HEURISTICS FOR AWARENESS SUPPORT IN GROUPWARE SYSTEMS

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ABSTRACT:

Groupware Systems or collaborative systems are software systems that support the development of activities in which a group of users interacts to combine their skills, abilities, and work to achieve a common goal. In these systems, an important feature is the awareness, which is the understanding of the events beyond current tasks that provides a context for your activity. This understanding is developed from the awareness information provided by collaborative systems, so it is a fundamental element in this kind of software. In the design and construction of these types of systems, heuristics are used as design guidelines that serve as a useful evaluation tool for product designers and usability professionals. However, current heuristics focus on supporting team awareness in the shared workspace without considering the informational needs of the individual's interaction within the workspace. To address this problem, we developed 13 heuristics integrating principles of Human-Computer Interaction and Computer Supported Cooperative Work to help groupware designers meet individual and team awareness needs. For evaluating the validity of the proposed heuristics, a structured and iterative consultation process was performed with experts in Human-Computer Interaction and Computer-Supported Cooperative Work. The proposed heuristics can help software engineers develop collaborative systems that integrate awareness information and satisfy users' contextual information needs.

Keywords: Awareness, virtual groups, collaborative work, heuristics.

RESUMEN:

Los sistemas Groupware o sistemas colaborativos son sistemas de software que apoyan el desarrollo de actividades en las que interactúa un grupo de usuarios para combinar sus habilidades y trabajo para alcanzar una meta en común. En este ámbito, un concepto importante es el de awareness, que es el entendimiento de los eventos más allá de las tareas actuales que provee un contexto para el desarrollo de actividades; este entendimiento es desarrollado a partir de la información awareness proporcionada por los sistemas colaborativos, por lo que es un elemento fundamental en esta clase de software. En el diseño de este tipo de sistemas se usan heurísticas como directrices de diseño que sirven como una herramienta de evaluación útil para los diseñadores de productos y los profesionales de la usabilidad. Sin embargo, las heurísticas actuales para el diseño del apoyo de awareness se enfocan en apoyar la conciencia del equipo en el espacio de trabajo compartido, sin considerar elementos para apoyar las necesidades de información de la interacción individual del usuario dentro del espacio de trabajo, lo cual implica un trabajo adicional en la labor de evaluación para los ingenieros de software. Para abordar este problema y para facilitar el diseño de sistemas colaborativos, con base en el análisis de la literatura se definieron 13 heurísticas que integran principios de Interacción Humano-Computadora y de Trabajo Cooperativo Asistido por Computadora para ayudar a los diseñadores de sistemas Groupware a cubrir las necesidades de awareness individuales y grupales. Para evaluar la validez de las heurísticas propuestas, se llevó a cabo un proceso de consulta con expertos en Interacción Humano-Computadora y Trabajo Cooperativo Asistido por Computadora. Las heurísticas propuestas pueden ayudar a los ingenieros de software a desarrollar sistemas colaborativos que integren información de awareness y satisfagan las necesidades de información contextual de los usuarios.

Palabras clave: consciencia, grupos virtuales, trabajo colaborativo, heurísticas.

1. INTRODUCTION

Groupware Systems (GS) or collaborative systems are software systems that support the development of activities in which a group of users interact, with the purpose of combining their skills, abilities, and work to achieve a common goal. These systems are designed to help a group of people either located in the same place or distributed at different places, that pursuing a common purpose, maintain communication, collaboration and coordination [1].

In practice, collaboration in computer- supported environments is not efficient due to conflicts among team members. However, in addition to the typical reasons for conflict, such as unequal participation of team members [2], people also face problems that arise

when coordinating their activities [3]. Carroll [4] mentions that when people work collaboratively, but not face-to-face, many natural resources of interaction are disrupted, such as the use of gestures that is limited, the sharing of resources that becomes difficult, the field of vision that is reduced to the size of the computer screen and therefore, the uncertainty of not knowing what the collaborators are doing, just to mention some examples of loss of background in remote collaboration.

By integrating teamwork support, GS must support the knowledge of the group and individual activity, facilitate coordination and teamwork [5], which translates into special requirements that need to be satisfied. One of these requirements is awareness, which refers to an understanding of a shared task's events and the social relations as a team. Collaborative systems provide awareness support that helps people understand events beyond their current tasks, for example, by providing information about who is participating, where they are, what they are saying, and what they are doing. Only by providing information on group members' work, systems allow each individual to make sense of the activity of others and adapt their own work accordingly [6].

