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Establishing the Awareness Assessment Process

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Abstract Different strategies in the literature seek to help support awareness mechanisms in collaborative applications. However, the most common approaches are often applied in a specific context and do not focus on evaluating these mechanisms or the support provided from the user's perspective. Few studies present methods or processes that provide awareness aspects in collaborative systems; thus, finding a good starting point in the literature can be challenging for beginners in awareness design. We build upon the findings presented by Mantau and Benitti [2023a], providing contributions towards developing an awareness assessment process that enables accessing awareness and, consequently, collaboration support by measuring awareness mechanisms from the participant's viewpoint. Then, we expose the model's artifacts to HCI and collaborative system examiners to gauge their appreciation and verify the suitability of the process based on reliability and usefulness criteria. The case study scenario demonstrated suitable indicators from the perspective of demographic data and IRT parameterization. As a result, the applicability of the awareness scale from the participant's perspective was achieved.

Keywords: Awareness, Collaboration, Assessment, Process

1 Introduction

Collaborative systems enable group members to communicate effectively with one another, coordinate their work, and collaborate efficiently. These three aspects are the pillars of the collaboration process, called the 3C collaboration model (communication, coordination, and cooperation). Collaboration occurs when two or more people, entities, or organizations work together to complete a task or achieve a goal [George, 2003]. To provide the 3C collaboration model in collaborative systems, cues/information must be available, allowing participants to communicate, coordinate, and cooperate. This support involves a fundamental element of a collaborative approach: the awareness [Dourish and Bellotti, 1992].

Awareness has been a significant concept in Collaborative Systems [Tenenberg *et al*., 2016] and is an essential part of it [Gross, 2013]. Over the last three decades, different awareness types have emerged in the literature. The works of Seebach *et al*. [2011]; Antunes *et al*. [2014]; Gallardo *et al*. [2018]; Mantau *et al*. [2017] present a broader list of awareness types. Detailed background on the origins of awareness, including early ethnographic and technology studies that led to the fundamental insights presented in Gross [2013]. Over the last three decades, various types of awareness have emerged in the literature. The works Seebach *et al*. [2011]; Antunes *et al*. [2014]; Mantau *et al*. [2017] present a broader list of awareness types. Lopez and Guerrero [2017] provides a brief review of awareness support technologies used in collaborative systems.

We consider awareness the backbone of a collaborative environment; all collaborative concepts are archived through it. An efficient awareness mechanism ensures a better understanding, and consequently, a more accurate projection of future actions. In contrast, its lack undermines comprehension and prevents participants from projecting their work accordingly. Second, each piece of awareness information supports the Cs of the 3C model. For example, workspace awareness helps people move between individual and shared activities, provides a context for interpreting others' expressions, allows anticipating actions, and reduces the effort spent coordinating activities [Greenberg, 1997].

As a process, awareness occurs at three basic levels of abstraction: representation, understanding, and projection [Brezillon *et al*., 2004]. At the representation level, we consider awareness through design mechanisms/elements that provide participants with cues about "what is going on"; These awareness mechanisms represent information regarding events and actions of all involved, whether individual, others, group, or the system itself. A solid base of elements/mechanisms is a constant concern throughout the area's evolution, and contributions can be seen in Gutwin *et al*. [1996]; Gutwin and Greenberg [2002]; Kirsch-Pinheiro *et al*. [2003]. In these works, awareness is related to the 5W+1H questions (who, what, where, when, why, and how), and to guarantee awareness aspects in a collaboration, it is necessary to provide a wide variety of information, such as identity, location, activity level, actions, intentions, modifications, objects, extensions, skills, the sphere of influence, and expectations [Gutwin *et al*., 1996].

At the understanding level, we consider awareness as an understanding of other people's activities that provides a context for their own behavior [Dourish, 2004]. This is a set of processes in which we recognize, organize, and find meaning in the stimuli we receive from the environment [Sternberg *et al.*, 2012]. From this perspective, awareness is the state of being conscious of something. We consider this level to be a mental state where, through the stimuli received from the environment and their experience and knowledge, the individual forms an understanding/consciousness of the situation and how they fit into this context. Ultimately, understanding/consciousness enable individuals to project their future actions and facilitate collaboration.

These three awareness gears must be in tune for collaboration. Thus, providing an efficient awareness mechanism ensures a better understanding and, consequently, a better projection of future actions. In contrast, the lack of awareness mechanisms undermines comprehension and prevents participants from projecting their work accordingly.

1.1 The awareness

Awareness is a well-established concept that has yet to be fully realized in collaborative environments. According to Gross [2013], this concept remains difficult to grasp, and future research should aim to achieve a better understanding of supporting and effortless coordination by conceiving and testing novel technologies that guarantee awareness aspects. Furthermore, since the 1980s, there has been no consensus on the awareness issue and how to understand it [Schmidt and Randall, 2016]. At this point, two main potential problems remain open. The first relates to understanding awareness and how it should be faced in collaborative applications. The second is establishing a basis for evaluating collaborative interfaces focused on it.

Considering awareness at a high level, people can differ in their understandings, and individual awareness can change as their background and the stimuli received change. People have different abilities in representing, understanding, and projecting human actions through the interface [Mantau *et al.*, 2017]. Sociotechnical factors such as participants' motivation, knowledge, and goals influence interaction [Cruz *et al.*, 2012; Mantau *et al.*, 2017]. Second, each piece of awareness information supports each C of the 3C model. For example, workspace awareness helps people move between individual and shared activities, provides a context for interpreting others' expressions, allows anticipating actions, and reduces the effort spent coordinating activities [Greenberg, 1997]. Furthermore, the knowledge of shared workspace enables users to project their actions in the environment (e.g., to cooperate) and exchange information with others in the group (e.g., to communicate). These aspects make awareness a crucial element in collaborative applications and a fundamental challenge.

Gutwin and Greenberg [2002] developed a descriptive theory of awareness, organizing existing research through a conceptual framework focusing on workspace awareness. The framework comprises design elements addressing the questions of who, what, where, when, and how. Combined with the "why", these questions constitute the 5W+1H framework and represent the primary awareness information that collaborative systems must support. Few papers address awareness from a broad perspective [Collazos *et al.*, 2019]. Most of these studies focus on a specific type of awareness in their approaches [Prouzeau *et al.*, 2018]. Many papers consider awareness dissociated from communication, coordination, and cooperation. The link between supported awareness elements/information and their influence on collaboration remains hard to achieve. Furthermore, few studies present methods or processes that help to provide awareness aspects in collaborative systems.

1.2 Aims of Study

In this work, we build upon the findings presented by Mantau and Benitti [2023a], providing contributions towards developing an awareness assessment process that enables accessing awareness and, consequently, collaboration support by measuring awareness mechanisms from the participant's viewpoint. In this model, we consider the participant's skill in understanding the awareness information provided by the application and the difficulty involved in perceiving each awareness piece.

2 Background

Several methods or processes for evaluating awareness and collaboration have been presented in recent literature [Mantau and Benitti, 2022a]. The most common strategy is an ad hoc approach that involves users through experiments or case studies. Questionnaires, interviews, brainstorming sessions, focus groups, conceptual modeling, direct observation, system logs, and static/dynamic analysis of the system were used in the assessment strategies.

