Reflexivity, Language Games, and Computer-Supported Cooperative Work

Being an Insider in Engineering Projects: The Case of Designing Maritime Technology

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***Abstract*—Computer-supported cooperative work (CSCW) researchers have plenty to say about designing through texts; however, implementation and the gap between the design material and texts are misunderstood by systems developers in engineering projects in the process of designing collaborating systems. This problem is not new but an ongoing issue of utilizing CSCW insights effectively and correctly in engineering projects. By reviewing a five-year, multiple-site ethnographic study in the maritime domain, this paper reflects on reflexivity and language games. These can be used by CSCW researchers as theoretical concepts to study their own contributions and better position themselves in engineering projects, thus producing the same images and languages between themselves and others. By examining their own contributions, CSCW researchers could reduce the gap between CSCW research and engineering practices.**

Keywords- engineering design; language games; CSCW; reflexivity; practice–research gap.

I. INTRODUCTION

For decades, researchers in the field of computer-supported cooperative work (CSCW) have assumed that they are able to inform the design of computer systems. However, this assumption has created gaps between CSCW research and engineering practices [1][2]. Systems developers in industries are considered outsiders by the computer science community and are mostly engineers within the fields of automation, machinery, electrical, and manufacturing and processing. Although information technology has successfully found its own role in the fields above, a common understanding of designing collaborative computer systems has yet to be achieved [3][4]. For example, the collaboration between systems automation and machinery engineering is about integrating machines with different functions. Designing such systems requires systems developers to reflect on the collaboration of machines and the machines' view of the end-user's work procedures.

Although CSCW researchers have plenty to say about designing cooperative systems to support end-users, the researchers have not done enough to translate the theoretical knowledge of CSCW into forms and instruments that can be used by the wider communities who might act on the researchers' findings [5]. Rather than consulting CSCW insights [6], systems developers primarily rely on their own professional knowledge and skills during systems development. This phenomenon causes a problem in which the final design does not involve end-users sufficiently.

The core problem is that CSCW researchers might assume that they are systems developers. To some degree, these researchers overlook systems developers as end-users of CSCW research [7]. Grønbæk et al. argued that the main CSCW challenges in large-scale technical projects are that "[u]sers do not make explicit distinctions between working in cooperative or individual 'modes', they just want to carry out their work" [6, p. 76]. The same could apply to systems developers, who do not always follow their work routine (analyzing, designing, implementing, testing, and iterating the process). Instead, the golden rule is to use and reuse any developed systems models in a new project and then update the development log to show the requirements were fulfilled [8]. This is an ongoing debate in the field of engineering. However, the present paper has no intention to reopen this debate, as this topic has been discussed repeatedly. Instead, this paper considers this phenomenon in seeking an approach that could support systems developers with fruitful and practical CSCW insights for designing maritime technology. The current CSCW literature does not always involve the insights of the systems developers or uncover many important aspects of general interest for work in the engineering setting, because many may not have been uncovered by engineering work routines.

In line with many other struggles in the CSCW community, such as the issues of implementing CSCW systems from scratch [2][7][8], the unsurprising failure to use CSCW insights in engineering projects can also be found in maritime technology. The application of current maritime technologies does not support cooperative work among operators on board [7][9]. The current design of operator–vessel interaction follows the principles of engineering design, including cognitive ergonomics and human factors [10][11]. The fundamental principle is to focus on the design applicability, the scope of the technical process, and the system structures to support the efficacy of machine use [12]. Operators are subjects in the experimental work conducted to verify whether a design is successful. However, the social aspects of human–vessel interaction have been largely dismissed. Moreover, operators are not encouraged to articulate their requirements, and the system design team is composed of various specialists serving as consultants to the project.

If the above are the facts, then how could CSCW researchers contribute to the design of maritime technology as a completely foreign group sharing few common interests with systems developers? In shifting the focus from machines to human challenges, the design of cooperative systems to support maritime operations entails positioning a CSCW researcher in the maritime field. However, very few studies have addressed how researchers can successfully conduct CSCW research outside this scientific community. For example, scholars have tried to extend collaborative computing in a design approach to shape the design processes, to help users articulate their requirements with other specialists in systems design in the aviation and maritime domains [13]–[15]. Thus, it would be worthwhile to discuss how CSCW can be extended beyond the classic discussion about the relationship between ethnography and design [16] to the collaborative effort of computer scientists and sociologists [17].

The remainder of the article is structured as follows. Section II presents the movement in CSCW research and the research question of the present paper. Section III outlines the main case (i.e., designing remote control systems as the fundamental background of the article). Section IV presents reflexivity and language games as the theoretical concepts and methods used in the paper. Section V describes how participants are recruited in designing remote-control systems with respect to CSCW insights. Section VI presents the reflection of using theoretical concepts to guide the work in engineering projects. In doing so, the paper discusses its contribution to CSCW research in Section VII, which moves the historical debate on the relationship between ethnography and design to a new focus on the role of CSCW researchers in engineering projects to support CSCW research. The paper is concluded in Section VIII.

II. The Movement in CSCW Research

The movement in CSCW research has been the subject of debates for several years [18]. Current CSCW research has moved beyond single disciplines, such as sociology and computer science, to establish itself well in a new field. However, in the key literature on the intervention of design in CSCW [18], little attention has been paid to intervention in CSCW research [18]. Even when intervention is addressed, it is not clear how, when, and what could be intervened. Although a few studies addressed how CSCW research can help in design technologies, mainly in the healthcare field, the difference is that the work practices of health workers require CSCW researchers to communicate with developers who, in most cases, share a similar background, such as computer science, software engineering, and the like.

However, it is quite a different story when CSCW researchers work with people who have different backgrounds while focused on control engineering and automation. In such contexts, priority is given to expertise outside CSCW, and interactive experiences of computation and cooperative work become less vital. Operators are affected by usefulness and usability issues in the given technology. Moreover, different priorities in the design process challenge CSCW researchers, who must design systems in cooperation with "outsiders." In protecting their own academic interests, CSCW researchers have to find ways to make sense of CSCW insights beyond their own discipline [7].

As a member of the new generation of CSCW researchers, the CSCW researcher ("the researcher") in the present work has multidisciplinary education ranging from software engineering to social computing. The researcher not only can understand the design site and the object of study but also has hands-on "practice." As Ehn [19] points out, this generation of CSCW researchers understands the language games (referring to a philosophical concept developed by Ludwig Wittgenstein where language use and actions into which the language is woven) [20] of use activities and can transform the bottleneck of computer-supported activities of users in real life into the rule explanations of systems development as procedural and reproducible practices for the design process. This is not a new and one-way approach to understanding practice, but a method addressing Ackerman's definition of "the divide between what we know we must support socially and what we can support technically" [21].

Thus, the research question for this article is formulated as follows: "How do we shorten the distance between CSCW research and its practice in engineering projects?" Unlike studies [1][15] that focused on organization (working division of labor) and CSCW, this paper adds new evidence and insights regarding the use of the concepts of reflexivity and the Wittgensteinian concept of "language games" to probe the practical implications of CSCW design as an evaluating the quality of CSCW research in engineering projects [14]. In the following sections, the design of remote-control systems for autonomous vessels is used as a case. The bottleneck of CSCW research in an engineering project is transformed into a contribution of procedural and reproducible practices in implementing the design process.

