would indicate an unequal distribution of participation.

Furthermore, as part of the analysis conducted for RQ3, we analyzed the subsample of students who perceived the GAT. Two-thirds of the overall sample (72,0%, N =98) took part in this analysis. Items from the questionnaire sections: experience and assessment of the feature, were calculated as percentages and mean values. The analysis also included a recodification of categories (agreement and disagreement groups) to examine the relationship between students' experience and the evaluation of tool functionality. A chi-square test was used to evaluate the association between these items.

## 4. Results

### H1: Discussion participation

Overall findings indicate a higher impact of the GAT on discussion participation. The GAT condition achieved the highest participation in discussion in the two levels of activity. The average participation in all groups was 88,7 % for Level 1 and 80,5% for Level 2. In comparison to the control condition, the second level showed the largest difference in participation discussion (80,5% vs 66,1%). A Mann-Whitney U test showed significant differences between the two conditions ($Z= -2,04$, $p= < .05$) as the discussion participation for the GAT condition in all groups was higher ($Mdn= 87$) than in the control condition ($Mdn = 78$). Figure 2 displays the results concerned with the effect of the GAT on discussion participation in each group.

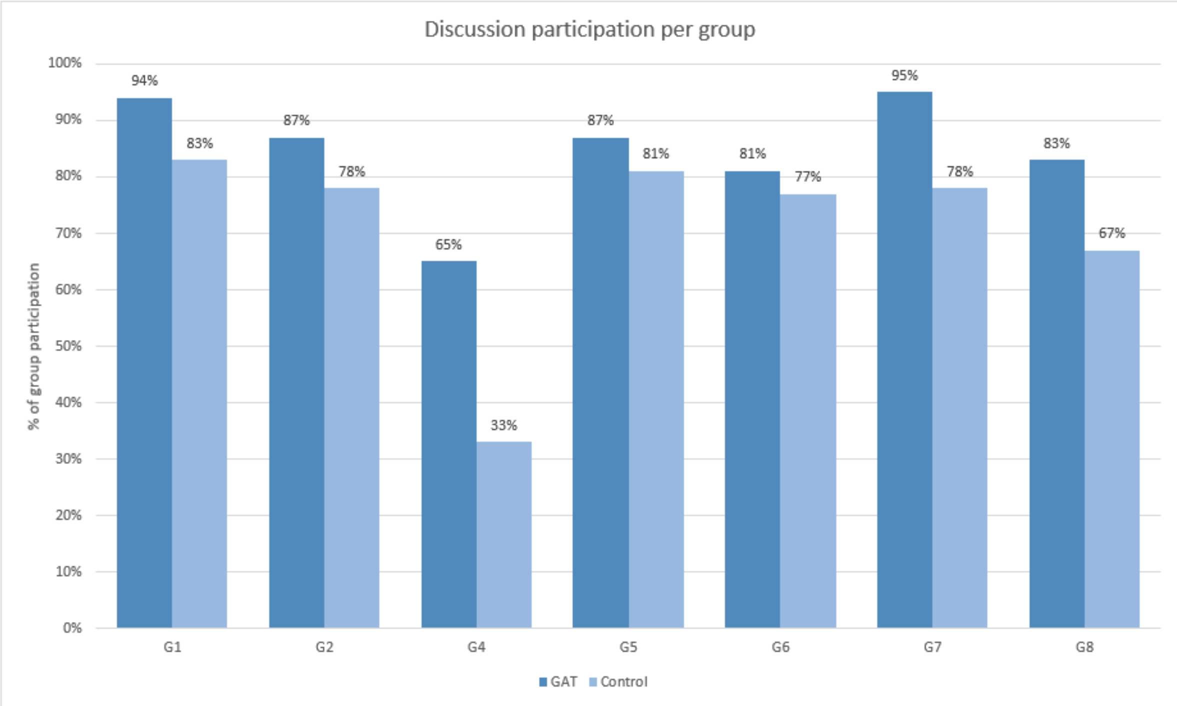


**Figure 2.** Discussion participation per group.

**H2: Quality of discussion**

Concerning the balance in the discussion participation, the analysis showed moderate symmetry in both GAT and control conditions. The analysis for the control condition achieved a Gini coefficient of 0,55 whereas the GAT group achieved 0,45. The data suggest more symmetrical participation for the case of the GAT and asymmetrical for the control condition in relation to their position with 0 - 1 values. The Mann-Whitney U test revealed no significant difference between the conditions (p = 0,27).

