An Interaction Design Method to Support the Expression of User Intentions in Collaborative Systems

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Abstract. The communication and interpretation of users' intentions play a key role in collaborative web discussions. However, existing mechanisms fail to support the users' expression of their intentions during collaborations. In this article, we propose an original interaction design method based on semiotics to guide the construction of interactive mechanisms, which allow users to explicitly express and share intentions. We apply the method in a case study in the context of collaborative forums for software developers. The obtained results reveal preliminary evidences regarding the effectiveness of the method for the definition of interface components, enabling more meaningful and successful communications.

Keywords: Collaborative web · Intentions · Pragmatics · Collaboration · Interaction design · Organizational semiotics

1 Introduction

Collaborative web-based systems provide opportunities for lifelong learning and are no longer restricted to specific contexts of use [1]. The diversity and comprehensiveness of the web encompasses people with different physical constraints and from various cultural and social backgrounds, allowing them to share both professional and personal problems as well as solutions. This diversified context makes web-mediated communications increasingly complex, and requires advanced computational solutions to support more meaningful collaborations among users.

Various factors underlying collaborative discussions influence the interpretation of exchanged messages, which may prevent participants from easily sharing, managing, retrieving and exploring available content. In this context, pragmatic aspects of human communication, such as intentions, play a central role in enabling adequate

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collaboration support. During face-to-face communication, people explore a variety of mechanisms, such as facial expressions, gestures, inflection, etc. Nevertheless, people predominantly use written language when interacting via collaborative systems, which does not favor the clear expression of intentions, and other pragmatic aspects, in a way that participants can obtain successful communication.

The literature presents limited interactive solutions to support user expression and perception of intentions. For example, some approaches aim at analyzing audio feedback in controlled environments, while other studies focus on natural language text analysis to make user intentions more explicit through techniques of keyword tagging and metadata descriptions. However, existing approaches still demand a lot of user effort and are dependent on continuous monitoring of user activities. The complexity of the web requires more precise and effective approaches.

This research investigates the conception of an original Interaction Design (IxD) method that can lead to interactive solutions allowing users to efficiently communicate intentions with little effort. This article makes the following contributions: (1) we define and describe the Interaction Design for Intention Expression method (InDIE) demonstrating the phases and elements involved in the solution; and (2) we present a case study illustrating the application of the method in the design of prototypes. A total of 22 users participated in the activities in this study.

The InDIE method relies on empirical research studies of our previous work [1–3] aligned with techniques and concepts from Organizational Semiotics [4] (OS) and Speech Acts Theory [5] (SAT). The method is composed of five phases in an iterative (*i.e.,* phases occurring in small cycles) and interactive process, where design solutions are produced and analyzed with end-users.

The obtained results highlight the major advantages and limitations of the approach through an assessment of the proposed method via the case study. This study shows the potential benefits of the solution for supporting designers and users in their creation of meaningful interfaces for expressing the users' declared intentions.

We structure the remainder of this article as follows: Sect. 2 presents the related work as well as the methodological foundations; Sect. 3 details the proposed method; Sect. 4 describes the application of the method in a case study; Sect. 5 wraps up with concluding remarks and outlines future research.

2 Background

We present the related work followed by the methodological framework.

2.1 Pragmatic Web and Users' Intention Expression

The Semantic Web (SemWeb) stands for an extension of the current web [6] comprising meaning representation, sharing, and interpretation by artificial agents and humans. The Pragmatic Web (PragWeb) concept emerged to cope with several critical issues of the SemWeb [7]. PragWeb aims at investigating and capturing the complexity of social and human behavioral interaction via web-based technologies, which includes people's intentions, interests, and participation [7]. PragWeb includes less objective observable facts such as beliefs, norms, people's social and cultural background, as well as intentions.

Our systematic literature review emphasized the issues of detection and influence of intentions, as well as the design and communication of intentions, and explored indexed documents from ISI, IEEE, ACM and Scopus. The analysis revealed three categories closely related to our work. Category 1 refers to empirical examinations focused on understanding human behaviors, and points out a view of the users' behavior that must be considered. Category 2 presents methods for the recognition of user's intentions via an interface that maps onto alternatives that can be employed in design solutions. Category 3 encompasses investigations of pragmatic factors in the design and construction of interactive web systems. Table 1 summarizes the objectives and results of each study and denotes their category.