In the context of Groupware systems, awareness has been the subject of study by the Human-Computer Interaction (HCI) and Computer-Supported Cooperative Work (CSCW) communities [7], which over decades of research have developed multiple definitions, models, awareness classification systems, and heuristics [6], [7], [8], [9]. Heuristics are design principles that serve as an evaluation tool to discover quickly, cheaply, and effectively problems in systems. Heuristic evaluation is an inspection method in which evaluators inspect a user interface for non-compliance with one or more heuristics. This technique is a valuable tool in the system design process because heuristics can be used to detect usability problems during the software design and development stages. Heuristics can also be used to conduct usability inspections where evaluators use them to analyze the design [10], [11], [12], [13]. Concerning awareness support heuristics, research has traditionally focused on design principles of shared workspace awareness mechanisms, leaving aside other important elements in a groupware system, such as awareness of a user's interaction with the system. Although the information of self-interaction (also known as feedback) has been studied in HCI by authors such as Nielsen [14] and Shneiderman [15]; and awareness information needs have been examinated in CSCW by Gutwin [16] and Baker [17], among others [5], [18], [19], it is necessary to support both in a GS. Therefore, design heuristics to help GS designers meet individual and group awareness needs are needed. This issue has been addressed by Baker, Greenberg, and Gutwin [11] and Claros, Collazos, and Cobos [20], who propose a set of (not validated) heuristics for evaluating GS awareness mechanisms or services, based on the review of the literature and their personal experience with GS.

Given the diversity of guidelines and heuristics in IHC [14], [15], [21] and CSCW [11], [16], [22] and with the aim of developing comprehensive and user-friendly design guidelines, we proposed 13 heuristics, based on the literature review, to help GS designers meet the awareness needs of collaborative systems. These heuristics integrate principles from HCI (usefulness, ease of use, consistency and standards, visual hierarchy, feedback from my own status) and CSCW (awareness of the people we collaborate with, visibility of system status, shared workspace awareness, support for collaborative activity, ease of coordination, communication support, social situation awareness, and flexible presentation). In order to evaluate the validity of the proposed heuristics, an experiment was conducted with experts in the areas of usability and collaborative systems to analyze the usefulness of the proposed heuristics for awareness support in groupware systems. After three consultation cycles, the experts confirmed the clarity and usefulness of the heuristics. The proposed heuristics can help software engineers develop and evaluate collaborative systems that integrate awareness information in order to have more functional systems than current ones.

This paper is organized as follows. Section 2 reviews the concept of awareness, its characteristics, and its role in GS. Section 3 describes the materials and the procedure performed to develop the heuristics for awareness support in GS. Section 4 presents the resulting heuristics, and in Section 5, a case study is presented where heuristics are used to evaluate the support of awareness in two collaborative systems. Finally, Section 6 presents conclusions and possible future work.

2. AWARENESS IN COLLABORATIVE SYSTEMS

The term awareness was adopted in the area of Computer Science to refer to the information that a system delivers to a user with the purpose of generating a state of consciousness about a situation. In the context of collaborative systems, the term awareness is defined in different ways [1]. It should be noted that although there are differences between definitions, many of them take as a starting point the one established by P. Dourish and V. Bellotti [6], who define awareness as "the understanding of the activities of others, which provides a context for your activity ".

In physical workspaces, people naturally maintain awareness using their senses; for example, by observing the progress of colleagues or even listening to them. But in virtual spaces provided by GS, people receive just a fraction of the information about other people that they would receive in a face-to-face environment, making it more difficult to maintain awareness [16].

The awareness information delivered by a GS not only involves being aware of individual pieces of information, but requires a complex level of understanding of the situation [23]. As Gutwin et al. [23] point out about awareness: "it should cover more than just knowledge of others' interactions with the workspace: it also includes knowledge of the state of the workspace and its artifacts, and your own actions within the context". So, without considering the information of state of the system, the individual actions, and the context of collaborators, users would not be able to perform their tasks effectively.

