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 projected to a specific context and do not focus on evaluating these mechanisms or the provided support from the user's point of view. 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 evolve the findings presented by (MANTAU; BENITTI, 2023a), providing contributions towards developing an awareness assessment process that allows accessing the awareness and, consequently, the collaboration support through measuring awareness mechanisms from the participant's viewpoint. Then, we expose the model's artifacts to HCI and collaborative system examiners' appreciation to verify the suitability of the process by reliability and usefulness criteria.*

1. Introduction

Collaborative systems allow group members to communicate clearly with each other, coordinate their work, and cooperate. 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; BELLOTTI, 1992).

Awareness has been a significant concept in Collaborative Systems (TENENBERG; ROTH; SOCHA, 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; BECK; PAHLKE, 2011; ANTUNES et al., 2014; GALLARDO; BRAVO; MOLINA, 2018; MANTAU; BERKENBROCK; BERKENBROCK, 2017) present a broader list of awareness types. Detailed background on the origins of awareness, early ethnographic and technology studies that brought about the fundamental insights we found in (GROSS, 2013)[1].

[1]Over the last three decades, different awareness types have emerged in the literature. The works (SEEBACH; BECK; PAHLKE, 2011; ANTUNES et al., 2014; MANTAU; BERKENBROCK; BERKENBROCK, 2017) present a broader list of awareness types; (LOPEZ; GUERRERO, 2017) presents 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 better 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; GREENBERG; ROSEMAN, 1996; GUTWIN; GREENBERG, 2002; KIRSCH-PINHEIRO; LIMA; BORGES, 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; GREENBERG; ROSEMAN, 1996).

At the understanding level, we consider awareness as an understanding of other peoples' activities that provides a context for their own (DOURISH, 2004); this is a set of processes in which we recognize, organize, and find meaning for the stimuli we receive from the environment (STERNBERG; STERNBERG; MIO, 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 its experience and knowledge, the individual forms an understanding/consciousness of the situation and how he fits into this context. Finally, understanding/consciousness allows individuals to project their future actions and ensures 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 problem

Awareness is a well-known concept that has still not been fully reached in collaborative environments. According to (GROSS, 2013), this concept remains difficult to grasp, and future research should achieve a better understanding of supporting and effortless coordination by conceiving and testing novel technology that guarantees awareness aspects. Furthermore, since the 1980s, there has been no consensus on the awareness issue and how to understand it (SCHMIDT; 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 interface (MANTAU; BERKENBROCK; BERKENBROCK, 2017). Sociotechnical factors such as participants' motivation, knowledge, and goals influence interaction (CRUZ et al., 2012; MANTAU; BERKENBROCK; BERKENBROCK, 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; 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 point of view (COLLAZOS et al., 2019). Most of these studies consider just a specific kind of awareness in their approaches (PROUZEAU; BEZERIANOS; CHAPUIS, 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 evolve the findings presented by (MANTAU; BENITTI, 2023a), providing contributions towards developing an awareness assessment process that allows accessing the awareness and, consequently, the collaboration support through 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. Methodology

This work was carried out in two main stages. First, based on a systematic mapping of the literature[2], 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?*

[2]A detailed overview of the systematic mapping results can be accessed at (MANTAU; BENITTI, 2022a).

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' appreciation to verify the process's suitability by 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, researcher observations and questionnaires assessed the usefulness of the model's conceptual view artifacts and evaluation process. Before starting the case study, participants were invited to a briefing in which the evaluation model and their 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, printed and online), and a report model of the assessment results were exposed to all examiners 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; BENITTI, 2023a). Examiners were accompanied during the artifact preparation and assessment process activities.

3. The evaluation problem

Different strategies emerged seeking to help support awareness mechanisms in collaborative applications; still, most are projected to a specific context and do not focus on evaluating these mechanisms or the support provided from the user's perspective. For example, (GALLARDO; BRAVO; MOLINA, 2018) presented a framework for the descriptive specification of awareness support. They focused on multimodal user interfaces for collaborative activities, and a tool to help engineering implement the awareness in collaborative applications was provided; however, few clues toward evaluating these mechanisms have been presented. In recent efforts, (BRAVO et al., 2023) evolved this specification technique approach into a visual modeling language, and a software specification technique was found; however, how participants acquire and evaluate these elements remains open.