Questionnaires were the primary data collection tool reported: by user experience [Kim *et al.*, 2010], usability [Berkman *et al.*, 2018], NASA-TLX user workload [Gutwin *et al.*, 2017], or ethnographic [Herskovic *et al.*, 2011] questionnaires; by ethnographic questionnaire combined with system logs and researcher's observations [Mantau *et al.*, 2014], and system logs [Mantau *et al.*, 2017]; by participatory observations, non-structured and mostly ad hoc interviews, and discussions [Talaei-Khoei *et al.*, 2014]; by semi-structured interview and a 7-point Likert scale questionnaire combined with statistical analysis [Yang *et al.*, 2018]; and by 7-points Likert scale ethnographic and usability questionnaire combined with researcher's observations, system logs, audio and video recordings [Prouzeau *et al.*, 2018].

Frameworks, guidelines, design requirements, or groupware heuristics were also applied during development and evaluation, namely: a checklist to assess awareness support in collaborative systems [Antunes *et al.*, 2014; Espirito Santo *et al.*, 2018]; set of requirements and assessment metrics Mantau *et al.* [2017]; usability groupware heuristics for mobile environments [De Araújo *et al.*, 2014]; frameworks or taxonomies [Gallardo *et al.*, 2011; Souza and Barbosa, 2015; Collazos *et al.*, 2019; Niemantsverdriet *et al.*, 2019]; or questionnaires, laboratory testing, heuristic evaluation, automatic logging, and eye-tracking techniques [Molina *et al.*, 2015].

Steinmacher *et al.* [2010, 2013] systematically reviews and maps the literature on awareness support in distributed software development; however, they do not study other collaborative systems. In general, most primary studies (79%) focus on introducing a new tool with some awareness support, and there is a lack of studies and tools giving solutions to awareness support.

Antunes *et al*. [2014] developed an awareness checklist to help software designers inspect the quality of awareness support in applications under development or evolution. The checklist comprises 54 design elements and six awareness types: collaborations, Location, Context, Social, Workspace, and Situation. A recent adaptation of the checklist is presented by Espirito Santo *et al*. [2018], where the authors investigate awareness support in the context of software engineering development.

Molina *et al*. [2015] proposed an evaluation approach combining subjective (e.g., the subjective perception collected by questionnaires about his/her satisfaction) and objective (eye tracking techniques) to evaluate interactive systems. This approach enables the examiner to assess the awareness support of collaborative systems by combining inspection (heuristic evaluation), subjective (questionnaires, interviews), and objective (automatic logging) methods, as well as usability testing in a lab (retrospective thinking aloud, eye tracking, and recording of use).

Collazos *et al*. [2019] conducted a systematic mapping study of frameworks and design processes for awareness support. This article reviewed which types of awareness information have been helpful to the collaborative systems field and identified three types of context information sources: people, tasks or projects, and resources, such as workspace objects. The authors have elaborated a descriptive theory for collaborative systems development to assist engineers in incorporating awareness mechanisms, focusing on the aspects to be considered when designing and implementing awareness mechanisms in collaborative tools.

Souza and Barbosa [2015] proposed an extension to the MoLIC (Modelling Language for Interaction as Conversation) that helps designers project collaborative applications by considering the interactions among users, cooperative tasks, and awareness mechanisms.

Gallardo *et al*. [2011] proposed an awareness ontology that conceptualizes aspects related to awareness in collaborative modeling systems. The method encompasses the conceptual (steps to be carried out), methodological (factors to be considered in generating the collaborative tool), and technological frameworks (specific IDE plug-ins that support collaborative functionality).

Lopez and Guerrero [2017] focused on a systematic review of collaborative tools that use ubiquitous mechanisms to provide awareness in the collaborative domain.

Niemantsverdriet *et al*. [2019] proposed a framework for awareness designers, structured into a list of design considerations to support awareness interactions that can be used during the design process.

The works of Souza and Barbosa [2015]; Collazos *et al*. [2019]; Niemantsverdriet *et al*. [2019] have a central focus on the design and development of collaborative environments. The central focus of these works is to provide design considerations to support interaction designers during their design process. Despite the work of Antunes *et al*. [2014], which described a checklist to inspect the quality of awareness support, this focuses mainly on the development stages and software designers. Additionally, the validity and reliability of the proposed instrument were not verified.

The model proposed by Molina *et al*. [2015] uses a notable set of different evaluation strategies; however, it requires a specific evaluation environment (laboratory), and the peculiarities of employing a dynamic evaluation approach, like eye-tracking or usage recording techniques, can also be a limiting aspect for its replication in scenarios with limited computational resources available to conduct experimentation. Additionally, due to the small sample size, the results should be considered preliminary.

As we can see, there remains a need to develop awareness assessment strategies for collaborative environments, aiming to evaluate the awareness support in the context of use and from the participant's perspective. There are no standardized tests to assess awareness [Niemantsverdriet *et al*., 2019], and it remains necessary to identify awareness evaluation criteria and establish quality indicators for collaborative environments [Prouzeau *et al*., 2018].

3 Methodology

This work was carried out in two main stages. First, based on a systematic mapping of the literature [Mantau and Benitti, 2022a], we identify the main approaches (e.g., models, methodologies, or processes) used to evaluate awareness and collaboration aspects in groupware systems. This systematic mapping study aims to answer two research questions (RQ):

RQ1 *What research methods and techniques were adopted? How was the approach evaluated or validated? What were the evaluation methods and instruments adopted?*

RQ2 *What are the challenges and limitations of evaluating awareness and collaboration?*

Second, an awareness assessment model was defined and evaluated by exposing its artifacts to HCI and collaborative system examiners to verify the process's suitability based on reliability and usefulness criteria.

The case study consists of two parts. First, examiners adopted the model artifacts and process to evaluate the awareness support in general-purpose collaborative office tools (e.g., most common text editing tools, spreadsheets, and document managers). Second, researchers' observations and questionnaires assessed the usefulness of the model's conceptual view of artifacts and the evaluation process. Before starting the case study, participants were invited to a briefing session where the evaluation model and its artifacts were presented. At this stage, all materials necessary for the study, including a detailed overview of the evaluation process, the awareness taxonomy, the inventory of assessment questions, a template of collection instruments (questionnaires, both printed and online), and a report model of the assessment results, were made available to all examiner groups.

We mainly selected novice examiners in HCI and collaborative system application evaluations to identify potential difficulties in replicating the proposed model. Thus, we sought to evaluate whether novices see the practical use of the model and its artifacts in the same way as the previous model's expert panel validation indicated [Mantau and Benitti, 2023a].

Examiners were accompanied during the artifact preparation and assessment process activities.

4 The awareness problem

Different strategies have emerged to support awareness mechanisms in collaborative applications; however, most are tailored to a specific context and do not focus on evaluating these mechanisms or the support provided from the user's perspective. For example, Gallardo *et al.* [2018] presented a framework for the descriptive specification of awareness support. They focused on multimodal user interfaces for collaborative activities, and a tool was provided to help engineers implement awareness in collaborative applications; however, few clues have been presented for evaluating these mechanisms. In recent efforts, Bravo *et al.* [2023] has evolved this specification technique approach into a visual modeling language, and a software specification technique has been identified; however, the mechanisms by which participants acquire and evaluate these elements remain unclear.