III. The Case: Designing Remote-Control Systems

Traditionally, maritime technology focuses on control systems, machinery, and the automation of maritime vehicles of any kind. The design process is purposeful, systemic, and iterative. Systems developers conduct their work in various constraint conditions to find possible solutions for problems, which are usually limited to the given scenarios. Systems developers communicate with a small group of users, for whom the design follows a positivist paradigm with the intention to ultimately test a system. Design requirements are usually based on three principles: corporate, technology, and social [3]. The primary principle is that the corporation must be able to generate design requirements in line with the company's organizational structures, strategic vision, and available resources, based mainly on the knowledge and expertise of the systems developers. This principle does not change until social aspects challenge the company's framework through markets. The second principle, which Gershenson and Stauffer [24] termed "technology," is the knowledge of engineering principles, material properties, and physical laws [12]. User requirements are considered last. The requirements of the third principle are weighed to optimize the trade-off with the requirements of the first two principles and to align them with the needs of the users, including the "must-have need" and the "attractive need."

Thus, in line with the principles, systems developers consider artefacts important for remote-control systems. In addition, systems developers narrow the design specifications to comply with reliability, ergonomics (i.e., human factors), manufacturability, and control ability similar to software engineers, who use models to automatically synthesize an executable code [25]. The philosophy underlying all the solutions is technology-centered design. In other words, by using a certain algorithm to represent situational awareness [26][29], systems are expected to represent information as accurately as possible in human decision making [25][27][28]. The common principle that underpins these previous studies is the assumption that the systems will be well-designed to support human tasks, such as drawing patterns, creating models, and making sense of a machine's actions. Through well-structured technology-centered experiments, as in most engineering projects, systems developers expect that human factor specialists [21][22] can investigate whether interfaces could be built to satisfy the operators. If so, what kinds of "human error" could be investigated? Hopefully, the results can be utilized to reform the systems according to a better vision. As a consequence of this approach, operators are expected, oddly enough, to be re-trained in the skills needed in the autonomous future [30][31]. The others, without protection against the failures, errors, and faults caused by technology, which cannot be called human errors, are treated as regulatory and policy issues [24][25][32]. Politicians, societies, and shipowners require clarification of the potential liabilities (e.g., collisions) introduced by autonomous technologies [33][34].

However, the cost of the running ships may not be decreased as expected. Instead, it might increase significantly due to infinite maintenance and changes in remote-control systems, which will certainly displease operators and shipowners. When changes are introduced, people quickly learn the changes' characteristics and discover how to maximize them. When autonomous technology and remote control are introduced, people react in the same manner.

IV. Theoretical Concepts and Methods

To better understand the role of CSCW researchers in engineering projects, two concepts are of interest, namely, reflexivity and language games. Reflexivity is a method for sharing sense-making between practitioners and an ethnographer in terms of gaining performative knowledge of professional expertise. Language games are a method for guiding CSCW researchers to practice their interpretation of findings in various ways that fit engineering projects for systems developers and the sponsors of the projects (i.e., the shipowners).

A. *Reflexivity*

Calas and Smircich [35, p. 240] define reflexivity as the "constant assessment of the relationship between knowledge" and "the ways of doing knowledge." Through "reflexivity," researchers can pay attention to *"the way* *different kinds of linguistic, social, political, and theoretical elements are woven together in the process of knowledge development during which empirical materials is constructed, interpreted and written"* (p. 9). In conducting a reflexivity study, interpretation is used as a tool for producing scientific knowledge [36]. In doing an interpretation, we reflect on how *"we become observers of our own practice"* [37]. Reflexivity suggests the complexification of thinking and experience or thinking about experience [37]. It is a process of exposing or questioning our ways of doing. In a discussion of the third wave of human–computer interaction (HCI), Bødker [38] calls for a crucial and conventional understanding of reflexivity. Reflexivity, according to her, is different from positivism: Reflexivity is an intervention for data gathering. Bødker does explain how this process impacts the quality of the data itself. In the end, reflexive practices can find structural patterns in what they have observed, thus extending the theory the practices used. However, reflexivity has had difficulty finding a place in HCI and in CSCW literature. Due to the subjectivity of the methods used, it is difficult for reflexivity researchers to open their work to future scrutiny. Geirbo [39] states that reflexivity itself is important as a kind of methodological consideration, which can guide researchers as they attempt to enter a community, phenomenon, or practice considered foreign to the researchers. In the present, it is possible for researchers to share sense-making between practitioners and an ethnographer in terms of gaining performative knowledge of professional expertise. Researchers also have the capability to articulate and analyze such performative knowledge gained through an insider role [40]. In this effort, it is possible to bridge the practice–research gap by enacting researcher-practitioner roles across community boundaries, developing and disseminating new knowledge, and engaging field professionals outside the CSCW community.

Thus, in line with this specific theoretical concept, CSCW researchers can be reflexive about how their ethnographic accounts will affect the research process. This action can help *CSCW peers* gain a better understanding of the choice the researcher has made during the entire research process, including the design, data collection, and interpretation phases. Reporting and discussing the theoretical struggles of interpretive empirical research can also help fulfill the principles of "dialogue" [41] through languages in between the fieldwork material with the reflectivity thinking and engineering projects. The core of the "dialogue" interpretation relates to the experience, so that CSCW peers can understand what the researcher has seen and experienced, and learn how to evaluate that work. In turn, they can sense the socio-technical gap within the CSCW research itself, as well as that between humanity and engineering in general. Meanwhile, in most cases, CSCW researchers have to contribute to other engineering fields. Researchers' writings and insights are also considered in other research and development activities. Thus, evaluating the application of the CSCW insights in dialogue is useful not only for CSCW peers but also for others through some meaningful forms.

B. *Language Games*

To make sense of the CSCW insights in a dialogue for non-CSCW systems developers in engineering projects, language games [13][35] have been considered in the literature for a long time [1][14]. Wittgenstein speaks of coming to understand what people mean by having someone explain the meanings of the words. He emphasizes that one needs to be trained to learn language games. That is, being able to speak and understand what one said—knowing what it means—does not mean that you can say what it means, or is that what you have learned. Wittgenstein [42, p. 32] gave an example in his book, *Philosophical Investigations*: "*Augustine describes the learning of human language as if the child came into a strange country and did not understand the language of the country; that is, as if it already had a language, only not this one."* In other words, you might see whether systems developers know techniques, notations, and norms by asking the developers what the expressions mean. However, that is not how CSCW researchers can tell whether systems developers can read thick descriptions of identified design issues from the system development. Moreover, it is not what systems developers learn when they learn to practice the technical languages and skills of systems design. Thus, the mandatory skill of using different forms of descriptions of CSCW insights now seems vital to CSCW researchers.