The existing studies highlight multidisciplinary research issues, including the need to deeply investigate communication on the Web, as well as to apply these studies to design methods and complex computational mechanism. Although the explored literature indicates various relevant aspects to be included in the design of systems that consider intentions and other pragmatic aspects, the related work lacks a proposal of design process that explicitly guides the construction of interfaces to communicate intentions, which is addressed in this research.

2.2 Methodological and Theoretical Framework

Organizational Semiotics and Pragmatics Communication Analysis. OS studies organizations and information systems using the Peirce theory of signs [16]. In OS, the organization concept is not only restricted to enterprises. It refers to a social system in which people behave in an organized manner. MEASUR (*Methods for Eliciting, Analyzing and Specifying Users' Requirements*) stands for a set of methods employed by the OS researchers [17]. In this work, we considered and adapted some of the methods from MEASUR, described as follows:

- *Stakeholder analysis (Organizational Onion).* The stakeholders are analyzed according to their involvement in the given problem. This includes an informal level where the intentions are understood and the beliefs are formed; a formal level where meanings and intentions are replaced by forms and rules; and a technical level where the formal system is automated by computers;
- *Semiotic framework (Semiotic diagnosis).* This method is used to examine the organization based on Stamper's six semiotic layers [17]. In addition to Morris' syntactic, semantic, and pragmatic Semiotic layers (*i.e.,* structures, meanings, and usage of signs), Stamper [17] proposed three additional layers: physical, empirical, and social world. While the *pragmatic layer* deals with the purposeful use of signs, intention, negotiation, and the behavior of agents, etc.; the *social layer* deals with the social consequences of using signs in human affairs, including beliefs, expectations, commitments, law, and culture.

In addition to these methods, we adopted the Liu [4] perspective of pragmatics, which is based on OS and Speech Act theory (SAT) [5]. In the *Pragmatics*

Table 1. Summary of the existing approaches

Cat	Objectives	Results	Ref
1	Examined the effects of distinct interface styles on users' perceptions and behavioral intention to accept/use computer systems	Interface styles indicated direct effects on the utility and perceived usability by users, which affected the intentional behavior of system usage	[8]
1	Identified the motivational behavioral factors influencing students' intention to participate in online discussion forums	The students' intentions to participate were positively influenced by hedonic outcome, utilitarian outcome, and peer pressure	[9]
2	Investigated the recognition of users' intentions in virtual environments, more specifically in a fight simulation	Highlighted the possibility of recognition of intentions by using virtual interfaces that monitor the users' behavior and compare with predefined actions models	[10]
2	Explored natural language interfaces, such as dialogue systems, in ambient assisted living. Their aim was to incorporate conversational agents that consider the external context of interaction and predict the user's state	A context-aware system, which adapts to the context of patients with chronic pulmonary diseases	[11]
2	Captured and interpreted users' search intentions to improve image based search engines	Use of visual information as a search parameter was described as positive, but dependent on extra user actions. The work also highlighted limitations on the use of a single image to express intentions	[12]
2	Proposed observation of users' behavior using pattern recognition of linguistic features via data mining techniques to gather user intentions	Data mining techniques can support the recognition of users' intentions	[13]
3	Automatic synthesis of user interfaces based on intentions captured by communication acts	The automatically generated interfaces showed good usability levels	[14]
3	Proposed a conceptual framework for interaction design based on the WebPrag concept	Contributions of the interaction design for the realization of WebPrag, such as the design of mechanisms for the materialization of intentions in user actions	[15]
3	Investigated the dynamic aspects of pragmatics in messages exchanged during collaborative problem solving	Presents the influences of intentions on Web collaboration and proposes an entire research framework	[1]

(*Continued*)

Table 1. (*Continued*)

Cat	Objectives	Results	Ref
3	Identified recurring situations of use that might require the design of solutions to facilitate or avoid the manifestation of a wrong interpretation in collaborative systems	A set of recurrent patterns detailing problems, examples and abstract design solutions	[3]

Communication Analysis, a communication act refers to the minimal unit of analysis. A communication act consists of a structure with three components: the speaker, the listeners, and the message. A message has two parts: the content manifests the meaning, while the function specifies the illocution, which reflects the intention of the speaker. The illocutions has three dimensions: *time* (*i.e.,* whether the effect is on the future or the present/past), *invention* (*i.e.,* if the illocution used in a communication act is inventive or instructive, it is called prescriptive, otherwise descriptive), and *mode* (*i.e.,* if it is related to expressing the personal modal state mood, such as feeling and judgment, then it is called affective, otherwise denotative).