Regarding the individual awareness, this comprises the information of the user's interactions with the workspace, which is usually presented in the form of feedback of the state of the system or the current status of the user's interactions. Concerning the awareness of the collaborators in the workspace, it includes information about who the collaborators are, what they are doing and how. The awareness of the relationship between people provides information directly related to the interaction of users, for example, *emoticons* or "Like" tags provide information about what a person thinks or feels. This information might or might not be related to teamwork; however, it is relevant to the interaction with that person.

Although there are different types of awareness, they are all made up of three key components: Perception, Comprehension, and Projection. Awareness begins with perception, defined as the use of sensory means to generate a state of knowledge fed by the environment's perception. Comprehension refers to the creation of new knowledge from the existing one, while projection is the ability to project or approximate the values of elements in the near future [25].

In computer-mediated collaborative activities, awareness support helps compensate for inefficiencies in communication, coordination, and collaboration by providing information on the collaborative environment situation. Each activity has its requirements, so several types of awareness have been defined to support the needs of the teams within the systems [26].

3. **MATERIALS AND METHODS**

There are different methods for the development of heuristics. Quiñones and Rusu [27] identified the most commonly used approaches to create usability heuristics. The results of the literature review of [27] show that most heuristics are based on existing heuristics, literature reviews, usability problems, and guidelines. However, some studies apply a methodology such as Rusu et al. [28] and Ouariachi, Gutierrez-Perez, and Olvera-Lobo [29] to define, validate, and refine the set of proposed heuristics.

We developed a set of heuristics to support awareness in collaborative systems using the methodology suggested by Ouariachi, Gutiérrez-Pérez, and Olvera-Lobo [29]. The methodology starts by analyzing the literature to collect relevant information and identify possible heuristic principles, then applies the Delphi method to examine and validate the heuristics. Therefore, we performed a literature review on awareness and evaluation of collaborative systems to collect relevant information to develop the heuristics. Then through expert judgment, the heuristics were refined and validated. The method that we followed is presented in Figure 1.

In this study, expert judgment was used to develop and validate the heuristics through the Delphi method. This Delphi method is "a systematic, interactive and collaborative process aimed at obtaining opinions and consensus from the subjective experiences and judgments of experts" [29]. Based on expert judgment using the Delphi method, Ouariachi, Gutiérrez-Pérez, and Olvera-Lobo [29] developed validated criteria for evaluating climate change games. Regarding the optimal number of experts in the process, Ouariachi, Gutiérrez-Pérez, and Olvera-Lobo [29] recommend a panel of at least seven experts to be considered as valid. Following the methodology of [29] for applying the Delphi method, our proposed heuristics for awareness support in GS were validated based on the judgment of nine experts with studies, knowledge, and experience in HCI and CSCW.

During testing, volunteer experts explored a GS (in this case, they used GitHub, a collaborative code control tool) to familiarize themselves with it and then inspected it using the heuristics for assessing awareness support. Evaluators recorded the identified awareness problems on a form and weighted them using the Nielsen severity scale: 0-- Not a problem, 1- Unimportant problem, 2- Minimal usability problem, 3- Severe problem, 4- Critical usability problem.

At the end of the tests, the experts evaluated the ease of interpretation of the heuristics and their usefulness in determining the quality of awareness support in the groupware. This assessment was conducted with a questionnaire with closed questions, in which the experts answered if they agreed or not with the proposed heuristics. Finally, the evaluators were asked for additional observations or comments. Based on their answers, the heuristics were redesigned, and then the new version of the heuristics was used and evaluated by experts following the same method. This process was carried out in a structured and iterative manner until a minimum consensus of 80% was reached among the experts' opinions. For the present case study, and as illustrated in Fig. 1, three cycles of consultation with the experts were enough to reach a final and consensual version of the heuristics.