**H3: Quality of discussion**

Regarding the second research question, the influence of GAT on the quality of discussion, the analysis did not show any significant differences. Interestingly, in both conditions, the content analysis showed a higher orientation of the groups to introduce Not Task Related (NTR) topics. Conversely, when focusing on the task, students showed a major interest to discuss a problem solution. As observed in Figure 3, an initial analysis of occurrences showed a higher number of NTR messages in both GAT and Control conditions (78,7% and 73,5%, respectively). This included messages of the informal type such as trivial phrases, jokes, and nonsense sentences. Condition comparison did not reveal significant statistical differences, however. Concerning the task-related messages (TR) (N = 398), the FCS categories of Problem Definition (PD), Orientation (OO), Solution Development (SD), Agreement, and Disagreement (AD) showed consistent outputs. These categories revealed that in both conditions participants were keen to discuss the task for solution development. In comparison to the control condition, the GAT condition affected the problem definition and the orientation of the discussion. No statistically significant differences were found, however. A detailed analysis of the discussion quality according to FCS categories can be found in Table 3.

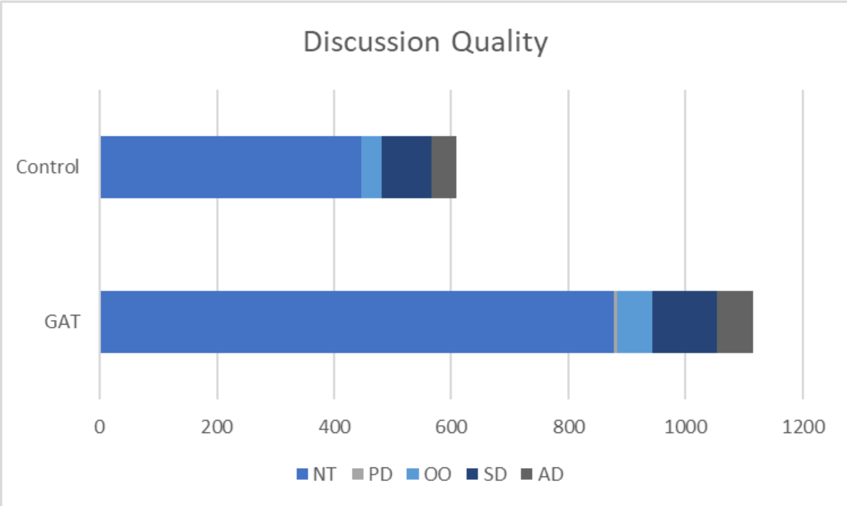


**Figure 3.** The quality discussion per group condition

| FCS categories | Occurrences reported in overall groups | | Sig. |
|---|---|---|---|
| | **GAT** N = 237 | **Control** N = 161 | |
| Problem Definition (PD) | 5 (2,9) | 0 | 0,209 |
| Orientation (OO) | 61 (35,5) | 35 (25,4) | 0,383 |
| Solution Development (SD) | 110 (40,2) | 84 (45,5) | 0,620 |
| Agreement/Disagreement (AD) | 61 (21,3) | 42 (29,0) | 0,710 |

Differences were reported as in Mann Whitney u test.

**Table 3.** The quality of TR discussion in conditions.

**RQ3: Students' perceptions of the GAT**

The evaluation of the GAT was positive in a large number of students as 80,6% of them affirmed the tool was a means to reflect their participation. Moreover, the tool was rated as useful to regulate participation in almost two-thirds of the analyzed sample (68,4%). Concerning the students' experience with the GAT, users manifested divided opinions. On one hand, a higher number of participants agreed that the tool did not influence their participation (61,1%), nor it was a pressure to participate (60,2%). The effect of the bar on participation contribution, sense of being monitored, and feeling stressed showed also divided values. A chi-square test of students perceiving the tool and valuing its effect on participation revealed that the students who found the tool useful felt their participation was supported by the feature (64,2%, $X^2 = 19,58$, $p = < .001$); in addition, they felt the need to participate due to the presence of the bar (50,7%, $X^2$= 10,60, p = < .001 ). The analysis also showed a significant association between the students who reflected on their participation and those who agreed to be affected by the presence of the bar (46,8%, $X^2$= 11,15, p = < .001). Table 4 displays the levels of agreement and disagreement concerning the perception and assessment of the GAT.