As presented by Santos *et al.* [2012], various methods exist to evaluate collaborative systems, whether pre-existing, new, or ad hoc. In general, adapted methods are commonly used, as most of these methods are already well-established and allow, with some adaptations, the incorporation of collaborative aspects of the systems [Santos *et al.*, 2012]. On the other hand, considering specific awareness evaluation approaches, few studies present methods or processes that provide awareness aspects in collaborative systems. Many of them are based on a limited number of explorations, making it difficult to generalize the knowledge.

The works of Steinmacher *et al.* [2013]; Lopez and Guerrero [2017] investigated challenges related to providing awareness support during collaboration. Both papers highlight the lack of consolidated awareness assessment methods that enable precise assessment of collaborative applications from their perspective. Finding a good starting point in the literature can be challenging for beginners in awareness design [Niemantsverdriet *et al.*, 2019]. With a blank slate for each new application, designers must reinvent awareness from their experience of what it is, how it works, and how it is used in the task at hand [Collazos *et al.*, 2019].

4.1 Research methods and techniques [RQ1]

The primary strategy adopted in the research approach is the development of collaborative applications and evaluation involving users (22 papers), either by experiments (2 papers) or case studies (20 papers). Nine papers presented guidelines through a literature review; 4 papers carried out surveys through questionnaires in specific groups and using a qualitative or specialist analysis; and seven adopted other research approaches, such as technical review, comparative study, or heuristic evaluation.

Figure 1 summarizes the relationship between the research method used (X-axis) and paper classification (Y-axis).

Regarding instruments and materials, data were collected through questionnaires, interviews, brainstorming sessions, focus groups, conceptual modeling, direct observation, system logs, and static/dynamic analysis of the system. Questionnaires were the primary data collection tool that was reported. We identified the following approaches: by using user experience [Kim *et al.*, 2010], usability [Berkman *et al.*, 2018], NASA-TLX user workload [Gutwin *et al.*, 2017], or ethnographic [Herskovic *et al.*, 2011] questionnaires; by using ethnographic questionnaire combined with system logs and researcher's observations [Mantau *et al.*, 2014], and system logs [Mantau *et al.*, 2017]; by using participatory observations, non-structured and mostly ad-hoc interviews, and discussions [Talaei-Khoei *et al.*, 2014]; by using semi-structured interview and a 7-points Likert scale questionnaire combined with statistical analysis [Yang *et al.*, 2018]; and by using 7-points Likert scale ethnographic and usability questionnaire combined with researcher's observations, system logs, and audio and video recordings [Prouzeau *et al.*, 2018].

Frameworks, guidelines, design requirements, or groupware heuristics were used during development and evaluation, namely: checklist to assess awareness support in groupware systems [Antunes *et al.*, 2014; Collazos *et al.*, 2019]; set of requirements and assessment metrics [Mantau *et al.*, 2017]; usability groupware heuristics for mobile environments [De Araújo *et al.*, 2014]; and frameworks or taxonomies [Souza and Barbosa, 2015; Gallardo *et al.*, 2011; Collazos *et al.*, 2019; Niemantsverdriet *et al.*, 2019].

4.2 Evaluation challenges [RQ2]

Evaluating collaborative systems is more complex and challenging than conventional ones. We have compiled the four main reasons supporting this scenario here. First, providing awareness and addressing aspects of the 3C model while dealing with issues and challenges, as previously presented, represents a significant challenge in building groupware systems. In this context, there is a need to balance two main trade-offs: informativeness versus privacy: if current status of a person is visible enough to be helpful to others, it often violates that person's privacy [Rocker, 2012]; information versus overloading: the lack of awareness information may compromise group's activities, on the other hand, it is essential to avoid information overload, presenting just relevant information to user Mantau *et al.* [2014].

Second, due to the groupware evaluation spanning more than one temporal dimension, it is complex to obtain data about each view in a single way [Antunes *et al.*, 2012]. Information about an individual is gathered focusing on events occurring in a time frame of a few minutes or even seconds; the group information is gathered addressing activities happening in the range of several minutes and hours; and information regarding organizational impact concerns much longer time frames, usually in the order of days, months, and even years.

Third, research still fails to address conceptual frameworks covering the four trends: theoretical frameworks, context modeling, collaborative design, and awareness [Belkadi *et al.*, 2013]. It remains necessary to establish a theoretical framework for analyzing or modeling cooperative work and specifying requirements of computer-based systems to support collaborative work [Cruz *et al.*, 2012]. A practical, holistic framework can help organizations and other social entities

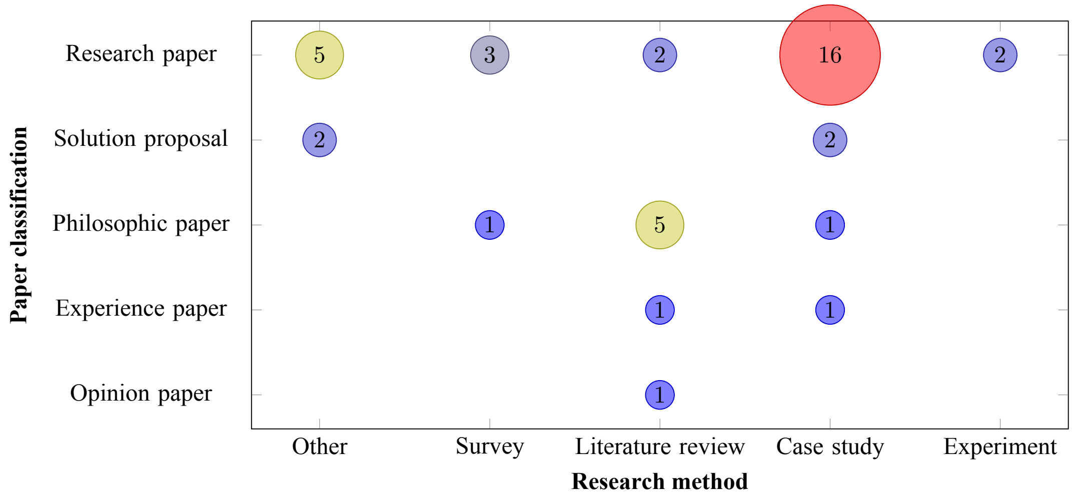


Figure 1. Papers classification and research methods

in their efforts to design, evaluate, and acquire collaboration systems that support their needs [Cruz *et al.*, 2012]. It is challenging to generate adaptation rules automatically, and no frameworks assist designers in incorporating users' feedback semi-automatically [Altenburger *et al.*, 2012]. According to Bravo *et al.* [2023], this problem remains true; it is necessary to fill the gap in methods and tools to guide and facilitate the design and development of the awareness support, and build suitable awareness support for a groupware system according to the users' requirements and tasks.

Fourth, few works present methods or processes that assist in providing aspects of awareness in groupware systems [Collazos *et al.*, 2019], and there are no standardized tests for awareness assessment [Prouzeau *et al.*, 2018]. There is a need to establish measures to assess awareness [Prouzeau *et al.*, 2018], identify the criteria for achieving awareness, and establish indicators [Niemantsverdriet *et al.*, 2019]. Future research in this direction is necessary and will lead to significant advances in designing, developing, and evaluating groupware systems.

4.3 Constraints in awareness support

We have identified several non-functional constraints related to support for awareness and collaboration aspects. These findings were compiled into six categories: awareness, collaboration, interaction, technical, contextual, and design.