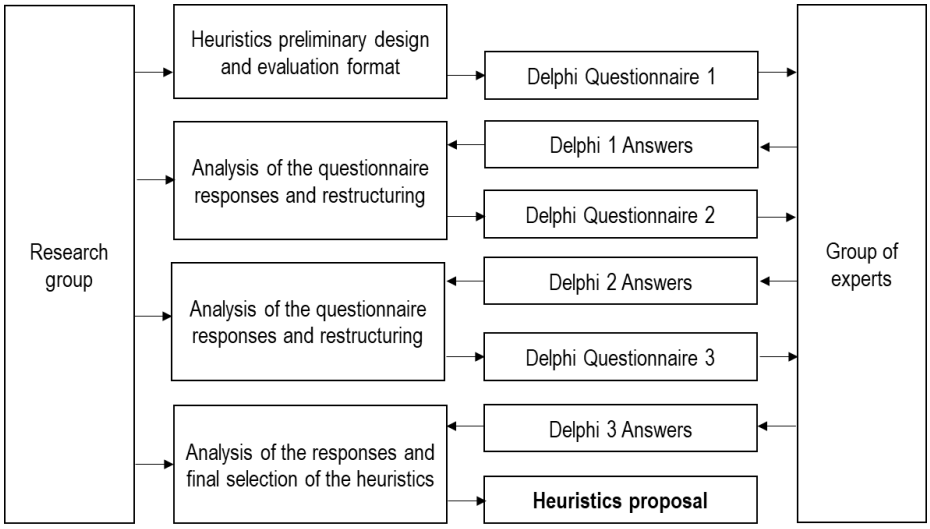

Fig. 1. Delphi process adapted from Ouariachi, Gutiérrez-Pérez, and Olvera-Lobo [28].

During each evaluation cycle, the experts used the proposed heuristics to test their usefulness in evaluating GS's awareness support. In the first cycle, the experts used the heuristics to analyze the collaborative code control tool GitHub; in the second iteration, the experts used the heuristics to analyze co-flows (a collaborative flowcharting application). In the third iteration, they analyzed AssaultCube (a collaborative first-person shooter video game). The selected GS are systems that support remote collaborative activities and integrate different awareness mechanisms to facilitate teamwork.

4.- RESULTS

We proposed a series of heuristics for the evaluation of awareness support in an GS based on the literature review on awareness and evaluation of collaborative systems [8], [16], [17], [18], [19], [11], [22], [30]. In the definition of the heuristics, some usability principles of Nielsen [14] and Somervell [21] were also considered, since a GS is a system with which a person interacts, and therefore it also has to satisfy the basic principles of a single-user system. It is worth mentioning that we took up only Nielsen's heuristics related to awareness support since this paper focuses on it.

An experiment was conducted to evaluate the usefulness of the proposed heuristics for awareness support in groupware systems. The experiment involved the participation of 9 expert evaluators in usability and collaborative systems. The profiles of the evaluators' were:

- "Experts" are evaluators with knowledge and experience in HCI but lack substantive knowledge in collaborative systems and CSCW principles [30]. We recruited four individuals with this profile, each one with a Master's degree in User-Centered Interactive Systems. Three of the expert evaluators at the time of testing were additionally pursuing a Ph.D. degree in Computer Science.
- The "double experts" have knowledge and experience in both HCI and CSCW [30]. We recruited five people with a Master's degree in User-Centered Interactive Systems whose research line is focused on CSCW.

To test the heuristics and determine their usefulness in assessing the quality of awareness, the experts analyzed the awareness support in three GS: GitHub, co-flows, and AssaultCube. This section presents the results of the development and evaluation of the heuristics.

In the first evaluation, 80% of the experts agreed that the proposed heuristics were useful, while the remaining experts had a neutral position (neither agree nor disagree) on this point. To the second question, all the experts agreed that the heuristics helped them to determine the quality of the awareness support in the groupware. However, the experts noted that it was difficult to fill out the evaluation instrument due to the lack of space for the description of the problems identified during the evaluation.

After the first evaluation, the instrument used by the experts to perform the heuristic evaluation was restructured. The proposed instrument contains the following information: instrument title, name of the system to be evaluated, name or ID of the evaluator, date

of application, instructions, scale of severity for usability problems, heuristics, description of the heuristics, and space to write the description of the problems identified with the heuristic and its assessment.

In the second evaluation, the experts indicated that, although the instrument was clear and the heuristics covered the different aspects of awareness, heuristics 5 and 6 were repetitive, therefore they could be included in a single heuristic. Table 1 shows the results obtained in the second evaluation.