| | Not find the tool useful | Found the tool useful | Did not reflect participation | Reflected participation |
|---|---|---|---|---|
| The bar affected my contribution to the discussion | 8 (25,8) | 30 (44,8) | 1 (5,3) | 37 (46,8)* |
| The bar helped me contribute more to the discussion and get my voice heard | 5 (16,1) | 43 (64,2)* | 6 (31,6) | 42 (53,2) |
| On occasions, I felt that the bar caused me stress | 8 (25,8) | 18 (26,9) | 7 (36,9) | 19 (24,1) |
| The bar made me feel monitored | 16 (51,6) | 32 (47,8) | 6 (31,6) | 42 (53,2) |
| I felt the need to participate in the discussion to fill the bar. | 5 (16,1) | 34 (50,7)* | 5 (26,3) | 34 (43,0) |

*Statistically significant differences reported in the chi-square test for recoded variables

**Table 4.** Students' perception of the GAT: experience and assessment

## 5. Discussion

The aim of this study was to explore the effect of a behavioral GAT on discussion participation and quality, as well as to investigate students' understanding of this type of tool in the context of a synchronous extracurricular CSCL activity. Hence three research questions were formulated following prior research. RQ1 targeted students' discussion participation (H1) complemented by analysis to explore equal participation (H2). Results showed that discussion participation under the experimental condition (GAT) in all groups was significantly higher than in the control condition whilst the equality of the participation did not show any significant differences. RQ2 explored the effect of the GAT on the discussion quality (H3). Between the two conditions, no significant differences were found. Finally, RQ3 was formulated to understand students' perceptions and use of the GAT. Students reported that the tool was a useful method to regulate participation.

In relation to the hypotheses and prior research, the findings of this study have shown some interesting insights into the impact that a GAT has on online collaborative discussion. Regarding hypothesis 1, the use of the GAT has shown a significant difference in the level of participation of students demonstrating that the presence of the tool further encourages students to participate in discussion. This is in line with previous work that saw GATs as an effective method to promote participation in CSCL (Janssen et al. 2007; Janssen et al. 2011; Liu et al. 2018). Behavioral GATs can be seen as features that provide students direct feedback on how much they have participated in a collaborative task and at the same time create a medium of comparison of students' contributions (Peng et al. 2022). Prompting students to further participate and demonstrate their involvement in the task. This however implies that students would attempt to balance their contributions which has so far not shown to be supported by these types of tools. Findings from this study have shown no conclusive evidence that the GAT can promote balanced participation. Both GAT and control conditions showed moderate values. This finding does not support hypothesis 2, although GAT was more oriented to a symmetrical discussion there were no significant differences. This observation is in line with previous research (Strauß & Rummel, 2021; Janssen et al. 2007), where the GAT did not have a significant difference in the discussion balance but showed a slight improvement.

Consistent with (Janssen et al. 2007; Abedin et al. 2011), this study shows interesting results regarding the quality of discussion and the possible implications of the GAT. The first finding revealed students under the GAT condition were able to produce more messages. Nonetheless, the production of a higher number of messages in CSCL has not always signified better collaboration among participants (Velamazán et al. 2022). Due to the design of the GAT, an initial assumption was made that students under the GAT would contribute to significantly more non-task-related messages as they would feel the need to visualize some kind of contribution. However, this was not the case as students did not engage significantly more in non-task-related discussions as both task and non-task occurrences increased. Similar to the work of Abedin et. al (2011), the present study observed that students tend to co-mingle learning with non-task-related conversations during CSCL discussions.

A further look into the task-related discussion revealed that students under both conditions focused on discussion related to solution development (SD). Moreover, tentative results suggested that students under the GAT condition engaged more in coordination discussions as students sent more orientation and problem definition messages. This is in line with the findings of Janssen et al. (2007) where students with the presence of a GAT engaged in more messages to coordinate their social activities. However, in our study, no significant differences were observed between the two conditions and hypothesis 3 could not be confirmed. We believe that this could be due to the type of task students were asked to complete. During the workshop students were asked to provide their opinion towards an open-ended question. The use of open-ended questions was seen as an opportunity for students to co-construct a solution based on individual opinions; however previous work has shown that this type of task requires further intervention by teachers to reach learning outcomes (Amarasinghe et al. 2021). Regarding the high amount of non-task-related messages in both conditions, we find that the inclusion of synchronous CSCL activities in schools can result in the discussion reflecting the class environment with students initiating conversations to entertain each other and talk about irrelevant subjects. However, this does not mean that non-task-related messages are unimportant during collaboration as they can promote the feeling of community among students (Wegerif, 1997). The findings under RQ2 contribute toward a further understanding of how high school students behave in CSCL with the presence or absence of a GAT.