In his Blue book, Wittgenstein encourages us to analyze our own ordinary language as though we want to discover something that goes on in our language as we speak it, but which we cannot see until we take this method of getting through the mist that enshrouds it [20]. As he [13, p. 17] puts it, "The study of language games is the study of primitive forms of language or primitive languages. If we want to study the problems of truth and falsehood, of the agreement and disagreement of propositions with reality, of the nature of assertion, assumption, and question, we shall with great advantage look at primitive forms of language in which these forms of thinking appear without confusing background of highly complicated process of thought. When we look at such simple forms of language the mental mist which seems to enshroud our ordinary use of language disappears. We see activities, reactions, which are clear-cut and transparent. On the other hand, we recognize in these simple process forms of language not separated by a break from our more complicated ones. We see that we can build up the complicated forms from the primitive ones by gradually adding new forms." Wittgenstein further emphasizes in his Brown book [42, p. 81]: "We are not, however, regarding the language games which we describe as incomplete parts of a language, but languages complete in themselves, as complete systems of human communication." With this in mind, CSCW researchers might see people who are taught their "native" language (i.e., engineering techniques, etc.) by such a language game in which they even have their own forms of games. The CSCW researchers' duty is to convert our writing of system design into simple languages that can be useful tools (i.e., activities, reactions, and other forms that are clear-cut and transparent) for the entire systems of communication of the development team. In this sense, we (CSCW researchers and systems developers) are all on the same team and use the same simple languages.

Language games as the second concept are fruitful in this endeavor. This is because they help CSCW researchers move further from reflectivity positions—a somewhat struggling social invention in CSCW system design toward *ostensive expression* [20] of our writing in CSCW research and engineering projects. Language games encourage CSCW researchers to state their insights not only for their peers but also for the outsiders of the CSCW community. A few researchers believe that language games might be a method for helping researchers (CSCW researchers and other researchers in design disciplines) to shorten the distance between humanities and engineering, thus building a bridge to help systems developers recognize what we write and know what we mean through the "signs" [20] that we use, such as Use Case language [3], systems modeling language, or contractual statements [43].

C. Methods

For a long time, the role of CSCW researchers in the maritime domain has been questioned. The researchers struggled to answer this question, because the contributions of CSCW might not remain in their area (i.e., *interpretive ethnography*) but extend to a foreign context in which CSCW researchers would have to change their tone and voice so that those living there could understand the researchers. Although the initial question in 2015 was, *"What is going on in designing maritime technology?"* when fieldwork at sea was conducted, other questions were asked by the project owner about how maritime technology was produced, assembled, and maintained then. These questions were frustrating but somehow easy to answer. After addressing these questions, the researcher successfully demonstrated the importance of CSCW insights in analyzing maritime operations for better maritime technology designs [14]. As an extension of that successful analysis of maritime operations, remote-control systems were chosen, because the ongoing research on automated ships might benefit from the researcher's previous work.

The remote-control systems were designed on land. Due to the natural complexity of the projects, multi-site projects [44] were conducted at sea and on land to observe and interview the people who would become the users of these systems. Seminars, workshops, and conferences were held in which shipowners and various stakeholders, such as systems developers, policymakers, and other relevant participants, celebrated their technical achievements. The researcher is part of a land-based maritime design team. In addition, he also observed, conducted interviews, and then wrote about findings from the fields after conducting fieldwork in different workplaces, such as on board, design companies, education conferences and seminars, and videoconferences. The fieldwork began in the first year when the researcher was a doctoral student at the University of Oslo and continued after he received his doctorate degree.

Although the research project required long-term engagement in the maritime domain, fortunately, the heterogeneous group has not changed much since 2015. A group of professionals, including operators, systems developers, educators, and shipowners, are involved in the study. The present work is a long-term project to observe and interview them in different places at sea and on land throughout European countries. An online platform was established in which systems developers could share information via email, conduct videoconferences, and chat and leave comments on documents. Topics that the researcher did not understand were posted so that someone could explain them by leaving comments and observations. In addition, interactions with systems developers were carried out through individual emails and videoconferences to construct an ethnography of their experiences in design work. Several new participants joined the long-term study, but others have been part of the study since the beginning. Thus, informed consent was not required, and the research was only verbally introduced to the newcomers. Several stopped participating as they were starting new career paths.

However, they kept in touch occasionally in case any questions needed to be followed up.

Table I illustrates the research activities conducted since 2015. Notes were taken during the interviews, seminars, and workshops, but no audio-recordings were made due to ethical considerations. At sea and in land-based simulator rooms, the observations were video-recorded. However, not all videos were transcribed. Instead, only those that were relevant to engineering projects, particularly the design process, were transcribed. This is because cooperation between seafarers at sea and on land is essential.

TABLE I. RESEARCH ACTIVITIES SINCE 2015

Settings	Methods		
	Number of Interviews	***Hours of Observation***	***Year***
At sea, on board	72	1838	Autumn 2015–Spring 2016
Land-based simulator room	18	48	Autumn 2016
Conferences on sites	4	-	Autumn 2017–Autumn 2019
Seminars	9	-	Autumn 2016–Autumn 2020
Workshops	7	72	Autumn 2016–Autumn 2020
Emails	232	-	Autumn 2015–Spring 2020
Videoconferences	4	-	Spring 2018–Autumn 2020

The data analysis has been ongoing since 2015, which involved thematically indexing words, such as "cooperative work," "design," "remote-control," "systems collaboration," "team's cooperation," "remote control," and so forth. Themes were also identified. However, these themes were used to describe not only the remote-control system design but also the other works of the project. They were also emphasized during investigation and design in the maritime domain in general. The purpose of the data analyses is to offer an ethnographic account of the practice and associations orchestrated by crossing multiple sites off- and online, particularly in the case of a remote-control system. Moreover, the analyses aimed to direct attention to the researcher's self-reflectivity [45], focusing on language games [1][14][15][35], to bridge the gulf between what Dourish calls the "sociotechnical gap" [23] and Ackerman's definition of "the divide between what we know we must support socially and what we can support technically" [21] without pre-conditions. In other words, this paper addresses the gap between CSCW research and CSCW practice in industrial contexts.

V. IMPLEMENTATION OF CSCW INSIGHTS IN AN ENGINEERING PROJECT

In the maritime domain, operators are rarely involved in the design process. As previously stated, they are used as subjects for testing purposes when a product is being developed. Educators are also rarely involved, because they teach operators without considering their concerns about technology. Moreover, CSCW researchers are also not typically involved in a maritime design project, because their expertise is invisible in the engineering field. Likewise, shipowners are rarely consulted in design projects for various reasons. Thus, in this study, a group of stakeholders was assembled to balance their interests in design for a sustainable solution for all based on the CSCW perspective.

A. Involving Stakeholders in the Implementation Process

In 2016, various challenges emerged. The operators thought the researcher was a systems developer or at least someone who knew how to develop their computer systems. They thought that the researcher was only concerned about examining their work. However, that was not the case, as he was a CSCW researcher who was also trained as an ethnographer. The researcher was on board to evaluate work but also to observe what was going on. The researcher also wanted to interview the operators. Based on those findings, the researcher would work with systems developers to design the remote-control systems.