Heuristics	Clarity (%)	Usefulness (%)	Implementation relevance (%)
1. Usefulness	78	67	78
2. Ease of Use	67	67	89
3. Consistency and standards	67	56	89
4. Visual hierarchy	78	67	78
5. Stay update	89	78	100
6. Visibility of system status	97	78	78
7. Feedback on one's own status	97	78	67
8. Awareness of the people we collaborate with	89	89	100
9. Context generation	56	78	67
10. Workspace awareness	78	100	89
11. Activity support	44	56	78
12. Ease of coordination	56	67	89
13. Knowledge of the social situation	78	89	89
14. Communication support	89	89	89
15. Global Vision	89	100	78

Table 1. Heuristics and total agreement percentage (concensus) in the evaluation 2.

As can be seen in Table 1, the results obtained in the second evaluation did not reach the minimum consensus of 80% in nine of the heuristics proposed. Taking into account the results and observations noted by the experts, the heuristics were modified: heuristics 4 and 5 were unified, as were heuristics 9 and 15, leaving a total of 13 heuristics, which were again evaluated with the procedure described above. The results obtained in this evaluation are shown in the Table 2.

Heuristics	Clarity (%)	Usefulness (%)	Implementation relevance (%)
1. Utility	94	89	86
2. Ease of use	94	89	83
3. Consistency and standards	89	83	91
4. Visual hierarchy	89	94	89
5. Feedback on one's own status	97	91	94
6. Awareness of the people we collaborate with	91	91	97
7. Visibility of system status	97	97	91
8. Shared workspace awareness	91	100	91
9. Activity support	86	86	91
10. Ease of coordination	94	94	89
11. Knowledge of the social situation	91	91	91
12. Communication support	94	94	94
13. Flexible presentation	89	80	83

Table 2. Heuristics and total agreement percentage (concensus) in the evaluation 3.

In the third evaluation (as Table 2 shows), a favorable consensus was reached (greater than 80%) in terms of clarity and usefulness of the proposed heuristics. Regarding their usefulness, the experts agreed that the heuristics were useful to identify areas for improvement in awareness support. All experts also considered the heuristics as appropriate and agreed that they helped determine the quality of awareness support in the GS being evaluated.

After three cycles of consultations, the experts confirmed the clarity of the heuristics, their usefulness, and their implementation relevance. Table 3 presents the proposed instrument for the heuristic evaluation of awareness support in GS, which considers the heuristics for evaluating the awareness support, the description of the identified problems, and the assessment of the severity of the problems.

	Heuristics	
H1	**Usefulness** It is necessary to ask if the awareness elements incorporated in the system are useful. The awareness elements that are present should not contain information that is irrelevant or rarely needed. Each unnecessary unit of information competes with relevant information units and decreases its relative visibility [14].	
	Identified problems [Description]	**Rating (0-5)** [Result]
H2	**Ease of use** The mechanisms to generate awareness must be easy to use and interpret. These elements must be presented in a clear, effective, and easy-to-understand manner. It is recommended to present awareness information in a familiar way to the user.	
	Identified problems [Description]	**Rating (0-5)** [Result]
H3	**Consistency and standards** The user should not wonder if different words, figures, situations or actions mean the same thing [14]. The use of standards and conventions is recommended to facilitate awareness interpretation mechanisms.	
	Identified problems [Description]	**Rating (0-5)** [Result]
H4	**Visual hierarchy** Elements should be organized based on their order of importance and use an appropriate color scheme to understand the information. The screen space must be delegated according to the importance of the information [20].	
	Identified problems [Description]	**Rating (0-5)** [Result]
H5	**Feedback on one's own status.** The user should not have doubts about whether the system has correctly identified him, have uncertainty about the status of his activities, if changes have been made, or if they have been saved.	
	Identified problems [Description]	**Rating (0-5)** [Result]
H6	**Awareness of the people we collaborate with** It is essential to have basic information about the people the user interact with (respecting their privacy). Personal information such as name or alias, a photograph or avatar is what facilitates awareness in the interaction [8].	
	Identified problems [Description]	**Rating (0-5)** [Result]
H7	**Visibility of system status** Collaborators can perform activities at any time, so environments change over time. Therefore, the system should always keep users informed about what is happening through feedback in a reasonable time and in an appropriate manner [14],[8].	
	Identified problems [Description]	**Rating (0-5)** [Result]
H8	**Shared workspace awareness**	