Emotions and Meta-Communication. Emotions can affect the interpretation and meaning of a communication. According to [18] people express their emotions to establish a more sociable and friendly conversation. To minimize communication problems in online conversations, users explore various alternatives to express their emotions, including graphical tricks, pictures with text symbols, and emoticons.

Several studies show the benefits of using emoticons in communication. Emoticons are highly disseminated on *Instant Messaging* (IM) tools. They can produce positive effects on personal interaction, perceived usefulness, user satisfaction, among other benefits [19]. Hayashi [20] employed OS methods in participatory activities to identify requirements for tools with expressive components (*i.e.*, that express emotions) to support users via meta-communication mechanisms on inclusive social networks.

Based on these studies, we propose that emotions can be an alternative to express intentions in collaborative systems, which is originally explored in the method presented in the next section.

3 The InDIE Method

The InDIE method relies on preliminary studies [1] based on OS and SAT. These studies were important to elucidate how the theoretical framework would adequately support the method. InDIE is composed of five phases in which the design solutions are produced and validated with end-users in an interactive and iterative process. In each phase, we pay special attention to how to elucidate the pragmatic aspects so that they can be incorporated into the requirements for design interactive mechanisms. Dashed rectangles in Fig. 1 represent the five phases. Each phase is composed of specific activities. We detail the method as follows:

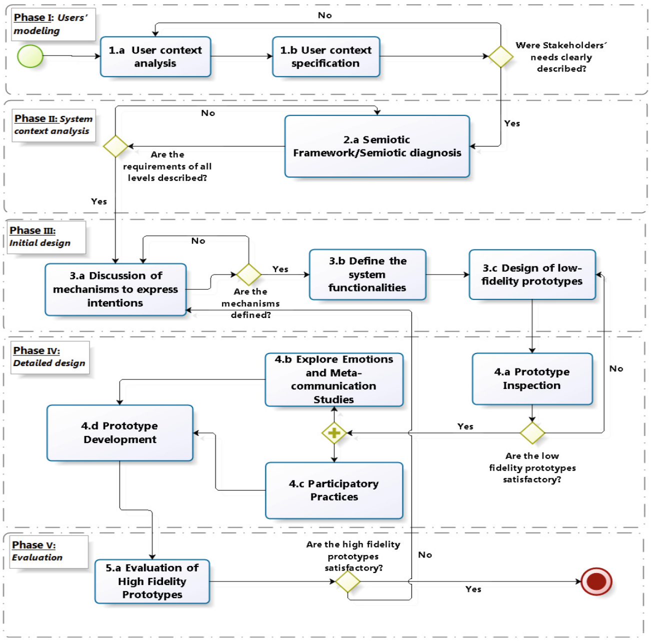

Fig. 1. Overview of the InDIE method

1. Phase I: *User modeling* – focuses on how end-users explore and make sense of information systems to communicate on a daily basis, and how they express intentions in collaborative tasks. This phase contains two activities: (1.a) *User context analysis*. It studies the users' context, their discussions in the collaborative systems and their location. Various activities can be used to elicit and understand the users' context, such as: interview techniques, focus groups, and participatory activities. The results should be formalized and summarized in order to be used in further activities. Designers may inquire about specific aspects of intentions via questions elaborated for this purpose. The questionnaire results are evaluated using statistical tools. (1.b) *User context specification*. This activity proposes the use of the organizational onion artifact [4], as well as the detailing of problems and stakeholders' needs. This is relevant in order to understand the way that stakeholders can communicate with each other and the types of intention elements they explore;
2. Phase II: *System context analysis* – emphasizes the analysis of the context where the systems will be used. This phase contains one activity: (2.a) *Semiotic Framework*. The requirements, problems, and possible solutions are grouped according to the semiotics levels. For each level, problems are elicited from the users and discussed collaboratively. The analysis of the pragmatic and social levels focuses on the investigation of problems due to misunderstanding of the users' intentions;
3. Phase III: *Initial design* – elicits from users the system functionalities where the pragmatics communication aspects are critical. Both users and designers discuss the benefits of having mechanisms to directly express intentions in each case of specific