After the explanation above was provided to the operators, they were worried that what the researcher observed and heard would be documented as evidence for changing the vessel design to automatic shipping. They thought that the researcher could be a spy who was studying them and would try to create a technology that would replace human operators. Although the purpose for being on board was thoroughly explained, and they had given informed consent to participate in the study, they initially misunderstood the researcher's basic objectives. However, later, the operators apologized and added that they actually hoped that their expertise and knowledge could someday be acknowledged rather than overlooked when remote-control systems are designed. Since then, the researcher also noticed that not everyone welcomed the possibility of shifting to a remote-control system.

On board, one of the operators expressed his concern that he did not believe the systems could do what he was good at. He felt that his experience at sea could not be simply cloned into a machine. He also felt anxiety thinking about the possibility that the shipowners just wanted to save costs and did not care about the operators. The researcher did not know how to respond to such concerns at that time, because it was hard to promise that they would be assisted rather than replaced by the remote-control system. It was also not easy to say that their expertise would be acknowledged and used in designing maritime technology. Moreover, the systems developers adopted a concept called "human-in-the-loop" anyway, which meant that the machines would interact without human assistance, and human operators would simply serve as a backup if a problem arises.

This concern was not unique. In 2018, the same worry about remote-control systems was expressed by maritime educators. These educators expressed their concern during a conference on upgrading the skills of maritime operators for digitalization in the future. In a panel discussion, several educators questioned remote-control operations and worried that no one knew how to teach the technology as no one had actual experiences using it. Although the educators believed that re-training themselves was needed, they did not believe that the simulator-based system was the best solution. In addition, although the educators said they might be re-trained, systematic training was not available. Simply put, remote-control systems have yet to be fully delivered to users. The work was mainly conducted in engineering projects firms, and only systems developers ran the design work. However, systems developers assumed that they had knowledge of remote-control technology, and that it was less important to observe current maritime operations or consider the concerns raised by other stakeholders. During a design workshop at a company held during the autumn of 2018, a question was asked: *"What was the purpose of the remote-control technology?"* One system developer replied that a remote-control system aimed to replace human beings on board due to the unsafe operations brought about by human errors. In this case, human operators must be relocated on land to learn new abilities to control an object that they would not actually touch. Another concern was also raised at this point: the cybersecurity issue.

The answer was not convincing, as the skills referred to by the systems developer were not clear. The developer was asked about the new skills, the issue of cybersecurity, and who would take responsibility for the control vessels. A satisfactory nswer was not given. Instead, the systems developer assumed that skills were about interaction. Operators must take responsibility for handling any problems and make decisions or interventions if needed. To give a reasonable answer, the systems developer guided the researcher to a lab, in which a huge screen with much information was presented. A systems developer sitting in front of the screen brought out four small screens to simulate a case. The case was about a vessel that was remotely controlled but under attack from unknown hackers. The systems developer said he would lose control of the vessel, so he was finding ways to solve the problem. The solution was to protect the user interfaces through developed software. Using the mouse, the systems developer opened a software application and ran it to protect his user interfaces. The developers believed that it was a method related to remotely controlling a system and that no operators had had a chance to learn it. It was not surprising that systems developers expected to train everyone to use the new technology. However, it was strange that operators needed to be trained to click a software application to protect the vessel.

In terms of other factors, such as the weather, waves, and swimmers in the fjord, if the simulation was not real, why would educators worry about training? Operators could become familiar with the interaction styles in the new technology. However, although the educators were eager to welcome remote-control systems, they often mentioned that their goal was to obtain educational funding and not improved outcomes of their teaching and students' learning. They said nothing about learning how to interact with computers. However, this is not new in maritime studies. When the researcher discussed this issue with an educator at another conference in 2019, the educator replied that simulator-based training was a kind of computer game and not a true operation at all. Thus, the whole shipping industry may have misunderstood a basic question: "*What learning outcome and what level do we expect to achieve in simulator-based training*?"

Interestingly, the educator knew it might be questionable to accept the systems developers' proposal to conduct training with simulators. However, the entire maritime domain seems to follow the systems developers' wishes. The educator cannot challenge that value. Although the researcher tried to play a mediating role between the engineers and operators, there were invisible hands pushing for engineering projects to be conducted as quickly as possible.

B. The Role and Activities of the CSCW Researcher in Implementation for Design

The scenario above indicates that intervening directly in the design process is difficult. This situation is not like an empirical study conducted before the actual design process has begun. In the maritime domain, systems developers assume that software and computer systems follow mathematical models, but this assumption is incorrect [46]. In 2019, by chance, the researcher was able to observe the application process for innovative educational programs for maritime studies. There was a call for applications by nautical science departments at universities to use a bottom-up approach to position students in the center of designing new study programs. The objective of the call was to establish an ecosystem to support life-long relationships among technology, engineering companies, educational institutions, and most importantly, operators. As the researcher was engaged with the educators, he invited systems developers during the application process and wanted to contribute to making the voices of operators heard. However, it did not happen in the beginning, because how they would react to such a call was vital. In that case, the researcher might help with translated CSCW insights in the following workshop with systems developers. In CSCW research, balancing outsider–insider roles and avoiding inserting the researcher's biases into the project are important. Although CSCW insights may help design technology, it is unclear whether those insights would pose difficulties for systems developers, challenge their professional expertise, or even interfere with their work on the ground. The same applies to working with educators. In addition to using CSCW insights to shape technology design, the intention is to scrutinize the usefulness of such insights outside the CSCW community. The power relations between different stakeholders could be balanced by their own interests rather than by an external force, such as the role of the researcher in the present project. Thus, instead of interviewing the stakeholders, as most ethnographers would have done, a few challenging, structured questions were asked, with the aim of fostering a new way of thinking about design.

The researcher participated in a design workshop again in 2019, in which the systems developers were asked how they understood a bottom-up approach in the design process. The goal of the researcher was to investigate how CSCW insights can be used in engineering project. There were no clear answers. However, no one doubts that in systems developers' eyes, a user is the person who pays for the project: the shipowner. During the dialogue in the workshop, the operators were not mentioned even once. The researcher reflected on the fact that multidisciplinary design is a challenge that requires the reconciliation of diverging design perspectives [47]. Although software engineers and CSCW researchers in software design projects in the CSCW community can share and integrate their viewpoints in the design process, such a process could still miss important aspects of the design problem [48]. If that were the case in the CSCW community, then this would also apply to the engineering field [49]. Systems developers lacked the ability to demonstrate the effects of their design concepts because of their insufficient thinking and reflection about such effects. CSCW researchers may also be unaware that systems developers are also the end-users of CSCW insights. In line with these arguments, during the workshop, the researcher translated what he observed from the remote-control design into Use Case techniques. A diagram-based description [15] of the system was used to show the systems developers how operators work in reality and how current systems failed to support the operators' work. If we are trying to move cooperative work on board to the land control room, we must support their natural work practices as they are offshore. Then other technical considerations, such as cybersecurity, will make sense to operators. In this case, systems functions for the needs of products fully respect the expertise and professions of the operators. The final component, training through simulators (a colon version of a true remote-control center) could answer the educator's question: *"What is the final outcome of learning?"*

This workshop was successful. The systems developers were happy to design together with the researcher, and they stated that this workshop was different from other CSCW research in which only storytelling was delivered. In this workshop, the researcher stood in their situations to discuss with them how systems functions could be designed from the stretch. The researcher was not just a researcher in the project; he also played roles as a systems developer and an operator to draw a comprehensive image of maritime operations—something that no systems developer has ever experienced.