4.3.1 Awareness Issues

Awareness support considers awareness obtainment, creation, modeling, labeling, distribution, and manipulation [Talaei-Khoei *et al.*, 2012; Poulovassilis and Xhafa, 2013]. There is a need to represent awareness information to the participants, demanding to consider the types of awareness information needed [Niemantsverdriet *et al.*, 2019], possible mechanisms for its representation [Yang *et al.*, 2018], and different personas (participants' roles and rules) to model shared representations [Belkadi *et al.*, 2013].

The light-weight mechanisms and filtering techniques allow us to exchange valuable and up-to-date information, reducing the overhead of notifications to the user and intrusiveness [Poulovassilis and Xhafa, 2013; Poulovassilis *et al.*, 2015; Mantau *et al.*, 2017; Niemantsverdriet *et al.*, 2019]. Restrictions such as information overload [Mantau *et al.*, 2014], effort load required [Niemantsverdriet *et al.*, 2019], and cognitive load must be transposed [Mantau *et al.*, 2017].

4.3.2 Collaboration issues

Collaboration involves communication, coordination, and cooperation processes. In collaboration process, participants need different interaction modalities [Rocker, 2012; Souza and Barbosa, 2015; Niemantsverdriet *et al.*, 2019] and suitable communication mechanisms [Cruz *et al.*, 2012; De Araújo *et al.*, 2014; Mantau *et al.*, 2017].

The communication process involves implicit (non-verbal), explicit (text, messages, annotations), and secondary or alternative notations [Collazos *et al.*, 2019]. The coordination process involves group management [Xhafa *et al.*, 2013; De Araújo *et al.*, 2014; Mantau *et al.*, 2017] and the use of mechanisms to enable participants to organize themselves into a shared environment [Cruz *et al.*, 2012]. Time, tasks, shared artifacts' management, coordination protocols, and control models are additionally required [Cruz *et al.*, 2012].

The cooperation among participants involves considering group issues like its composition, structure (leadership and hierarchy), and autonomy [Cruz *et al.*, 2012; Teruel *et al.*, 2017], participants' behavior, their background/grounding and attitude towards technology [Cruz *et al.*, 2012; Berkman *et al.*, 2018] and group consistency and standards [Gross, 2013; De Araújo *et al.*, 2014; Mantau *et al.*, 2017].

4.3.3 Interaction issues

Cooperative work involves interaction among participants. This process is complex, and it is necessary to consider some tasks, sociotechnical, and outcome concerns. Performing collaborative tasks involves participants' creativity, intellect, commitment, and decision-making problem-solving competencies [Cruz *et al.*, 2012; Mantau *et al.*, 2017], and the progressive self-evaluation [Souza and Barbosa, 2015]. The tasks' viscosity, visibility, complexity, goals, and physical setting should be considered [Souza and Barbosa, 2015; Teruel *et al*., 2017].

People are different in their social norms, previous experience [Cruz *et al*., 2012] understandings [Niemantsverdriet *et al*., 2019], levels of familiarity [Yuill and Rogers, 2012], and attention level [Gutwin *et al*., 2017]. They have different capabilities in representing, understanding, and projecting human actions through interface [Mantau *et al*., 2017]. Some sociotechnical factors influence the interaction: the participants' motivation and mediation, group vitality, patterns, scripts and techniques, division of labor, and sharing of participants' viewpoints, knowledge, work, tasks, and goals [Cruz *et al*., 2012; Mantau *et al*., 2017].

The outcomes are related to the quality of group performance, expectations and satisfaction with system use, appreciation of group membership, individual breakdowns, individual rewards, organizational results, learning monitoring, interaction degree, and group integration Cruz *et al*. [2012]; Berkman *et al*. [2018].

4.3.4 Technical issues

Hardware and software can help to change the constraints on mechanisms of behavior identified [Yuill and Rogers, 2012]. In a generic view of these technical constraints, it is necessary to incorporate design considerations to different types of applications and contexts [Niemantsverdriet *et al*., 2019] to deal with device and environmental restrictions such as screen dimensions, power limitation, network data use, or communication delays [Mantau *et al*., 2017], to support long periods of disconnection in synchronous environments [Gutwin *et al*., 2017], to provide user mobility, and to avoid system intrusiveness during user actions [Mantau *et al*., 2017].

At the application layer, it is necessary to consider the architecture, functional and quality properties, group processes support, core functionality, supported actions, proper alert mechanisms, intelligent or semi-intelligent software components, actors, tools, and roles involved [Cruz *et al*., 2012].

At the network layer, there are concerns like automatic connection service and device discovery [Herskovic *et al*., 2011; Neyem *et al*., 2012], network limitations [Poulovassilis and Xhafa, 2013; Mantau *et al*., 2017], message exchange (synchronous, asynchronous and pushing) [Herskovic *et al*., 2011; Neyem *et al*., 2012; Cruz *et al*., 2012], dynamic network conditions and multiple nodes for sending information (passive and active mode) [Poulovassilis and Xhafa, 2013; Poulovassilis *et al*., 2015], data synchronization [Xhafa *et al*., 2013], and response time [Mantau *et al*., 2017].

The mobile and tabletop platforms present challenges that must be overcome during the design and construction of groupware systems. In the mobile context, we have mobility, mixed-presence, simultaneous interaction, weak/tightly coupled interaction, and territoriality [Kim *et al*., 2010; Mantau *et al*., 2017]. In tabletop environments, it is necessary to support interpersonal interaction, fluid transitions between activities (personal and group work), the use of physical objects, and transitions between tabletop collaboration and external work. Additionally, it is necessary to provide shared access to physical and digital objects, to establish an appropriate arrangement of users, and to support simultaneous user actions [Jonasson, 2010].

4.3.5 Contextual issues

It consists of information gathering, representation, and dissemination [Talaei-Khoei *et al*., 2012; Rocker, 2012; Mantau *et al*., 2017]; and the peripheral information presentation [Rocker, 2012]. It is hard to represent the contextual/situational factors (rewards, budget, and training), cultural contexts (trust or equity), and group environment (competition, uncertainty, time pressure, and evaluative tone) [Cruz *et al*., 2012].

Data consistency and availability involve data replication, caching, and conflict resolution strategies [Herskovic *et al*., 2011; Neyem *et al*., 2012]. It is necessary to avoid the overload of irrelevant or loosely relevant information and deal with information uncertainty [Collazos *et al*., 2019]. Multiversion data management, fine-grain locking, user-level locking, application-defined transactions, operation semantics-based concurrency control, and notification messages are reported techniques that allow maintaining the level of consistency and availability of the shared data [Rocker, 2012; Mantau *et al*., 2014, 2017].

4.3.6 Design issues

It encompasses general issues such as usability constraints, user protection, information availability, and user mobility and flexibility. The usability constraints are related to the aspects of the visibility of system status, aesthetic and minimalist design, ease of input, viewing and screen reading, aesthetic, social and private conventions, tailoring, recognition, attention level, and transition among activities [De Araújo *et al*., 2014; Souza and Barbosa, 2015; Mantau *et al*., 2017].

Users' protection is related to the error management [De Araújo *et al*., 2014; Souza and Barbosa, 2015; Mantau *et al*., 2017; Niemantsverdriet *et al*., 2019], avoid intrusiveness [Mantau *et al*., 2017], user control [Rocker, 2012; Niemantsverdriet *et al*., 2019], user security and privacy [Herskovic *et al*., 2011; Neyem *et al*., 2012; Mantau *et al*., 2017; Niemantsverdriet *et al*., 2019], authorization and access rules [Kim *et al*., 2010; Cruz *et al*., 2012; Poulovassilis and Xhafa, 2013; Prouzeau *et al*., 2018], rules management (constraints, norms or work rules) [Kim *et al*., 2010; Cruz *et al*., 2012; Teruel *et al*., 2017], rules-based collaboration [Kim *et al*., 2010], context-dependent privacy profiles [Rocker, 2012], and ad-hoc work session [Herskovic *et al*., 2011].