As presented by (SANTOS; FERREIRA; PRATES, 2012), many 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 consolidated and allow, with some adaptations, to include the collaborative part of the systems (SANTOS; FERREIRA; PRATES, 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; CHAVES; GEROSA, 2013; LOPEZ; GUERRERO, 2017) investigated challenges related to providing awareness support during collaboration. Both papers highlight the lack of consolidated awareness assessment methods

that allow collaborative applications to be assessed precisely 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).

3.1. Research methods and techniques [RQ1]

The main 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.

Regarding instruments and materials, data were collected using questionnaires, interviews, brainstorming, focus groups, conceptual modeling, direct observation, system logs, and static/dynamic analysis of a 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; KARAHOCA; KARAHOCA, 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; BERKENBROCK; BERKENBROCK, 2014), and system logs (MANTAU; BERKENBROCK; BERKENBROCK, 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; BEZERIANOS; CHAPUIS, 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; BERKENBROCK; BERKENBROCK, 2017); usability groupware heuristics for mobile environments (ARAÚJO et al., 2014); and frameworks or taxonomies (SOUZA; BARBOSA, 2015; GALLARDO et al., 2011; COLLAZOS et al., 2019; NIEMANTSVERDRIET et al., 2019).

3.2. 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 3C model aspects while dealing with issues and challenges, as previously presented, represents a grand 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; BERKENBROCK; BERKENBROCK, 2014).

Second, due to the groupware evaluation being in more than one temporal dimension, it is complex to obtain data about each view in just one 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 may conduct organizations and other social entities in their effort to design, evaluate, and acquire collaboration systems that can support their needs (CRUZ et al., 2012). It is hard to generate adaptation rules automatically, and no frameworks help designers to incorporate semi-automatically users' feedback (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; BEZERIANOS; CHAPUIS, 2018). There is a need to establish measures to assess awareness (PROUZEAU; BEZERIANOS; CHAPUIS, 2018), identify the criteria for achieving awareness, and establish indicators (NIEMANTSVERDRIET et al., 2019). Future research in this direction is necessary and will bring significant advances towards designing, developing, and evaluating groupware systems.

4. 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 allows us to classify the collaborative environment into the awareness quality level. The assessment quality scales have been developed adopting the Item Response Theory (IRT) statistical technique (BAKER; KIM, 2017)[3]. The model comprises the *Conceptual View* and the *Awareness Assessment Process*.

[3]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).

4.1. The Conceptual View

The *Conceptual View* is a framework composed of the following artifacts [4]:

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; 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; 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; BENITTI, 2023b);
iv) The assessment scales and measurement items represent useful elements to analyze and classify the collaborative environment at an awareness quality level through the participants' perspective (MANTAU; BENITTI, 2023b, 2024).

4.2. The Awareness Assessment Process

The *Awareness Assessment Process* is based on a set of HCI guidelines (BARBOSA; SILVA, 2010; ROGERS; SHARP; PREECE, 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 1).

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 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 complete assessment model consists of three primary awareness perspectives and allows us to assess 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, thus allowing the flexibility of the model to address the relevant aspects of the application.

[4] A full reference of *Conceptual View* artifacts can be found at our Awareness Assessment Model repository (MANTAU; BENITTI, 2023b).