For CSCW researchers in the maritime domain, the work is about breaking the circular relationship: "shipowner–engineering designer–shipowner." In the article "Located Accountabilities in Technology Production," Suchman reflected on her experience in addressing a similar problem as *"a central dilemma of CSCW researchers' participation in increasingly complex divisions of labor and professional specialization were the layers of mediation between each of us and the consequences of our work"* [50]. Although it was the responsibility of the research to the process of technology production, the researcher, his or her participation, of course, can break the relationship into pieces. The question for the systems developers was about investigating whether they wanted to take responsibility for tracing the usefulness of the production. However, they simply hand off the production after delivery, and they might never revisit it until someone requests updates or changes. In the present study, one of the systems developers discussed the following with the researcher privately after the conference: *"The whole industry works in a mechanism like a design-test-deliver-maintenance loop. It is about business. Our motto is that users know very little about what they do and what they want."* This is not, however, a convincing explanation. Bannon [51] warned that users are as professional as anyone else about their workplace and tasks in designing computer systems. They have an insiders' overview of their work and the tools (including technology) that assist them.

CSCW researchers are challenged in thinking about how to assemble different insights to propose balance between design and use. According to Suchman, she dwelt uncomfortably in the gap between design and use for many years in the 1980s. Trying to find a balance between design and use forced her to think about her role in technology design projects. She concluded that she, as an anthropologist of technology, could only translate her practice into design terms. However, because of the division of professional labor, the problem was caused by neither her ability nor that of the design team [50].

After studying the maritime domain for several years, the researcher's feeling is different. As the researcher is part of the new generation of CSCW research, the origin of the problem is known: the mismatch of design problems across multiple disciplines, such as design, science, and engineering. We also knew where, when, and how to contribute to a project to benefit everyone. However, we could not fully address the issue. The reason was not the capability but the role of the CSCW researchers in the projects: There was simply no chance to intervene in the design process from the very beginning. Due to the rapid marketing changes and technological development in the shipping industry, technology companies would like to respond quickly to shipowners' expectations. Thus, CSCW researchers will always intervene late in a project. In fact, in the worst cases, CSCW researchers are expected to focus on how their studies can be used in future projects based on the results of investigating current technology. However, could this also be a good chance to make a contribution?

On this occasion, the situation was changed. Although no one has actually developed remote control, for various reasons, researchers could intervene during an early stage to learn how to position themselves in potential projects. In this case, the researcher must be sensitive about the ongoing discussion in the industry, as well as the intersection between engineering departments at various research institutions and project funding organizations.

Thus, when continually asked whether systems developers can predict the future of remote control, none could provide a definite reply. Instead, the chief developer said there were too few opportunities for them to learn from the operators. The systems developers knew where to gain knowledge, but they chose to ignore the chance because they had very limited time to read the thick and rich descriptions written by CSCW researchers. When the researcher was continually asking and inviting operators to design workshops, however, recruiting even one participant became a challenge due to various reasons. Although the operators did not accept the invitation, they seemed happy that their messages were delivered through the study. However, to some degree, it seemed that the researcher not only managed to get the developers to accept the idea that other opinions are also important in technology design but also inspired systems developers to read the diagram-based design texts to work from scratch. Moreover, the researcher inspired the operators to share their experiences and expertise with others. The researcher unconsciously stepped into the project to play the two roles of designer (i.e., guiding systems developers) and user (i.e., inspiring operators). On several occasions, the researcher formatted and reformatted the ideas and opinions of the operators, educators, and systems developers, and even his own reflections, into a language game [19] between investigation and design [41].

C. Evaluating the CSCW Research Outcomes as Contributions to Implementation for Design

Including only operators, educators, and systems developers in this study was not enough. As previously stated, the design requirements are given by shipowners. Without their participation, the design work would be unrealistic, and there would be problems if requirement conflicts arose among the operators, educators, and shipowners. The research results were documented in various formats. However, considering the differences between traditions in CSCW research across the Atlantic, it is notable that a few previous studies concentrated on how cooperative technologies could be created with a focus on articulating the work of users [52], as in the European CSCW tradition. Some studies focused on how to intervene in the design process and how such an intervention is implemented in design [18]. In interviews with Volker Wulf and Myriam, Lewkowicz, Richter, and Koch [53] observed that the term practice-based CSCW was descriptive. Lewkowicz argued that the importance of CSCW was that it enabled designers and social scientists to use the same communication channel. However, the researcher of the present work does not fully agree, because according to many CSCW studies, at least in the European context, the true design process is conducted by systems developers. Thus, it would be questionable how an intervention could be implemented realistically without a monitor. Moreover, most CSCW researchers have evaluated the outcome of the design, which can actually be seen as the performance of technology. However, only a few studies utilized CSCW insights during the engineering design process. The problem of how we can evaluate the quality of the CSCW research in engineering projects, that is, the design work in connection with CSCW research, remains.

Bratteteig and Wagner [54], in the field of participatory design, asked the following question: *"What is a participatory design result?"* They argued that *"[i]deally, a project outcome should be evaluated in a real-use situation when users have had a chance to integrate it into whatever they are doing and (eventually) develop a new form of practice"* (p. 142). As a participant in designing remote control systems, did the researcher improve the knowledge of the systems that are supposed to be designed? Through the activities to assemble participants, did the research introduce a better "tool" for all stakeholders in the projects? Did it inspire them to understand that all their voices were important (but no one had priority)? Similar to the reply of the chief developer, they acknowledged that without information from operators, it would be impossible to ensure the quality of remote-control systems in the future. The educators replied in a similar manner. Therefore, to evaluate the quality of the CSCW research in the engineering project, the researcher interviewed three shipowners at their offices at different times from August 2019 to February 2020. The aim was to enable them to develop a realistic expectation of remote control and evaluate CSCW research in engineering projects from an outsider's point of view. In turn, it was also an opportunity for the researcher to communicate his descriptive findings in a language that might not be difficult for outsiders to understand. Videos of several cases based on fieldwork conducted in 2015 and 2018 at sea and in land-based simulators were shown to the owners. The shipowners expressed their astonishment after they watched those videos. They saw a great difference between realistic operations and training using simulators. Although they all invested money in training courses for the operators, after seeing the videos, the owners expressed uncertainty as they addressed the usefulness of the current training programs. It seemed no one was sure that there was a link between training and real work in ensuring safer operations. However, everyone wanted to hear from the operators, at least the most experienced ones, and recognize their voices in decision making about technology design, including decisions about material artefacts on board (e.g., dynamic positioning systems).

In February 2020, while talking with the operators and educators during a seminar in Athens, both were offered a chance to participate in designing a remote-control system. A positive answer was given this time: *"If that could happen, it would be great that we were not just treated as tools. We do not need to bind ourselves to the terms and conditions offered by systems developers through their productions. We will not outsource our decision-making and capabilities to someone who has no knowledge of our business. We are the core elements of technology*."