The study also analyzed the perception of the GAT among the students. Findings in the administered questionnaire showed that most of the students were aware of the tool while performing the online activity. The GAT was perceived as a helpful way to help regulate students' online collaboration. However, as observed in the results, students' perception of regulation was different as the effect of the tool did not significantly affect the balance in participation during the discussion. Concluding that even though students are aware of GATs and perceive them as helpful they do not utilize them towards achieving equal participation. Implicating that researchers investigating equal participation in CSCL environments need to further explore aspects that affect it. This contradicts the findings of (Bachour et al. 2010) where students explicitly reported that the GAT helped them regulate their participation and statistical differences showed an improvement in the equity of participation during discussion. Similarities to the design used by (Strauß & Rummel, 2021) and our study saw the visualization of behavioral group awareness through bars as an additional feature to the CSCL tool, whereas (Bachour et al. 2010) explicitly visualized group awareness as the main component. Hence, the key to equal participation in CSCL could be hidden within the design of behavioral GATs (Buder, 2011). Future studies need to investigate if differences in how GA is visualized can provide more opportunities for students to take advantage of them.

Ultimately, a closer analysis of the tool revealed that the presence of the bar may have caused some students a sense of being monitored which makes the GAT a double-edged sword as causing stress and pressure to contribute. In line with studies targeting stress and learning (Rudland et al. 2020), we consider moderate stress levels as a beneficiary element of learning, since students from our experiments associated the GAT with its main purpose. Since GATs serve as a way for students to monitor their level of activity and compare it with their peers, the sense of being monitored demonstrates that students were aware of their own contributions and of their peers (Fransen et al. 2011).

The findings of this study have shown that the use of GATs can encourage students to participate more in discussions without explicitly hindering the quality of discussion taking place. Implying that the use of GATs can effectively promote participation. However, when it comes to balancing the discussion GATs have yet to show any significant effects despite students perceiving such tools helpful. Suggesting that the key to equal participation in CSCL could be hidden within the design of behavioral GATs as students not only perceive them as helpful towards equal participation but have reported a sense of being monitored making them aware of their contributions and of their peers. Moreover, students reported that the tool played a role towards their contributions implying that students utilized effectively the GAT to self-monitor their contributions in the discussion.

## 6. Limitations of the present study and suggestions for future research

Considering the design of this study we have identified a few potential limitations. For instance, the study was conducted as part of a school workshop as an extracurricular activity and was completed during school hours. We interpret that the systemic constraints associated with naturalistic learning situations and the effects of confounding situational variables such as the student's motivation and interest in completing the particular types of activities may have an influence on the study findings. On several occasions, we observed students engage in face-to-face collaboration outside of the platform which is unavoidable in co-located situations. The instructors were asked to advise students to minimize such behaviors and to redirect them to continue the discussion using the CSCL tool. Additionally, we foresee that the presence of the teacher in the classroom could have potentially impacted students' participation. This could have influenced students to further participate to not receive disciplinary consequences. Finally, the study was designed as a within-subject and saw students participating in two CSCL activities. We presume, as the topics of the two CSCL activities had to differ (even if they were largely similar; the same type of task), that a lack of interest or knowledge on one of the two topics could have influenced the results.

In relation to the design of the CSCL activities, we address a few limitations that should be taken into account for similar future research. In our study, students were assigned to groups automatically using the CSCL tool without following any criteria-based team formation approach. At present, the tool does not have features implemented to support the formulation of heterogeneous and homogeneous groups (for instance considering learners' profile attributes, e.g., gender, previous knowledge, and expertise) although previous research findings indicated that group formation policies influence collaboration and the achievement of shared goals (Spoelstra et al. 2015; Moreno et al. 2012). Likewise, group sizing in CSCL plays an important role as it can affect participation rates (Yang et al. 2022; Shaw, 2013). The CSCL platform used in our study applied a group formation algorithm to divide students into groups of three at the initial level and then into groups of six or more depending on the classroom size (both control and experimental conditions used the same group sizing algorithm). Aside from the automatic allocation this aspect was not further explored and we encourage future research to explore the effects of group sizes on synchronous CSCL activities enhanced with GATs.