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	People should be aware of what is happening in the workspace Who do they share it with? Who are connected? What can they do and see? What have they done or what are they doing? What events or changes have occurred in the workspace? [16]. A fundamental strategy is to have a shared visibility area, where all collaborating members see exactly the same objects [22]. In the case of synchronous collaboration (at the same time), the user must know at all times, where he and the other collaborators are located (within the application) in order to avoiding not getting get lost in the application [25].	
	Identified problems [Description]	**Rating (0-5)** [Result]
H9	**Activity support** The interface should support individual and group activities related to the collaborative work. It is essential to consider the following questions: Do the awareness resources provided help the participants to have a notion of individual and joint activities or efforts? Can you see the overall picture of the collaborative process? Considering the context of use, executedould activities be executed efficiently?	
	Identified problems [Description]	**Rating (0-5)** [Result]
H10	**Ease of coordination** The system should provide tools to enable a group of people to perform activities simultaneously and coordinate effortlessly [16]. The coordination in these situations depends on the availability of information that facilitates the understanding of the team plan and how the work of the team members is being performed [26].	
	Identified problems [Description]	**Rating (0-5)** [Result]
H11	**Communication support** The system should provide the necessary elements for collaborators to communicate transparently and efficiently. In communication support, meta-information complementary to the body of the message must also be included. The common meta-information available in communication tools is the subject of the message, sender, its date, and priority [26].	
	Identified problems [Description]	**Rating (0-5)** [Result]
H12	**Knowledge of the social situation** The system must have mechanisms that facilitate collaborators to express their position on a topic and emotional state, for example, emoticons in a chat. In the case of having roles, these should be clearly marked.	
	Identified problems [Description]	**Rating (0-5)** [Result]
H13	**Flexible presentation** Awareness should be presented according to the system and device used by each team member, therefore, it should be flexible and adaptable to the different devices used by the users [31]	
	Identified problems [Description]	**Rating (0-5)** [Result]

Table 3. Proposed instrument for heuristic evaluation of GS awareness support

It is recommended in the heuristic evaluation that the experts use the same instrument or format during the assessment. The instrument will consist of a field to collect the evaluator's name or identifier, the name of the evaluated tool, a table with each of the heuristics, the description of the detected problem and its severity according to the severity scale [32]. Particularly for the evaluation, it is recommended to use the Nielsen severity scale for usability problems (see Table 4) because it is a reliable tool , easy to use and rate. [33], [12].

Rate	Meaning
0	No problem
1	Minor problem: does not need to be fixed unless there is time to spare.
2	Minimal usability problem: the solution is of low priority.
3	Major problem: it is important to solve it, so it should be considered a high priority.
4	Critical usability problem: the solution must be immediate.

Table 4. Severity scale for usability problems [14], [34].

In the heuristic evaluation of awareness support, the usability experts -preferably with knowledge of collaborative systems- use the heuristics to inspect the interface elements, analyzing whether the heuristics were fulfilled since each violated heuristic is a potential awareness problem. According to Nielsen [35], the ideal number of evaluators is between three and five experts since fewer than three are insufficient to obtain reliable results, while more than five are unnecessary since 3–5 evaluators can detect 60–75% of the interface errors.

It is recommended that the environment in which the evaluation takes place be similar throughout the different inspection sessions, in order to minimize the impact of external factors that may affect the evaluators. Each evaluator should inspect the GS at least twice; the first time to familiarize the evaluator with the interface and the second time to examine the GS and identify problems in the awareness support, indicating their severity according to the selected scale. The results of the heuristic evaluation provide a set of potential awareness support problems in collaborative systems.

5. CASE STUDY

We used as a case study a web platform for project management (Trello) and a graphic design tools website (Canva) to identify awareness issues during a collaborative activity. The heuristic evaluation was conducted by six HCI specialists: one software engineer with expertise in HCI, one person with a master's degree in applied computing, and four people with a master's degree in user-centered interactive systems. Let us note that -three of the participating evaluators were also specialists in collaborative systems.