Today, operators, educators, and shipowners gather in public and in private to discuss their opinions regarding design. One example is the joint call for proposals funded by the Education, Audio-Visual and Culture Executive Agency (EACEA) of the European Commission, the European Shipowner Association, and the European Transportation Workers' Foundation. They are meant to develop a bottom-up approach and a learner-centered, lifelong action plan involving education, research, shipping, and maritime technology, which are considered vital and mandatory [55] [56]. It seems timely for the maritime domain to respond to such calls rather than for the researcher to work on re-assembling them. In this way, the CSCW research work will not only describe the bottlenecks of the designed systems but also will become truly engaged in design work, representing knowledge from operators, the other stakeholders, and most importantly, the language games of the CSCW researchers.

VI. Discussion: Stakeholders' Design and Reform Design Policy of Engineering Projects

Being a CSCW researcher is about helping design stakeholders and shaping the work policy of the projects. It is about guiding various user activities to help CSCW researchers and project stakeholders comply with communication and facilitate research activities at the same time. Traditionally, however, CSCW researchers have not yet gained sufficient experience to do both jobs. The researchers mainly focus on reporting what is going on in the field, but somehow fail to technically shape the direction of the project to support cooperative work and privilege local knowledge from all stakeholders. In this section, a reflection from the experience of designing maritime technology is presented. The CSCW researcher is involved in the process of co-investigation and co-participation, and is a co-subject of the change and evaluation activities of the engineering projects. Through the experience, it is important to reflect stakeholders' design and the roles of CSCW researchers in shaping research policies and activities in various engineering projects.

A. Stakeholders' Design

User participation is currently being discussed in the CSCW community. Thus, it is essential for CSCW researchers to involve end-users, particularly weak parties - operators, during the design process [54]. Thus, CSCW researchers bring invaluable discussion on how to inform design to meet users' needs or in CSCW terms, the "usefulness of the technology" [57]. This discussion is similar to participatory design researchers' argument regarding the evaluation of the outcomes after participation.

However, CSCW researchers might have traditionally overlooked systems developers as end-users. In addition, shipowners are end-users, too. Thus, how can CSCW researchers balance all the interests of different stakeholders to achieve a good design outcome? Bratteteig and Wagner [54] asked the same question in participatory design research (i.e., *"Should researchers take sides in a project?"*). This question is relevant to the CSCW community. Traditionally, CSCW researchers have not been involved in the political issues surrounding design projects. Thus, can CSCW researchers represent different interests for an effective design solution?

In the present study on remote-control systems, the researcher took one side. In the beginning, the researcher started the fieldwork at sea to learn how operators work and see what was actually happening. After half a year, it was clear that the operators were not following the work procedures as instructed by systems developers on land. The stories and observations from the sea pushed the researcher to think about his role in the project. The question was, *"As a CSCW researcher, am I learning at sea and informing myself to develop systems to support cooperative work for the operators?"* As stated in the beginning of this paper, it was not as simple as the researcher supposed. Control theory, automation, and many related fields are the core concepts in the maritime domain. Although the researcher's background was in software engineering, this helped only with understanding some basic principles of designing maritime technology in the very beginning.

After a few field studies, the researcher's role shifted from a systems designer to a facilitator. Informing design was out of the scope of the CSCW researcher; instead, the important task was to convince systems developers to use CSCW insights from the field in a practical sense. This led the researcher to work on translating the insights into language that might be familiar to developers. The translations of the CSCW insights should be seen as activities and reactions that were clear-cut and transparent [20], just as the CSCW researcher did in the present project (i.e., gathering participants and evaluating his own work from a non-CSCW viewpoint). In that case, CSCW peers can recognize in these simple process forms of language not separated by a break from our more complicated ones.

Thanks to the multidisciplinary background, this translation work was not difficult, but it still required the CSCW researcher to spend some time understanding how systems developers work. This translation work also pushed the researcher to jump from the CSCW community to seek an external evaluation within the engineering project regarding the quality of CSCW research. For example, through several workshops from 2016 to 2019, a brighter picture of systems developers' work practices emerged. Not surprisingly, systems developers in the maritime domain perform the same tasks as the software engineers. Their work involves following orders from the project owners and carrying out their own work habits. Operators are not truly "users," as their work is to respond to the requests of the owners via the fastest and cheapest approach. Systems developers stated, "*The whole industry works in a mechanism like a design-test-deliver-maintenance loop.*" The researcher learned that knowledge from the participatory design field might help.

To involve participants to achieve a win-win situation [58], the researcher considered that a design process should respect the operators' cooperative work, as well as respect the systems developers' work practices. Additionally, the process must gain support from shipowners and show them that there is room for improvement if they want a safer and better workplace for the operators. In addition, if shipowners want more professional operators, the owners need to know who might have first-hand knowledge in the field. Although such knowledge might not be directly useable by systems developers, at least shipowners should acknowledge that the maritime technology might not be as good as they believe.

These relationships among systems developers, operators, educators, and shipowners helped the researcher draw a picture of the complexities of designing maritime technology. User involvement and the desire to understand work practices and processes are different. The researcher realized that it should be the responsibility of the CSCW community to coordinate all the considerations from various participants so that they all fit with their production and to come up with a schedule of completion for a design project [59]. The engineering project team had various types of knowledge about the work of users in the maritime domain. This was a side taken by the researcher to allocate the different interests and lead the communication to drive the design progress. Achieving good design in an engineering project seems to be a challenge for the new generation of CSCW community to balance the interests of stakeholders with better cooperative systems from the CSCW viewpoint. The decision making for a design process depends on how CSCW researchers lead the project with professional judgment based on several kinds of cooperation: between operators and maritime technologies, between operators and systems developers, between CSCW researchers and systems developers, and between CSCW researchers and project sponsors. Without this capability, it would be difficult for CSCW to step outside its own community.

Conducting CSCW research in engineering projects pushes a researcher to reflect on whether to keep the traditional CSCW work practices, focusing on the technology performance to support cooperative work, rather than adjusting the research to achieve the goal of creating something new by applying methodology against some design principle. However, the CSCW researcher may lose the chance to develop cooperative systems in the process. Carr [59, p. 9] states, "*The systems designers in either the instructional design or performance technology context must address issues of power and resistance, working with the leaders to help them see the hazards of leaving the users out.*" Thus, the present work with stakeholders might create an ideal design team and empower users to create visions apart from the agenda of the engineering project. Instead of controlling the stakeholders group, stakeholders must engage in the different takes of negotiating and working with the researcher toward a better maritime technology. This shift from expert systems developer in an engineering project to design facilitator exemplifies the design of systemic change movement, which facilitates the evaluation of CSCW insights and the work of CSCW researchers in engineering projects.

B. Shaping Engineering Projects with CSCW Insights

The dynamic role of CSCW researchers in an engineering project requires a long-term engagement in the investigated domain. Normally CSCW researchers must follow the domain effectiveness variables of performance and other indicators after one project is complete. In the present study, informing the design of a maritime technology should be successful outside the maritime context for which the technology has been developed. To achieve such a goal, CSCW researchers should provide a workable framework for generating and sharing sufficient knowledge about a solution that may be potentially transferred to other contexts. For example, when researchers discuss remote control and safety with shipowners, the researchers must know how to use their knowledge to tell the shipowners what can be done technologically and what should be avoided through the policies of the project. As Balka et al. [60] argued, developing a framework or tool to open up discussions about planning and implementation of information systems is important. This discussion is a step toward using CSCW insights to shape an engineering project, from the policy level to work practices.