Information availability refers to the data availability, their abstraction (sensor data, natural, multimedia) [Hincapie-Ramos *et al*., 2011; Souza and Barbosa, 2015; Niemantsverdriet *et al*., 2019], presentation (continuous, discrete or literal), delivery (always on, almost always on, on request or implicit interaction), symmetry (symmetric traceable, symmetric blind, asymmetric traceable or asymmetric blind), obtrusiveness (focal, selective focal, secondary appliance or peripheral) and temporal gradient (current, recent, historical or predicted availability) [Hincapie-Ramos *et al*., 2011].

User mobility requires considerations about device heterogeneity [Herskovic *et al*., 2011; Neyem *et al*., 2012; Mantau *et al.*, 2017], operational and technological interoperability [Xhafa *et al.*, 2013], and efficiency in resource usage [Mantau *et al.*, 2014]. The flexibility includes automatic user detection, connection, and disconnection support [Herskovic *et al.*, 2011; Mantau *et al.*, 2017; Niemantsverdriet *et al.*, 2019].

5 The assessment model

The Awareness Assessment Model is explicitly developed for evaluating collaborative systems. It measures their quality by analyzing the awareness information provided by the application. At least one examiner conducts the assessment. Considering the participants' perception as a data source, this instrument enables us to classify the collaborative environment according to its awareness quality level. The assessment quality scales have been developed adopting the Item Response Theory (IRT) statistical technique [Baker and Kim, 2017][1]. The model comprises the *Awareness Assessment Process* and *Conceptual View* (see Figure 2).

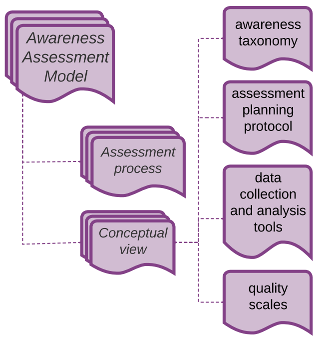


Figure 2. Awareness Assessment Model overview

5.1 The Awareness Assessment Process

The *Awareness Assessment Process* is based on a set of HCI guidelines [Barbosa and Silva, 2010; Rogers *et al.*, 2013] and is inspired by the evaluation process defined by the standard ISO/IEC 25.040 [2011]. The assessment process comprises three phases: *planning*, *execution*, and *reflection* (see Figure 3).

Phase 1 - Planning. It refers to activities related to assessment planning and involves three basic steps: determine the assessment objectives, the assessment scope, and the planning of the assessment. First, the examiner determines the assessment objectives. This is the starting point for building the evaluation approach and aims to select three essential activities: assessment objectives, context, and goals.

- *Activity 1.1. Define the assessment objectives.* This step defines the evaluation goal in terms of the object of study, purpose, perspective, and context [BASILI, 1992]: the purpose defines the intention of the evaluation; the perspective tells the viewpoint from which the evaluation results are interpreted (e.g., users or experts); and the context is the environment in which the evaluation is performed.
- *Activity 1.2. Select the awareness dimensions.* Identify the related awareness dimensions that will be considered in the assessment. The comprehensive assessment model comprises three primary awareness perspectives, enabling us to evaluate the collaborative environment from each perspective.
- *Activity 1.3. Select the goals to be measured.* For each awareness dimension considered, select which design categories are relevant in the collaborative environment. These design categories represent the specific awareness assessment goals, thereby allowing the model to address the relevant aspects of the application with flexibility.

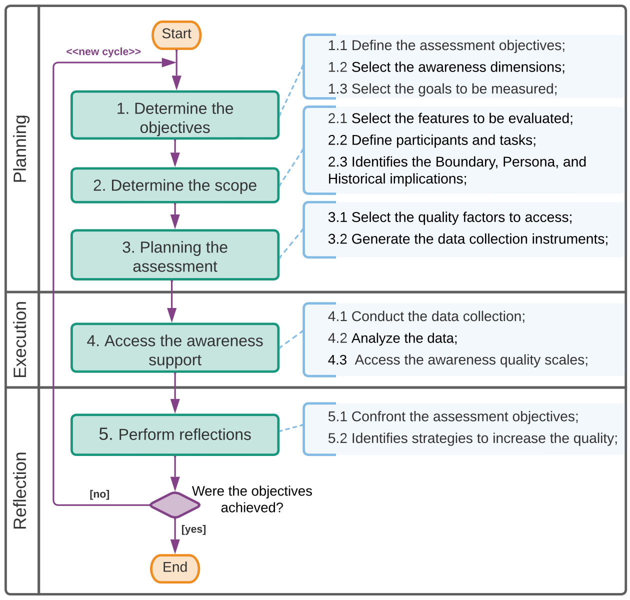


Figure 3. Awareness Assessment Process

Second, the examiner determines the scope. This phase represents the detailing of the context in which the evaluation will be carried out, the features of the environment that will be considered, the participants, their respective tasks, and finally, whether the boundary, persona, and historical implications will be considered:

- *Activity 2.1. Select the features to be evaluated.* Select the features or tasks of the collaborative environment to access. In some cases, the target environment can be complex, making it difficult to assess thoroughly, and some parts/features may not be relevant to the intervention. This activity allows building an assessment instrument focused on the relevant/exciting aspects.
- *Activity 2.2. Define participants and tasks.* Identify the participants involved in the evaluation process and the tasks that must be carried out within the collaborative environment. This evaluation instrument was designed to enable evaluation by specialists, involving users, or both. Thus, it is essential to clarify who is involved and what their roles and tasks are within the environment.

[1]The IRT refers to a family of mathematical models that relate observable variables (e.g., questionnaire items) and hypothetical unobservable traits or aptitudes (e.g., awareness quality). Thus, a stimulus (item) is presented to the subject, and he responds to it, and the response that the subject gives to the item depends on the subject's level in the latent trait or ability [Pasquali, 2020].
The IRT model is built by executing scripts in R source using the MIRT package (a multidimensional Item Response Theory package for the R environment) [Chalmers, 2012].

- *Activity 2.3. Identifies the Boundary, Persona, and Historical implications.* The awareness information can be categorized into the perspectives of Boundary, Persona, and Historical Awareness.

Third, the examiner determines the planning assessment. This phase represents the planning stage documentation, where it is established at what moment of the construction or use of the collaborative environment the evaluation will be carried out, and which quality factors will be considered. Therefore, the data collection instrument is prepared, including the assessment purpose, methods, life cycle, and artifacts:

- *Activity 3.1. Select the quality factors to assess.* The quality aspects define the additional quality factors under analysis in the evaluation, that is, to use this model together with another evaluation approach (e.g., usability, demographic, user experience).
- *Activity 3.2. Generate the data collection instrument.* This activity aims to prepare or customize the data collection instrument, considering the results of activities 1.2, 1.3, and 2.3.

Phase 2 - Execution. After the planning stage, the collaborative system assessment is done by adopting data collection and analysis instruments. In this phase, the examiner performs the awareness assessment of the target collaborative environment. The awareness support provided by the target environment is achieved through the use of data collection and analysis tools.