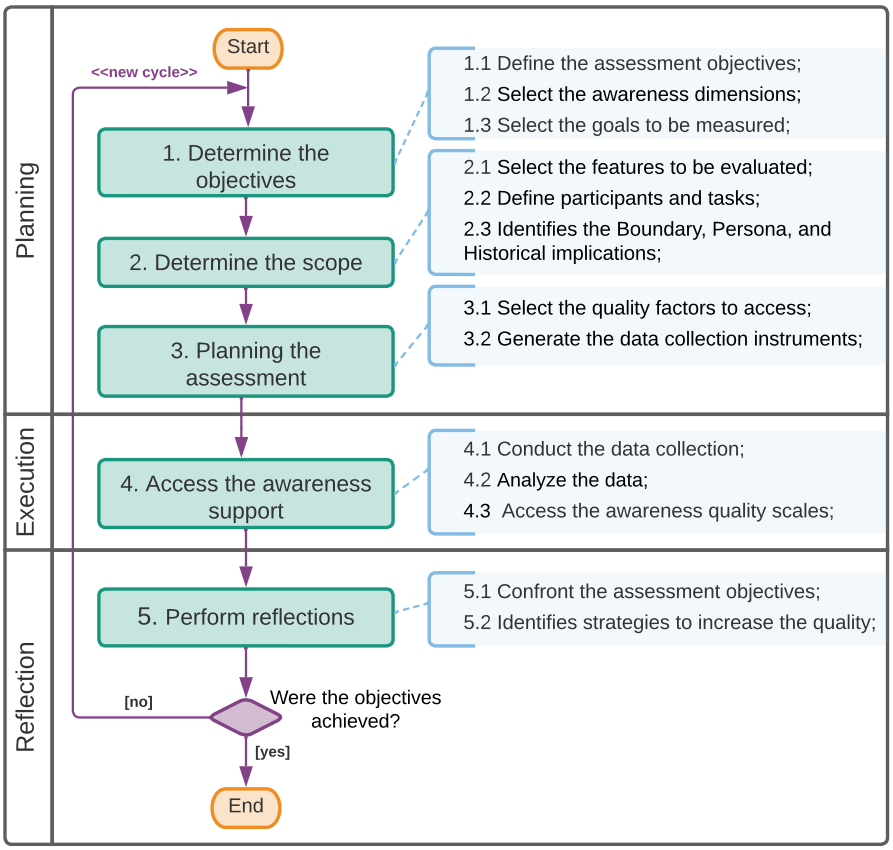


Figura 1. Awareness Assessment Process

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, thus making it difficult to assess it thoroughly, and some parts/features are not interesting for 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 even both. Thus, it is vital to clarify who is involved and what their tasks are in the environment.
- *Activity 2.3. Identifies the Boundary, Persona, and Historical implications.* The awareness information can be categorized in 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 access.* 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 raised in 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 reached through the 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 awareness mechanisms quality indicators, 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. Assessment 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 (e.g., artifacts, questionnaires, analysis spreadsheets, and synthesis available) and the evaluation process conducted; thus, both must be accessed for their reliability and usefulness.

According to (NICKERSON; VARSHNEY; MUNTERMANN, 2013; SZOPINSKI; SCHOORMANN; KUNDISCH, 2019), usefulness is related to the purposeful, unambiguous determination and applicability aspects. In this scenario, purposeful is the relevance of the assessment process (significance and objectivity of its elements/activities); unambiguous determination is the process's correctness and understandability (ability to represent its elements and activities concisely and unambiguously); and applicability refers to the process's authenticity, generality, usability, and concreteness attributes.

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; BENITTI, 2023a). All artifacts of this case study, including data collection and analysis instruments, are available in the Zenodo repository (MANTAU; BENITTI, 2023b).