Finally, previous studies have indicated that students' characteristics such as gender, culture and personality traits can have an effect on students participation, behavior and quality of collaborative learning (Prinsen et al. 2007; Reis et al. 2016; Noroozi et al. 2020). On the other hand, the formation of groups based on gender (Zhan et al. 2015; Curşeu et al. 2018) and cultural differences (Popov et al. 2014) has since demonstrated a positive effect on students' learning and is encouraged for CSCL environments. In an attempt to minimize the effect of students' characteristics from influencing the results, the present study saw the design of a within-subject experimental protocol. However, further analysis to determine if group formation based on students characteristics had an effect on the results should be considered for future work.

With respect to the analysis that was conducted, this study coded CSCL discussion messages using a coding scheme that was developed to study problem solving interactions of collaborative groups in online, synchronous environments. A different approach could have seen the coding of messages to determine the quality of discussion based on transactivity (i.e. building on the reasoning of one another, Teasley, 2017). Studies investigating transactivity in CSCL platforms see the coding of messages to identify actions such as elicitation, externalization, giving feedback, and coordination (Zoethout et al. 2017; Noroozi et al. 2013) to measure the quality of collaboration. The CSCL platform utilized in this study provides students the opportunity to acknowledge their peers' previous knowledge and opinions on the task by visualizing all group members' individual submissions before and during the collaborative stage providing possibilities for future work to investigate the transactivity in this context.

## 7. Conclusion and implications for teachers

Problematic interaction patterns in CSCL environments, such as unequal participation can potentially hinder fruitful collaboration. The present study evaluated the impact of a GAT within a CSCL setting on discussion participation and discussion quality. A within-subject experimental design saw 10 groups of 140 students participating in CSCL activities. The main findings of the study indicated that the presence of a GAT can increase students' participation in collaborative learning activities and it does not significantly affect the quality of participation. That is, the increased levels of participation did not lead to lower but moderately higher quality in the contributions. However, in regard to discussion participation balance, we did not find any significant differences.

Furthermore, this work has given insight into how students perceive group awareness tools. As students' understanding of such tools is crucial for regulating their learning (Janssen et al. 2011), it is important to take into account the students' perspective when utilizing such tools. Future work can see approaches aligned with human-centered design to allow students' opinions to be taken into account during the design process. In addition, future studies on existing tools need to provide a medium to hear participants' opinions on their limitations or advantages. It will be also interesting to study if the non-task-related participation in the discussions facilitated the creation of a good atmosphere for collaboration or was distracting. Our findings also suggest that further research is needed to explore the secondary effects that CSCL features can have on students, such as stress.

Finally, it should be noted that CSCL activities can place a high workload on the teacher. Constant distribution of teachers' attention across multiple groups considering both social and epistemic aspects of the learning situation, conducting on-the-fly activity adaptations as well as the constraints emerging from extraneous variables (e.g., time available, space restrictions) can demand significant effort from the side of the teachers (Dillenbourg & Jermann, 2010). To this end, the notion of orchestration load seeks to capture the attentive load teachers encounter when regulating CSCL activities in real time (Prieto et al. 2018). Recently designing and developing educational technologies that lessen the orchestration load of the teachers has gained attention (Amarasinghe et al. 2022). The present study contributes to this line of work as it provides evidence on how group awareness features can support students in self-regulating collaboration, therefore, lessening the burden on the side of the teachers and providing opportunities to share orchestration load across multiple actors i.e., teachers, students and supporting technologies (Sharples, 2013). Moreover, our study shows that the GAT was able to incentivize participation, without decreasing overall quality, achieving a perception in the students of support towards regulating their own activity participation and discussion. However, additional interventions are needed to better support equal levels of participation.

The visualization of learning analytic indicators, for instance, students activity participation with reference to group awareness features and the flagging of groups that require teachers immediate interventions, could increase actionability on the side of the teachers and extend the scope of the study in the future. Further research is required to frame a design space that integrates balanced human (teachers and students) and learning analytics interventions (group awareness features).

**Acknowledgements**

This work has been partially funded by the Volkswagen Foundation (COURAGE project, no. 95567). TIDE-UPF also acknowledges the support by FEDER, the National Research Agency of the Spanish Ministry, PID2020-112584RB-C33/MICIN/AEI/10.13039/501100011033, MDM-2015-0502 and by ICREA under the ICREA Academia programme (D. Hernández-Leo, Serra Hunter).

**Ethical approval:** This work has been approved by the Universitat Pompeu Fabra ethical committee, CIREP, and can be identified by the approval number 201.

The Version of Record of this manuscript has been published and is available in Behaviour & Information Technology, 12/4/23, http://www.tandfonline.com/10.1080/0144929X.2023.2200543.

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