Phase 3 - Reflection. Once the evaluation is completed and the data is analyzed, the evaluator conducts reflections to gather feedback and identify strategies for improving awareness quality. The main objectives are confronted, and the awareness of quality factors is checked. If unmet, the examiner determines strategies to increase the quality of awareness mechanisms, and a new intervention can be planned. This process enables both the assessment of collaborative environments through awareness mechanisms and the improvement by prompting reflection on results.

5.2 The Conceptual View

The *Conceptual View* is a framework composed of the following artifacts [2]:

i) The awareness taxonomy is constituted of three main awareness dimensions, their respective design categories, and respective design elements, combined with three additional dimensions that directly imply the design categories and awareness elements: persona, boundary, and historical awareness dimensions (full reference can be found at Mantau and Benitti [2022b]);
ii) The assessment planning protocol represents an instrument for planning and executing the assessment process. This artifact helps in defining the assessment objectives, factors to be measured, awareness dimensions, life-cycle phases in which the awareness assessment will be applied, and so on [Mantau and Benitti, 2024];
iii) The data collection and analysis tools present a set of support artifacts for conducting the collection and compilation of data obtained by interventions [Mantau and Benitti, 2023b];
iv) The assessment scales and measurement items represent useful elements for analyzing and classifying the collaborative environment at an awareness quality level from the participants' perspective [Mantau and Benitti, 2023b, 2024].

[2]A full reference of *Conceptual View* artifacts can be found at our Awareness Assessment Model repository [Mantau and Benitti, 2023b].

5.3 Assessment Planning Protocol

The planning protocol is a form that facilitates the planning of the evaluation. It consists of three main components: determining the intervention's objectives, scope, and life cycle. The planning protocol template example presented in Table 1 details the procedures performed in the planning stage of our assessment process.

6 Process Validation

Notably, representative results are expected from a good evaluation model or process. Conversely, hard-to-use models or processes obscure the reliability between the obtained result and the observed object. We believe that the success of a good evaluation is related to the rigor of the model (i.e., artifacts, questionnaires, analysis spreadsheets, and synthesis available) and the evaluation process conducted; thus, both must be assessed for their reliability and usefulness.

According to Nickerson *et al.* [2013]; Szopinski *et al.* [2019], usefulness is related to the purposeful, unambiguous, and applicable aspects (see Figure 4).

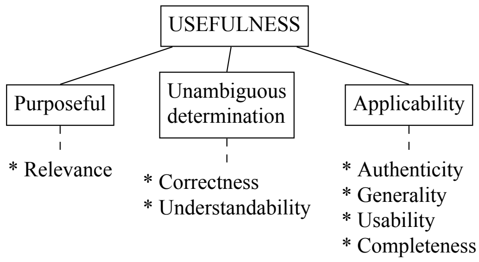


Figure 4. Usefulness evaluation criteria

Purposeful is the significance and objectivity of the model and its elements [Strasser, 2017], and it is related to the model's relevance. Relevance is achieved when all statements in the representation are relevant to the problem [Rittgen, 2010].

Unambiguous determination is the ability to represent the elements and characteristics in a clear, concise, and unambiguous way [Strasser, 2017], and it is related to the model correctness and understandability.

An artifact meets correctness when all statements in the representation are correct [Rittgen, 2010]; understandability when the reference model's purpose, concepts, and structure are clear to the users [MATOOK and INDULSKA, 2009].

Applicability seeks to assess its practical purpose and usefulness for classifying, differentiating, and comparing objects

Table 1. Planning protocol template

1. Determine the objectives	**Step 1.1** – Define the assessment objectives in terms of the object of study, purpose, perspective, and context. → *Object of study:* [...] → *Purpose:* [...] → *Perspective:* [...] → *Context:* [...] **Step 1.2** – Select the awareness dimensions. Identify the related awareness dimensions that will be considered in the assessment. → *Awareness dimensions:* [...] **Step 1.3** – Select the goals to be measured. We select which design categories are relevant in the collaborative environment for each awareness dimension. → *Goals:* [...]
2. Determine the scope	**Step 2.1** – Select the features to evaluate. Select the functionalities or tasks within the collaborative environment that will be the object of the assessment. → *Features:* [...] **Step 2.2** – Define the participants involved and the tasks that must be carried out within the collaborative environment. → *Participants:* [...] → *Tasks description:* [...] **Step 2.3** – Identifies the Boundary (physical, virtual, or both), Persona (individual, other participants, group as a whole, or system), and Historical (past, present, future) implications. → *Implications:* [...]
3. Planning the intervention	**Step 3.1** – Select the additional factors to assess (like demographic, usability, and UX). → *Additional factors:* [...] **Step 3.2** – Generate the data collection instrument based on activities 1.2, 1.3, and 2.3.

[Strasser, 2017], and it is related to the model's authenticity, generality, usability, and completeness.

Authenticity evaluates if the representation gives an accurate account of the domain [Rittgen, 2010]; generality indicates if the reference model is usable in different cases [MATOOK and INDULSKA, 2009]; usability consists of identifying if users can efficiently operate, implement, and apply the reference model [MATOOK and INDULSKA, 2009]; and completeness check if all the components of the reference model are present under a predefined scope [MATOOK and INDULSKA, 2009] and the representation contains all statements about the domain that are correct and relevant [Rittgen, 2010].

The validation of the proposed model was carried out in two stages. First, to improve the proposed assessment model, we expose the model's artifacts to expert appreciation through the expert panel approach [Beecham *et al*., 2005]. In this scenario, we aim to expose our taxonomy and assessment model artifacts to expert scrutiny to collect accurate criteria and assess the model content validity.

The expert panel comprises a multidisciplinary group of senior researchers with backgrounds in computing or statistics. The review analyzes the usefulness aspects, namely, clarity, relevance, consistency, and completeness of the measurement instrument items. The results of this step are presented in Chapter 7.

After this refinement, we started planning and executing a case study [Wohlin *et al*., 2012; Yin, 2009] through a large-scale evaluation of our assessment model. This approach assesses the reliability and validity of the proposed model.

7 Expert panel

When a new evaluation model emerges, the first concern is to verify whether the model enables measurement of the target; in our case, the latent trait of awareness support. In other words, we need to validate whether the assessment instrument (especially its items) is applicable or representative of different situations [Richardson, 2017]. This analysis can be done by adopting the expert panel technique [Beecham *et al*., 2005].

Experts discuss the issue and provide recommendations; this approach aims to gather expert viewpoints to inform decisions on recommendations or courses of action concerning a particular issue or proposal. According to Hakim [1987], small samples can be used to develop and test explanations and to gain expert feedback to evaluate and support model development. Some previous works describe the use of small samples of experts to gain input for assessing and supporting model development, including software quality evaluation [Rosqvist, 2003], preventing requirements defects [Lauesen and Vinter, 2001], software process improvements [Dyba, 2000], and software requirements analysis [El Emam and Birk, 2000].

To improve the assessment model, we expose the model artifacts to the appreciation of HCI and collaborative systems experts using the expert panel approach [Beecham *et al*., 2005]. In this scenario, we aim to expose our taxonomy and assessment model artifacts to the scrutiny of experts to collect accurate criteria and content validity for the model.