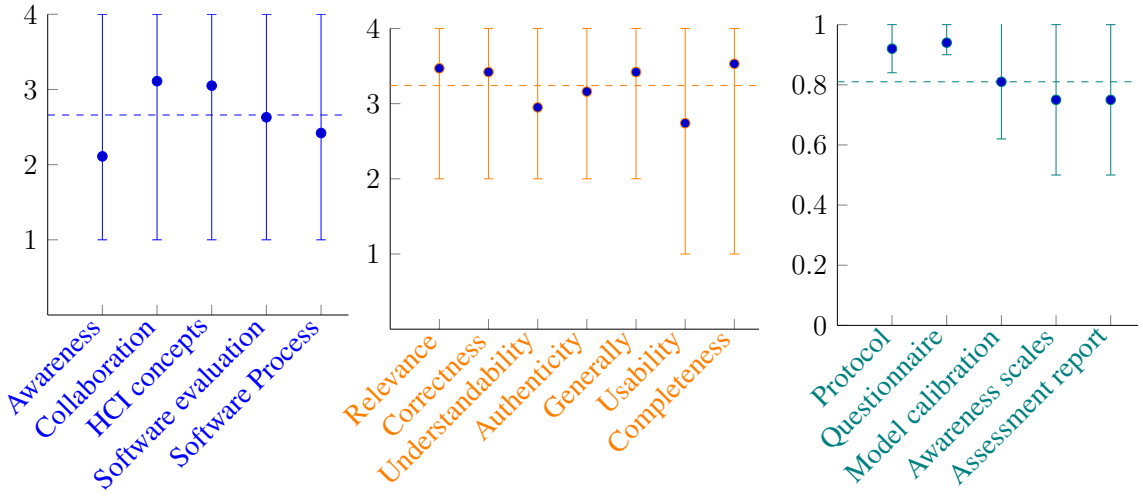
The group configuration was as follows: Groups 1 and 2 evaluated the Google Sheets environment, collecting 50 and 36 observations, respectively; Groups 2 to 6 evaluated the Google Docs environment, totaling 42, 49, 45, and 12 observations, respectively; and Group 7 evaluated the Trello environment, collecting 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; BENITTI, 2023b).

5.1. 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 2 summarizes the results in three basic facets: demographic, usefulness, and assessment artifacts.

On the demographic facet (Figure 2a), the examiners have a varied knowledge of awareness, collaboration, HCI, software process, and software evaluation. On a gradual scale, from 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 a small sample, the model's insight into the different skill levels was found. Furthermore, we observed that most of the difficulties in applying the model are related to the participant's skills in awareness concepts and statistical processes. Some reported not having in-depth knowledge about the evaluated tools; thus, planning the assessment (assessment protocol artifact) took a while, compromising time for other activities, such as data collection and analysis.



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

Figura 2. Assessment process validation results

On the usefulness facet (Figure 2b), the examiners indicated a good evaluation of both the model (artifacts, questionnaires, analysis spreadsheets, and synthesis available) and the evaluation process conducted. On a gradual scale, from 1 (strongly disagree) to 4 (strongly agree), the average usefulness reported was 3.24. The relevance, correctness, generality, and completeness aspects were significantly well evaluated (close to 3.5). Comprehensibility and authenticity obtained an average rating close to 3 (agree). Usability presented the lowest value in the usefulness assessment, pointing to 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 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 major 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 well, demonstrating that the model gives a valid domain account and indicates if the reference model is usable in different evaluation scenarios. Regarding usability, examiners generally showed that they could efficiently operate, implement, and apply the reference model, although they were supervised throughout the process. Regarding completeness, examiners indicated that the representation contains all statements about the domain that are correct and relevant. Only one of the respondents 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 2c) summarizes the results. We identified five primary artifacts generated: assessment protocol, questionnaire (data collection instrument), IRT model calibration, awareness scales definition, and assessment report. Overall, the groups elaborated artifacts with considerable quality, obtaining 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 first point of emphasis is that due to the limited sample size that each group obtained (between 15 and 75 observations), the calibration and subsequent steps were hampered. Furthermore, the knowledge of the group of examiners related to the key concepts necessary to conduct the assessment was varied (see Figure 2a).

5.2. 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 2a).

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 one 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).

6. 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 different awareness; likewise, the participant's understanding differs over time.

We evolve the Awareness Assessment Model (MANTAU; BENITTI, 2023a) by developing an awareness assessment process that allows access to awareness and collaboration support through measuring awareness mechanisms from the participant's viewpoint. Then, we expose the model's artifacts to HCI and collaborative system examiners' appreciation to verify the suitability of the process by reliability and usefulness criteria.

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

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