The participants were divided into two groups of three evaluators. With each group, an evaluation session was conducted virtually through the Zoom platform. Through this platform, a meeting was held with the evaluators to coordinate the heuristic evaluation, establish the evaluation's objective, explain the procedure, share the instrument for heuristic evaluation of awareness support in GS, and give a brief explanation of the systems to be evaluated. After establishing the evaluation procedure, the experts collaboratively used Trello (https://trello.com/) and evaluated the tool's awareness support. The evaluators used our proposed heuristics to identify possible awareness problems and, for each identified problem, they rate its severity according to the Nielsen severity scale. After the heuristic evaluation of Trello, the volunteers evaluated the graphic design tool Canva (https://www.canva.com/) following the same procedure.

For the analysis of the heuristic evaluation results, the scores of each heuristic from both Trello and Canva were averaged, and an analysis of the problems identified was made. The results of the heuristic evaluation from Trello and Canva are shown in Table 5.

Heuristics	Trello Average	Canva Average
Usefulness	0.3	0.7
Ease of use	1.5	1.8
Consistency and standards	0.8	0.2
Visual hierarchy	0.8	1.2
Feedback on one's own status	1.2	1.8
Awareness of the people we collaborate with	1.3	0.7

Visibility of system status	0.8	1.7
Shared workspace awareness	1.3	1.7
Activity support	2.2	1.7
Ease of coordination	2.0	2.5
Communication support	2.7	3.3
Knowledge of the social situation	2.8	2.8
Flexible presentation	0.3	0.7

Table 5. Results of the heuristic evaluation

The analysis of awareness support in Trello and Canva using the proposed heuristics shows that both tools present problems regarding coordination, communication, and social situation awareness. The experts identified the lack of a chat or a communication tool, which affects communication possibilities. The lack of communication hinders coordination and social situational awareness. The analysis of Trello also revealed minimal problems (rated 2.2) of activity support from the lack of clarity on what activity each participant is doing and where they are doing it. Hence, two experts suggested include a mark system to reflect where users are working and signaling the lists and tasks' authorship. The Canva analysis results indicate, in addition to communication limitations, difficulty in coordinating team tasks due to the lack of feedback on who is performing each action.

The results of the case study show that even commercial collaborative systems such as Canva and Trello have limitations supporting collaborative activity due to poor awareness feedback. The systems analyzed in the case study started as systems to perform activities individually and later evolved to systems that also offer teamwork tools. However, as the research shows, having access to a shared workspace is not enough for successful collaboration. In addition to the tools for developing the activity, it is necessary to incorporate awareness support in the GS to facilitate coordination and cooperation among team members. The proposed heuristics will help software engineers and designers of collaborative systems meet the needs of awareness of other people's actions, as well as the state of the workspace, its artifacts, and the knowledge of the individual's activity within the collaborative context.

6. CONCLUSIONS

In the present work, we conducted a review of the literature on awareness support in GS. The current literature analysis revealed that, although there are frameworks, taxonomies, and heuristics to evaluate collaborative systems, these resources tend to focus on the interactions of team members, without considering elements that support the individual user in the workspace.

Given the diversity of guidelines and heuristics in HCI for supporting individual activities and in CSCW for supporting the collaborative activity, we proposed a set of comprehensive heuristics to evaluate awareness support. The heuristics integrate HCI and CSCW principles to help GS designers meet the needs of awareness of other people's actions, as well as the state of the workspace, its artifacts [22], and the knowledge of the user's activity within the collaborative context. In this study, expert judgment was used to develop and validate the proposed heuristics through the methodology of Ouariachi, Gutiérrez-Pérez, and Olvera-Lobo [29] for the application of the Delphi method.

We tested the usefulness of the proposed heuristics to evaluate awareness support through a case study. The study found evidence of deficiencies in support for awareness in two commercial collaborative systems (Trello and Canva) that show limitations of support for communication and teamwork coordination. However, it could be relevant to apply the heuristics with a larger number of experts in more tools to analyze the heuristics' effectiveness for detecting areas of improvement in different collaborative systems.

Nowadays, with the increase of home office jobs and the need for remote collaboration between people and institutions, more and more people use collaborative systems for virtual meetings, not only for project planning and execution but also for socializing and having fun. Given the current needs for remote interaction and collaboration, more collaborative systems are emerging. The proposed heuristics will help software designers and engineers design collaborative systems and avoid content and presentation problems in awareness support. It should be noted that, although the proposed heuristics are useful for the analysis of awareness support, we recommend complementing the heuristic evaluation with usability testing.

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