user interface. Low fidelity prototypes are defined and constructed in this phase. This phase contains three activities: (3.a) *Discussion of mechanisms to express intentions*. In this activity designers and users discuss the existing computational mechanisms and how to employ or adapt these mechanisms to the system context. Designers may explore the classified illocutions and the defined dimensions of *time*, *invention,* and *mode* according to the Pragmatics Communication Analysis (*cf.* Section 2.2.1). Discussions involving these elements remain essential in order to materialize the design of interface structures for expression of intentions. End-users need to understand the illocutions in the context of collaboration to suggest how possible interface metaphors would be suitable to represent the illocutions. (3.b) *Definition of the system functionalities*. Discuss the integration of the mechanism to express intentions into the system functionalities. Designers can propose potential solutions based on the conducted discussions and share them with end-users. (3.c) *Design of low-fidelity prototypes*. Low-fidelity prototypes are constructed to evaluate high level concepts of the interface with the users. The low-fidelity prototypes enable a quick communication between designers and users, low-cost refinements, and detection of usability issues in an early stage.

4. Phase IV: *Detailed design* – proposes the design of alternatives and interface structures based on results from the previous phases. Additionally, this phase suggests that designers can explore studies on emotions and meta-communication, aiming to support the generation of the design alternatives. Practices with the users to discuss the design alternatives are also recommended. This phase contains four activities: (4.a) *Prototype Inspection*. The prototypes are deeply analyzed and examined with the users. Participatory evaluation, focal groups, interviews, among other techniques, can be used in this activity. Users can already detect whether their expectations regarding the mechanisms are materialized in the prototypes. (4.b) *Explore Emotions and Meta-communication Studies*. Determine possible design alternatives by exploring studies on emotions and meta-communication (*cf.* Sect. 2.2.2). For example, this activity includes the discussion of how to adapt interfaces and icons representing emotions for transmitting intentions. The illocutions can have representative emoticons that might make sense to users. (4.c) *Participatory Practices*. At this stage, the design decisions are more fine-grained and the design choices are duly documented. This action aims to define the adequate mechanisms discussed with end-users that would enable them to easily express intentions. (4.d) *Prototype Development*. Development of a high fidelity prototype and functional prototyping based on the previous decisions. Fast prototyping techniques and low incremental cycles should be used interactively;
5. Phase V: *Evaluation* –evaluates practices and proposes improvements for a next design cycle. This phase contains one activity: (5.a) *Evaluation of High Fidelity Prototypes.* This evaluation can be guided by key issues such as, if the design solutions enable users to explicitly express their intentions, and if users will make real use of these solutions. This evaluation may lead to the decision to take the mechanisms to the phase of implementation. Otherwise, designers would go back to Phase III.

4 A Case Study on Software Development Forums

This section presents the application of the InDIE method in a case study.

4.1 Context, Subjects, and Methodology

The case study examines the experimental evaluation of the InDIE method, and includes the identification of open issues in the design of mechanisms for intention sharing. The following questions guided the study: (1) To which extent can InDIE support the design of mechanisms to express intentions? and (2) What are the central strengths and deficiencies of InDIE?

First, we informally invited developers from the following programming forums: Clube do Hardware,[1] Clube da Programação,[2] Script Brasil[3] and GUJ.[4] Additional developers were personally invited according to their previous experiences and availability for face-to-face activities. We presented the participants a summary of the study, objectives, and subsequent activities. Afterwards, the participants answered an initial questionnaire with their profile.

Table 2 summarizes the key features from the participants' profile. A total of 22 developers participated in the study. These participants are from various parts of Brazil, have different experiences with using collaborative forums, and have different levels of programming skills. As shown in Table 2, the majority of the developers participated in the phases 1–2 of InDIE due to time restrictions.

Initially the designers interacted with the participants using distance communication technologies. We adopted the *Google Form*[5] tool for the questionnaires. A smaller group with users 1, 12, and 19 participated in face-to-face meetings according to the activity (*cf.* Table 2). In addition to face-to-face evaluation, designers constructed and digitalized the low fidelity prototypes (on paper) for distance evaluation. Supplementary tools including emails and online/video communication tools were also applied during the study.

4.2 Results and Discussion

The users' modeling analysis started with the application of two online questionnaires and interviews collecting information for the Organizational Onion (first phase). These activities contributed to the elicitation of stakeholders' needs as follows. The *informal level* presented a set of topics typically related to how users communicate using informal conventions, such as: What are the conditions for the community to accept the inclusion of a new topic on the forum?; and What is the commitment of a user to give a

[1] www.clubedohardware.com.br.

[2] www.clubedaprogramacao.com/.