For years, CSCW researchers have called for reforming policies through CSCW insights; however, researchers have had few opportunities to engage in political discussions and policy making [2][5]. In the present study, the researcher showed the possibility of shaping the policy of engineering projects through language games with systems developers, educators, and shipowners. He also used his knowledge to draft a scientific infrastructure and expertise [5] of the organizational complexities of distributed collaborative practices among systems developers, educators, shipowners, and operators. Using the form of CSCW insights into an engineering project, systems developers would no longer struggle to understand the effects of individual users and the ties of their own roles in the engineering projects with other stakeholders. The researcher removed the barriers of design models in the engineering fields and established crucial relationships among systems developers, operators, tools, and all aspects of practical work, thus demonstrating how CSCW can make a great contribution to supporting and improving policies, designs, and practices in engineering projects. This likely goes beyond the debate of power issues in participatory design research [54][58][61] (e.g., power to and power over [62][54]), but mainly addresses how CSCW researchers can use power as a leverage point [63] among stakeholders for designing engineering projects based on CSCW insights. Although the present work achieved a small success in shaping the engineering project, more studies can further explore how CSCW insights could guide policy making before the start of an engineering project.

VII. REFLECTION: BEING A REFLEXIVE INSIDER

This reflection may help CSCW peers understand the choice to combine reflexivity, language games, and CSCW research in exploring the maritime domain. The CSCW researcher is still active in the maritime domain and has helped introduce changes according to feedback based on observations, and where he must intervene to improve maritime technology. The intention of this combination is two-fold: 1) to deploy useful CSCW research in engineering projects, and 2) to contribute to CSCW research with practical feedback from the front line of engineering work. If the CSCW work on assembling participation and mediating outcomes between social and engineering phrases is a practical activity in language games, then the reflection on the roles and contributions of the researcher to the CSCW community is the highest achievement.

A. *Interest-driven CSCW Research in Maritime Design*

Nygaard and Bergo [64] suggested that designers, particularly participatory designers, take sides in considering the following: 1) improving the knowledge on which systems are built while aiming to build a better "tool" for users [60]; 2) enabling people to develop realistic expectations and reducing resistance to change [65]; and 3) increasing workplace democracy by giving the members of an organization the right to participate in decisions that are likely to affect their work [66]. Different from the objectives, the researcher does not side with operators, educators, shipowners, or systems developers. Nevertheless, the first two suggestions are firmly followed.

Eyal [67] warned that researchers must consider carefully who are the actual experts and who are the lay experts. As outsiders in the maritime domain, CSCW researchers may not have convincing expert judgment. Although all stakeholders have an interest in improving maritime technology, "better" is understood differently. For example, operators and educators believe that their experience and expertise are vital in remote-control systems. Systems developers rely heavily on their procedure-based design process. Shipowners seek to effectively invest in a project and reap the benefits. All these interests involve few or no political conflicts. In this case, how could CSCW researchers dare to say who is a better participant in designing remote control systems? The only certainty is that CSCW researchers can balance these interests and explore a design point via *languages* for system developers, and that such languages could represent all stakeholders in designing organizational frameworks for actions and in designing industrial relations [54]. However, unlike participatory designers who discuss political and policy contexts in design projects, CSCW researchers are interested in collaborating with systems developers to bridge the gap between CSCW research and CSCW design practice. Some CSCW researchers focus on recognizing various materials that have different qualities depending on how they are used in specific places as intervention areas. However, regardless of how the material is bounded through time and space in a cooperative work among stakeholders, it is completely static, irrespective of the execution of the coordination the material prescribes. Thus, CSCW researchers must consider that materials stipulate articulation work (e.g., a standard operating procedure in a social order) as an invention [68] and that such materials can be inscribed as a result (language games) of the delegation of social roles to nonhumans [69] and humans. In this manner, CSCW researchers can identify different aspects of interest in a design project and find the most appropriate engineering language (techniques) to translate the CSCW insights into various formats that can be understood by different stakeholders. Although the formats differ, the core interest of the engineering projects is held by CSCW researchers; thus, it is a "win-win" situation [58] that simplifies, rather than complicates, engineering projects. In this way, CSCW researchers can be spokespersons who address interactive relations among end-users (operators), artefacts, computer systems, systems developers, educators, and project sponsors (i.e., shipowners in the present study), thus improving their cooperation in such actor networks.

In the present case, as maritime technology becomes increasingly computer supported, the researcher feels that he has the responsibility to ensure that the final design benefits all stakeholders. By doing so, CSCW insights into designing maritime technology should be best used to change the mechanism of design in the maritime domain, including information technology [70]. In other words, stakeholders' insights do not pertain only to requirement specifications that inform design. By representing their interests, the researcher should trigger a *modus operandi* [15] for intervening in the project, which can be done by taking specific actions regarding when, where, and what forms in the design process to support interactive relationships between actors within the social–technical associations between humans and nonhumans. Such interactions are badly needed in engineering-oriented fields.

B. *Insider Roles Across Communities*

Regarding the issue of whether CSCW researchers could potentially address the social–technical gap, the CSCW community is divided. Some believe that it is possible, but others think that it will take a long time to achieve the division of what we knew socially and what we can support technically. Although some researchers advocate for intervention [18] as a solution, their peers remain uncertain about how to follow the "the guidelines" [37] owing to the lack of reflexivity in interpretive writing. In the present study, the researcher worked with a heterogeneous group. The work of CSCW goes beyond the CSCW accounts of epistemological and theoretical bases. Instead, we must understand not only the nature of the ethnographic encounter and its methodology but also the data sets collected in engineering work. Instead of discussing people as the objects of study through the so-called participant observation, the present study points out that CSCW researchers must take their own embodied experiences in the context of personal relationships to gain and exchange knowledge with stakeholders. It is not just a matter of methodology, such as writing detailed field notes and showing videos about practices. It is also a matter of relational epistemology in which a kind of language game is used to translate the CSCW insights into images that make sense to the stakeholders. Otherwise, if a CSCW study is inherently experiential, then it loses the voice in its writing, which in turn, limits our insights into the data and our ability to use them in design. Thus, a constant assessment of the relationship between knowledge and "the ways of doing knowledge" must be undertaken.

Positioning CSCW research in engineering projects also concerns reciprocal relationships with stakeholders [71]. In Beaulieu's [71] definition, the value of relationships in different fields in ethnographic studies goes beyond the central notion of face-to-face interaction to the co-presence with the ethnographer during the research. As the present study shows, the relationships among the stakeholders and between the stakeholders and the researcher had nothing to do with negotiating the conflicts of interest. Rather, the relationships among them were based on self-interest and then extended to integrate their willingness to participate in the network of actors. The participants all want their interests to be traceable and consistently represented by someone. The researcher of the present study coincidentally crossed various sites and moments during the research to successfully formulate representations that were useful to all. Perhaps another researcher could do the same.