The expert panel validation enables us to determine whether a purposeful and unambiguous definition is possible by evaluating the practical applicability and demonstrating whether a clear definition of its elements can be established [Strasser, 2017]. This approach also allows reflecting on the current state of research on an object [Khalilijafarabad *et al*., 2016], discovering similarities and differences between studies on this type of object [Agogo and Hess, 2018], and identifying potential research gaps [Hummel *et al*., 2016].

Based on the Goal-Question-Metric approach [BASILI, 1992; Van Solingen and Berghout, 1999], we designed an evaluation questionnaire by decomposing the study objective into quality aspects and analysis questions. The expert evaluation questionnaire contains three demographic questions and ten assessment items related to the usefulness concept. In this step, we expose our assessment model to expert evaluation, including awareness, collaborative systems, and HCI researchers, to assess its suitability for evaluating collaborative environments.

7.1 Expert panel results

We targeted experts from different backgrounds and audience groups, as recommended by Lauesen and Vinter [2001]; Kitchenham *et al*. [2002]. We consider an expert in this study to be a researcher who has published widely in recognized journals in CSCW and HCI fields and has practical experience in evaluating collaborative environments and awareness.

We mailed 28 experts an invitation to validate assessment model artifacts, and five experts accepted (representing a take-up rate of 18%). The experts were primarily selected based on publications related to our systematic mapping and the researcher's contact list. As we cannot confirm the reason for the non-participation of the 23 invited experts, there is a likelihood of bias.

Although the small sample of specialists all reported having a good experience regarding awareness, collaboration, and HCI concepts, this corroborates the quality of the responses. On a gradual scale, from 1 (novice) to 5 (expert), the reported expertise was close to 5 (average 4.1). Overall, the evaluation model received a good rating from the expert's perspective. On a gradual scale, from 1 (strongly disagree) to 5 (strongly agree), the assessment items M1 to M7 received values over 3.5 (average 3.8). Figure 5 summarizes the obtained results.

The results obtained were positive in all facets of usefulness assessment. From a purposeful perspective, experts recognized the relevance and confirmed an adequate representation of the problem. From the unambiguous determination perspective, the results evidence the correctness of the assessment statements. Finally, from the applicability perspective, the feedback pointed out that the representation provides an adequate account of the domain and that the assessment model artifacts can be usable in different cases, corroborating the authenticity and generality properties.

In the applicability perspective, a central concern was related to the model's usability. Due to the natural complexity of evaluating awareness support, approaches from this perspective can be somewhat complex, and the model must abstract this complexity from the examiner as much as possible. On the other hand, from the point of view of the assessment items' usability, the majority agreed that target examiners could efficiently operate, implement, and apply the reference model; still, prior knowledge of the process and awareness support are recommended.

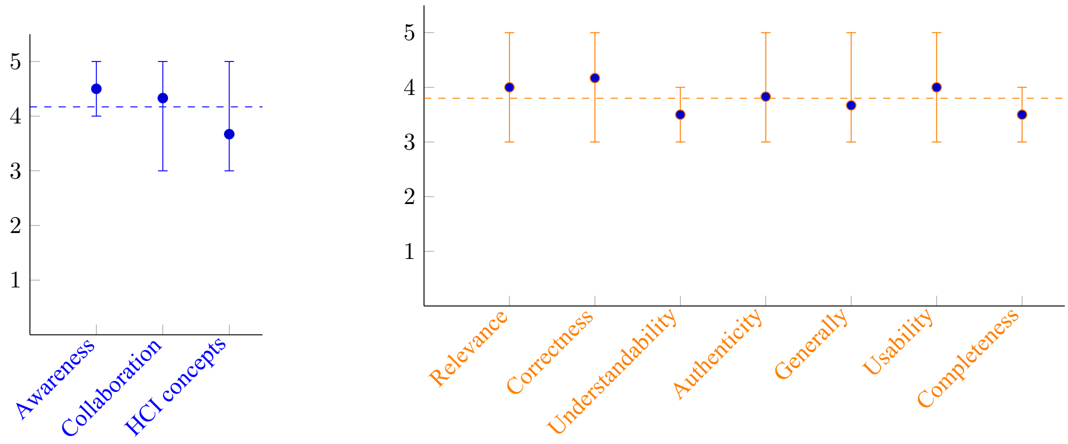
From the aspects of understandability and completeness, the received feedback demonstrates a concern regarding the clarity of the specification and whether the model encompasses all statements about the domain or can be applied to the same environment. We thought that, depending on the domain of the collaborative system, not all aspects would be used – and this will not necessarily be a weak point of the model. For example, the awareness information may differ depending on whether a system focuses on performing synchronous or asynchronous work. In some cases, the awareness mechanisms require balancing the need to present proper awareness support while dealing with information overload or intrusiveness.

We considered the feedback obtained through the expert panel to refine the assessment instrument. At this stage, we also improved the syntax of the assessment items by standardizing the assessment statements.

8 Case study

This scenario included 25 examiners (19 males and six females) divided into seven assessment groups. The sample comprises undergraduate computing students with a basic notion of HCI, software quality, and software process concepts. It took three meetings (2 hours each) to complete the evaluation activities. Finally, participants were invited to respond to the usefulness assessment questionnaire – similar to that used in the expert panel [Mantau and Benitti, 2023a]. All artifacts of this case study, including data collection and analysis instruments, are available in the Zenodo repository [Mantau and Benitti, 2023b].

The group configuration was as follows: Groups 1 and 2 evaluated the Google Sheets environment, collecting 50 and 36 observations, respectively; Groups 2 to 6 evaluated the Google Docs environment, totaling 42, 49, 45, and 12 observations, respectively; and Group 7 evaluated the Trello environment, collecting 15 observations. In total, 249 observations (157 males, 90 females, and two did not respond) were collected. All artifacts, including the Awareness Assessment Model templates, the artifacts generated from each team, and the demographic and utility questionnaire collected, are available in the model repository [Mantau and Benitti, 2023b].



(a) Demographic **(b)** Usefulness

Figure 5. Expert panel results

8.1 Case study results

We presented the demographic and usefulness questionnaire to the participants, and 19 responses were obtained (76%). Six examiners did not answer the questionnaire. Although a small sample was obtained, the assessment model received a good rating from the examiners' viewpoint. Figure 6 summarizes the results in three basic facets: demographic, usefulness, and assessment artifacts.

On the demographic facet (Figure 6a), the examiners have varying levels of awareness, collaboration, HCI, software processes, and software evaluation. On a scale of 1 (novice) to 4 (expert), the average reported expertise in these related concepts was 2.67, indicating a reasonable familiarity with this context. Awareness, software process, and software evaluation concepts were the least familiar aspects to the examiners (respectively, average 2.11, 2.63, and 2.42). Due to the examiners' sample variability, experience with key concepts ranged across the spectrum of the gradual scale.

Although the sample size was small, the model provided insight into the different skill levels. Furthermore, we observed that most of the difficulties in applying the model are related to the participants' skills in awareness concepts and statistical processes. Some participants reported not having in-depth knowledge about the evaluated tools; thus, planning the assessment (assessment protocol artifact) took a considerable amount of time, compromising their ability to focus on other activities, such as data collection and analysis.