[3] www.scriptbrasil.com.br.

[4] www.guj.com.br.

[5] www.google.com/Forms.

Table 2. Basic profile of the participants

N#	Age	Programming languages	Experience	Academic level	Employment position	Participation (Phases)
1	24	Java, C#, Delphi	1–5 year	MSc. Stud.	Scholarship	3–5
2	23	C#, VB, VB.net	5–10 year	Graduate	Director	1–2
3	30	Cobol, Abap	1–5 year	Graduate	System Analyst	1–2
4	27	C ++,C#, javascript	5–10 year	Graduate	System Analyst	1–2
5	32	Abap e Java	1–5 year	Graduate	Unemployed	1–2
6	25	Visual Basic	5–10 year	Specialist	System Analyst	1–2
7	21	php, Java, js	1–5 year	Undergra.	Web Develop.	1–2
8	22	C#,Delphi,Java	5–10 year	Graduate	Developer	1–2
9	27	C#,ActScr,Delphi	10+ year	Master	Proj. Manager	1–2
10	21	Html,Php,Python	5–10 year	Graduate	Developer	1–2
11	42	Python, Java	10+ year	Specialist	System Analyst	1–2
12	50	Java,Delphi,C ++	10+ year	Graduate	IT Manager	3–5
13	12	C, Python	1–5 year	Sec. School	Student	1–2
14	24	C,Pascal,Java	5–10 year	Undergra.	IT Technician	1–2
15	32	PHP, jQuery, Html	1–5 year	Graduate	Chief Develop.	1–2
16	30	Java,C#,VFoxPro	10+ year	Graduate	System Analyst	1–2
17	26	Java,C ++,Phyton	5–10 year	Graduate	System Analyst	1–2
18	34	Java	1–5 year	Specialist	Scholarship	1–2
19	35	Java, C, C#	10+ year	Master	Lecturer	3–5
20	19	.Net	less 1 year	Undergra.	Trainee	1–2
21	29	C#, Java, PHP	10+ year	Graduate	Owner	1–2
22	35	JS, C#, Java	10+ year	Graduate	IT Coordinator	1–2

solution? The *formal level* presented a set of topics on how the participants are aware of, and interpret the description of, the programming language problems, and how they formalize (express in a formal language) their intentions in the text. Finally, the *technical level* included questions about the software applications used to recover, share, and transmit questions and solutions.

The answers obtained during the first phase contributed to the identification of how stakeholders informally and formally interact with the collaborative system to transmit their intentions. These are key aspects to support subsequent steps, and the definition of the new mechanisms. For example, when we asked about the commitment of a user to present a solution, we are examining the strength of a prescriptive communication act (question) before determining a design solution to represent it. Similarly, at the formal level, we can analyze the way users express the prescriptive communication acts in writing language. The level of formalization can indicate, for example, whether or not it is acceptable to use icons embedded in the text (a design solution).

During the second phase, the semiotic framework guided the elicitation of requirements on all OS levels. The responses used to support structured interviews and discussions with users. The key topics addressed were:

1. Physical level. We analyzed the infrastructure necessary to access and host collaborative systems with solutions that support intention sharing. We verified if the design alternatives are feasible in terms of the existing computational resources, *e.g.*, the computational requirements for solutions with text interpretation algorisms;
2. Empirical level. We investigated the data transmission availability and throughput requirements to share intentions. This includes, for instance, the viability of sharing multimedia artifacts;
3. Syntactic level. We took into account the protocols, syntactic conventions, codes, and language structures used to transmit intentions in collaborative systems. This level includes, for example, the analysis of codification/programming limitations for implementing a proposed design solution, as well as syntactic conventions for expressing intentions in a formal language;
4. Semantic level. We examined the meanings of signs in the interfaces to represent and share intentions. A key aspect is whether the meanings of the interface components in the design candidates are correctly interpreted by the users or not;
5. Pragmatic level. We investigated if the participants' intentions are effectively shared in the collaborative systems. This level includes the analysis of how users share intentions in the existing systems, and the identification of limitations and misunderstandings. With respect to the initial design alternatives we were also interested in how the participants could share intentions;
6. Social level. We analyzed the consequences on the agents' social behavior as a function of whether or not they shared their intentions in the existing systems. At this level, designers examined the potential social consequences of a prospective design.