Thus, a few years after completing the research work, the researcher feels that he has no value-neutral stance in his research work in the maritime domain. CSCW researchers should make themselves explicit to stakeholders so that the latter can better understand their own interests, which, along with their reasons and motivations, are articulated by CSCW research. In this manner, CSCW researchers should make explicit their ideological assumptions to allow CSCW peers to see the world in which a researcher is embedded. Moreover, CSCW peers could create their own interpretations of the case study of engineering projects and reflect on their own assumptions and mindsets relative to the projects. On one hand, the purpose is to triangulate the sources of evidence with other peers although they use different contexts. Regardless of whether the context is the maritime domain or the healthcare domain, they all work with and within a heterogeneous group. In such cases, how should they share their reflexive insiders' views of epistemology and methodology in deploying CSCW insights in the design process? [39]. On the other hand, it is not a matter that only a CSCW researcher must address. It is also a matter of how CSCW researchers communicate with others, i.e., a way of creating opportunities to participate in an engineering project as early as possible. In the present study, the researcher, systems developers, and shipowners did not share the same mindsets in learning from experience. Thus, a dialogue between the three forms of knowledge helped promote mutual improvement and anchored the relevance of the CSCW research in policy making for design projects in the maritime domain. The change was created in the present work to influence epistemological assumptions, whereas the previous experience in the field influenced the dialogic process. It is likely that the best option is to position people (including the researcher) in the center when designing the usefulness of technology. Through the dialogue and the leverage point between stakeholders engaged in the research, it would be possible for peers to investigate and criticize the accounts of interventions, thus assessing whether the interpretations are valid.

C. Connecting Communities of Practice

Owing to the unique background of the researcher in the present work, his involvement in a group designing maritime technology was more than a quest to improve current design practices in multidisciplinary fields. To make sense of the problems, the researcher faced the issues in the maritime domain and attempted to create something new. Representing the group of practitioners–researchers in systems design, CSCW research is different in the engineering field, not only because it is new but also because it is considered a foreign element that is typically rejected by a group of professionals. The nature of the work practice of a professional community is to transform the status quo by new ways of working and interacting rather than by accommodating a completely new element. CSCW insights are examples in the present study.

Jackson et al. [5] proposed that CSCW has fewer concerns about translating its theoretical knowledge into forms and instruments that can be used by wider communities. The researcher initially faced similar challenges while working on the design of maritime technology, in which remote-control systems comprised only one of several design projects. The new generation of CSCW researchers may be different from the first-generation predecessors in that the former know about human-centered computing, how to do fieldwork, and how to translate their findings into special formats that can be easily communicated to systems developers [7]. However, the new generation of CSCW researchers may miss long-term engagement and design-sensitive analysis in dealing with their reflections on how they connect different communities. Most CSCW research is iterative in terms of the design process and does not challenge the lack of reflective voices [45] in the community. When researchers seek intervention as a bridge between research and practice, they might fall into their existing cognitive knowledge and create their own artificial worlds as they seek their own language in doing design. They may focus on exploring the inner symbolic space of a paradigm and try to convince others to believe that their languages are universal and useful. This, however, might be wrong.

If they do not accept procedure-oriented engineering work, is it correct to assume that CSCW can provide a solution? Suchman [72] suggested that we might need to find a customized solution rather than a universal solution for each engineering project. The challenge behind this idea is not only the cognitive aspect of engineering work and CSCW research. Rather, it requires the development of radically new forms of scientific inquiry. In this article, the researcher reported and discussed his theoretical struggles and success in interpretive empirical research to fulfill the forms of scientific inquiry in connecting communities of practice. In a heterogeneous group, collaboration in designing a remote-control system is not a straightforward process. When reading the CSCW literature, the researcher always turns on the software engineer mode to review praxis [40]. It is quite a challenge. Although he holds two sets of knowledge (CSCW and software engineering), he should have different perspectives on what has been read and should be considered equal contributions to knowledge. However, in a heterogeneous group, this inner attribute of his CSCW knowledge becomes both “he/him” and “others.” This is because the designer of remote-control systems is not the CSCW researcher or the CSCW practitioner. Instead, most of the work still depends on control engineering principles, and the scientific inquiry entails extensive empirical data and practical requirements, as well as a theoretical framework that might be perceived as disconnected from social construction [73]. Thus, for a CSCW researcher who has been uniquely trained in two fields, working in the complete unstructured maritime domain is a challenge. CSCW researchers must give their peers the tools to criticize their accounts of the work practice in the workplace. The researchers also need to play language games with systems developers to investigate the usefulness of the contribution from the CSCW perspective.

In the present work, although no one forced the researcher to make notes and work-in-progress drafts made available to all members of the project, he realized that opening up the data sets helped fulfill hermeneutic cycles and multiple interpretations. In interviews with systems developers, the CSCW perspective of maritime technology led to further discussions. Thus, multiple interpretations of the benefits and why the project should design alternatives became possible. The CSCW approach also made it possible for the systems developers, operators, educators, and shipowners to discuss the situation and switch from a cooperative project in which everyone had his or her own spot to engage in truly collaborative work. Moreover, the systems developers and the CSCW researchers recognized the value of reflectivity and language games. This is important in the discipline of design within CSCW and engineering. All stakeholders of the engineering projects could find a way forward to be comfortable with the various interests presented and reflect on them via a language game to find the optimal solution.

VIII. Conclusion

This paper discussed the use of reflexivity and language games in CSCW research when working across different communities. A case study of reassembling participation to improve the design of remote-control systems for all stakeholders was used as the background story. The reflective writing in this article offers a view of how CSCW insights and engineering practices have been transformed during the engagement of the CSCW researcher in designing maritime technology. In the last seven years, the CSCW interpretation of designing maritime technology suffered from blind spots.

However, following interpretive research and the knowledge and experience gained in CSCW research, the reward was not the creation of meaningful change. Instead, the reward came in the form of a better understanding of the challenges and opportunities related to bridging the gaps between applying CSCW insights and conducting research in CSCW within and outside the CSCW community to make real contributions to other fields.

As a result, the article suggests that the development of CSCW insights in the engineering fields should strongly focus on the participation of stakeholders, not only those who would use the technology but also those who fund and develop the technology. By doing so, CSCW researchers could learn more about self-reflection, self-revelation, and self-evaluation in making a contribution to the industry and the positive influence they may have in terms of encouraging policymakers to rethink framework development in the engineering field. In conducting research in the maritime domain, the CSCW researcher found that the best way is to reinterpret one's own research findings and activities and combine them in a wider scientific discourse by using the Wittgensteinian concept of the language games.

If intervention is an unavoidable condition of CSCW research in engineering projects, then by being there, the researcher could connect communities of practice and help make a difference by affecting the practice being studied. The case in this paper, the translation of the research work, the qualitative inquiry developed in the paper, and the reflective materials the researcher wrote are all tools that could serve the CSCW community and the community from which the CSCW insights emerged. The rest is up to others, within and outside the CSCW community, who want to confirm their own values to balance their position with the CSCW insights in their own work. As a result, the gap between research and practice within and outside CSCW research could be reduced.

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