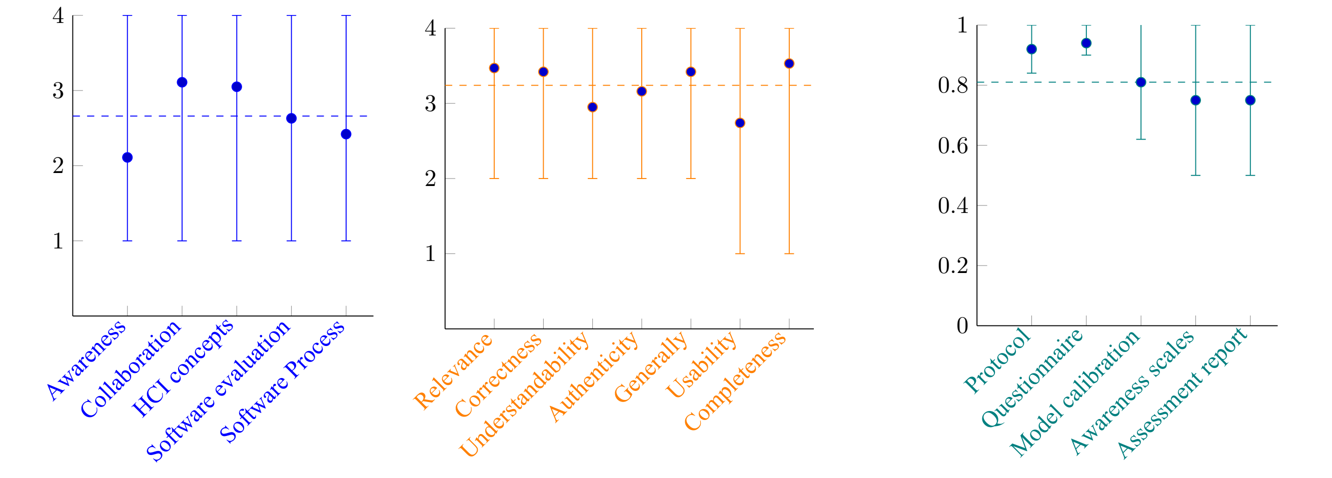
On the usefulness facet (Figure 6b), the examiners indicated a good evaluation of both the model (including artifacts, questionnaires, analysis spreadsheets, and synthesis) and the evaluation process conducted. On a scale of 1 (strongly disagree) to 4 (strongly agree), the average usefulness reported was 3.24. The relevance, correctness, generality, and completeness aspects were evaluated as significant (close to 3.5). Comprehensibility and authenticity received an average rating of nearly 3 (agree). Usability presented the lowest value in the usefulness assessment, with a score of 2.74.

The usefulness assessment results show that the purposeful perspective, captured by relevance, can be satisfactorily met, even for examiners unfamiliar with the related key concepts. Likewise, from the unambiguous determination point of view, represented by the correctness and comprehensibility elements, the evaluated model also presented good results. The model presents considerable clarity and consistency in its artifacts and assessment activities, which can be applied without significant difficulties by examiners, even those unfamiliar with the approach.

The model's applicability perspective, which considers authenticity, generality, usability, and completeness, presented an interesting result. All items were evaluated thoroughly, demonstrating that the model provides a valid domain account and indicates whether the reference model is usable in various evaluation scenarios. Regarding usability, examiners generally showed that they could efficiently operate, implement, and apply the reference model, despite being supervised throughout the process. Regarding completeness, examiners indicated that the representation contains all correct and relevant statements about the domain. Only one respondent strongly disagreed with the model's usability and completeness.

We also evaluated the artifacts constructed by each group of examiners to verify their elaboration and identify potential difficulties. Materials like model artifacts, raw data, spreadsheets, results, and other necessary auxiliary files were analyzed. We then assign a score from 0 (none) to 1 (excellent) for the quality of the generated material. Figure 6c) summarizes the results. We identified five primary artifacts generated: the assessment protocol, questionnaire (data collection instrument), IRT model calibration, definition of awareness scales, and assessment report. Overall, the groups produced artifacts of considerable quality, achieving an overall average score of 0.81.

The calibration of the model, construction of awareness scales, and assessment report, on the other hand, presented varied results. Although all presented an acceptable average general quality (above 0.75), some groups presented difficulties during preparation. A key point of emphasis is that, due to the limited sample size each group obtained (ranging from 15 to 75 observations), the calibration and subsequent steps were hindered. Furthermore, the knowledge of the group of examiners related to the key concepts necessary to conduct the assessment was varied (see Figure 6a).



(a) Demographic **(b)** Usefulness **(c)** Artifacts

Figure 6. Assessment process validation results

8.2 Discussion

The groups present minor difficulties regarding: *a)* unfamiliarity with the IRT and HCI assessment; *b)* model complexity, *c)* statistical analysis (novices); *d)* short time available to assimilate the resources of the target tool, select the categories and awareness mechanisms, and construct the data collection instrument (questionnaire) based on the chosen mechanisms.

In the cases (*a*) and (*c*), it is imperative to highlight that for a proper HCI assessment, the examiner's prior knowledge of the tool and the processes adopted, and the evaluation itself is crucial. This applies to IRT concepts and basic statistical knowledge. Therefore, we relaxed the analysis of this aspect since our interest in this evaluation involved the assessment model replication in other scenarios, contexts, and examiners – even those with little knowledge of the analyzed facets (like context, target tool, or awareness, collaboration and HCI concepts) (see Figure 6a).

The awareness assessment model was designed to encapsulate part of the natural complexity of IRT and statistical analysis, presenting some analysis and assessment scale templates alongside the model. However, it may be challenging to apply this model to examiners as their first contact with a statistically based HCI assessment model (*b*). At this point, the analysis of the model's complexity has been hampered, and broader scenarios can be considered. Similarly, appropriating awareness concepts and assessment elements was necessary in the second case (*d)*. Examiners with more favorable knowledge about awareness and collaboration concepts obtained the best results at this stage due to the short time available. As examiners explored the context, target tool, and assessment process, they quickly identified and selected the design categories and awareness mechanisms and constructed the data collection instruments (*c*); both artifacts presented an excellent overall average quality (above 0.9).

9 Conclusion

Awareness is an individual understanding, a mental state, about a certain object or environmental stimulus, and involves, from the participant's viewpoint, the representation and understanding/consciousness process. Furthermore, the awareness process depends on the participant's skills, whether in identifying, understanding, or projecting their actions; different individuals may have varying levels of awareness, and the participant's understanding also changes over time.

We enhance the Awareness Assessment Model [Mantau and Benitti, 2023a] by developing an awareness assessment process that enables access to awareness and collaboration support by measuring awareness mechanisms from the participant's viewpoint. Then, we expose the model's artifacts to HCI and collaborative system examiners to gauge their appreciation and verify the suitability of the process based on reliability and usefulness criteria.

The case study demonstrated that the assessment process can be replicated fully or partially in other scenarios and contexts by selecting the relevant dimensions, categories, and awareness mechanisms, and then adapting them. Due to the small sample size and examiners' limited knowledge of key concepts, new assessment scenarios may be necessary to verify the required or recommended knowledge for examiners to replicate the model accurately.

Declarations

Authors' Contributions

MJM and FBVB contributed to the conception of this study. MJM performed the experiments. MJM is the main contributor and writer of this manuscript. All authors read and approved the final manuscript.

Competing interests

The authors declare that they have no competing interests.

Availability of data and materials

A complete reference of *Conceptual View* artifacts can be found at our Awareness Assessment Model repository [Mantau and Benitti, 2023b].

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