In general, the semiotic framework contributed with the elicitation of issues such as: (1) many existing systems are basically restricted by the use of textual language; (2) many novice users do not understand the technical language used by expert users; and (3) programming codes shared by users are frequent causes of misunderstanding among the participants.

During the third phase, the participants were informed about the importance of sharing intentions in collaborative work, and then we discussed design alternatives. Low fidelity prototypes materialized the initial proposals. These prototypes included basic elements using emoticons (adapted to represent intentions) and meta-communication, which clarified how to express intentions in the proposed interface.

Figure 2a presents a low fidelity prototype of a Web form to post questions on a "generic" collaborative forum. The prototype included boxes to represent the writer's mood and a meta-communication area.

In the fourth phase, the designer defined a high fidelity prototype based on the low fidelity prototypes and design alternatives established as a result of participatory practices. During the prototype inspection (4.a), the participants proposed to move the emotions from the "format bar" to the right side as shown in Fig. 2b. The users

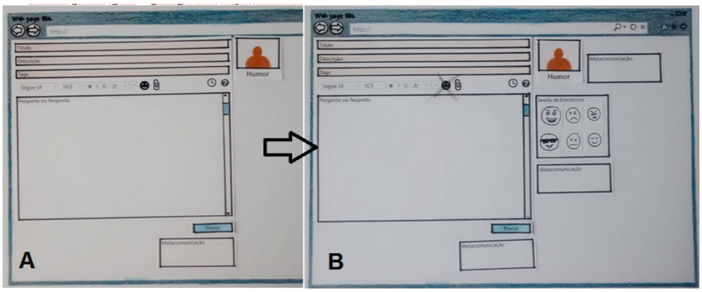

Fig. 2. Evolution of the low fidelity prototypes during the phases of InDIE

suggested additional meta-communication boxes to accommodate information close to the mechanism.

Figure 3 presents a prototype containing three mechanisms, in which users can optionally express intentions, as follows. (1) Associate a phase with a color according to a predefined palette. In this palette “cool colors” are denotative and “warm colors” are affective illocutions. (2) Use icons (named *intenticons*) in the text. Users can choose these icons from a predefined set. (3) Associate a selected illocution (from the text) with dimensions using “range sliders”. In the proposal, these dimensions are also displayed to the readers when the mouse hovers over the given mechanism.

We started the fifth phase with a preliminary evaluation in which the prototype was informally presented to users and other designers. Although the participants agreed on the general structure of the interface, they pointed out the need to advance the design of the proposed mechanisms. For example, they suggested the definition of a more representative set of icons. Consequently, we have to go back to the third phase.

This case study remains limited in the following major aspects: (1) it does not evaluate the effectiveness of the produced interface in real cases, and (2) it fails to directly compare the InDIE with other methods. Despite these limitations, the study was able to present how each InDIE phase contributed to the design of an interface mechanism, as well as how we considered users’ opinions and participation in the

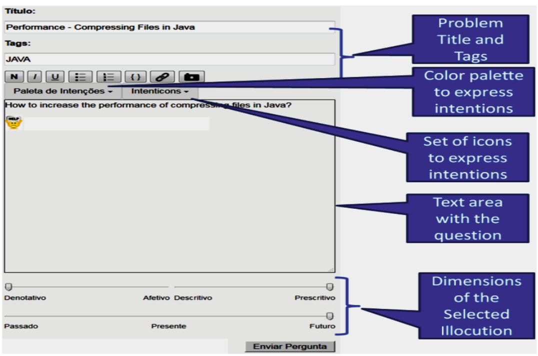

Fig. 3. High fidelity prototype proposed in the fourth phase

design decisions. The case study also pointed out the need for further research, including the study of (semi-)automatic methods that could suggest the positions of the proposed “range sliders”.

5 Conclusion

The expression of intentions plays a central role in human communication. Collaborative systems (*e.g.,* programming forums) are typically restricted to textual communication, which leads to misunderstandings and difficulties in the collaborative process. We proposed the InDIE method aiming to guide designers in the construction of interactive mechanisms that support users’ expression of their intentions in collaborative systems. The InDIE method was instantiated in the context of programming forums, and this research achieved a high fidelity prototype with the participation of 22 users. The results highlighted the potential of the mechanisms.

As next steps, the goal is to carry out detailed studies to determine a set of representative icons to express intentions, and to conduct a controlled experiment to verify the effectiveness of the proposed interface by comparing it to interfaces without the mechanisms. We also aim to improve InDIE by conducting new case studies with other collaborative contexts and users.

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