The Practical Indispensability of Articulation Work to Immediate and Remote Help-giving

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ABSTRACT
This paper argues that the design of remote help-giving systems should be grounded in articulation work and the methodical ways in which help-givers and help-seekers coordinate their problem solving activities. We provide examples from ethnographic studies of both immediate and remote help-giving to explicate what we mean by articulation work and to tease out common and characteristic methods involved in help-seeking and the giving of expert advice. We then outline how emerging technologies might best be used to support articulation work in the design and development of systems for remote troubleshooting of devices with embedded computing capabilities.

Categories and Subject Descriptors
H.5.3 [Information Systems] Group and Organization Interfaces – *collaborative computing.*

General Terms
Design, Human Factors.

Keywords
Immediate and remote help-giving, ethnography, articulation work, methods.

1. INTRODUCTION
There are numerous circumstances in everyday life where problems arise that we cannot solve alone and which require that we appeal for assistance to other parties who possess a more comprehensive expertise. In and across such mundane activities as way finding [22], buying materials for home improvement projects [8], handling medical problems [1], and using technology [28], indeed across a veritable host of everyday activities, we routinely encounter practical troubles that we cannot solve alone.

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Just as routinely we bring the expertise of others to bear on our practical troubles in a variety of ways: we may call upon persons to hand to help us address the practical troubles we face, such as when we are trying to find a building or location in an unfamiliar place; we might take the trouble to an expert, taking our car to a garage, our stereo to an electrical engineer, or ourselves to a doctor, for example; alternatively we might bring the expert to the trouble, bringing a service engineer to the office or workplace; and in contemporary times, we might appeal to the expertise of someone who is at a physical and geographical remove from our troubles – a 'remote expert' as it were.

There has been rapid and large-scale growth in the delivery and support of remote expertise in both private and public sectors over recent years. In a commercial context, it has been suggested that this has led to the emergence of the 'new factories' [3] – service centres - which seek to cut the overheads of service providers and customers alike by reducing service visits to site. The development of the new factories has led to an emphasis being placed upon the provision of alternate and cheaper forms of assistance. Telephone support is the prominent method of delivering assistance at the current point in time, though this has been complemented by the development of help systems to support assisted and non-assisted help-giving [e.g., 2, 13].

In either case there is an assumption that help systems encode relevant information that is of use to help-seekers and help-givers. However, as Yamauchi et al. [31] note, this "often does not work in reality". The reason for this is that (with the exception of gesture-based systems) help systems are often based on idealized versions of organizational memory [30], which seek to encode in databases what troubles occur and procedures to solve them. However, as Kristoffersen et al. [15] note, "organizational memory involves rather more than 'storage bins' [or databases] … instead we suggest that organizational memory should be seen as a collection of socially organized activities done by persons in organizations; that is, 'remembering' as a defeasible achievement."

Kristoffersen et al. situate knowledge, information, and useful memory of it, in the practical accomplishment of socially organized or collaborative activity. This is not to neglect the role of technology to troubleshooting, but to draw attention to the ways in which help systems are indispensably bound up with social interaction and cooperative work. As Yamauchi et al. [31]

put it, "practitioners' use of documents, tools and conversations are intertwined", bound together by what Bowers and Martin [3] call "mechanisms of social interaction", through which "expertise is leveraged" [19].

It might otherwise be said that the use of help systems relies on *articulation work* in both an ordinary and technical sense. Ordinarily speaking, the use of help systems relies on articulation work insofar as their use is embedded in a temporally unfolding stream of talk that (if successful) illuminates problems and solutions. Technically speaking, that talk consists of and reflexively elaborates distinct methods or assemblages of work-practices [11] that provide for the collaborative specification of problems and the identification of potential solutions. These methods enable remote parties to coordinate their activities [24] and their explication is of value to the design of future systems to support the enterprise [4, 31]. Naturally, while we may make distinctions in analysis, in practice the ordinary and technical work of articulation are inseparable.

In this paper we seek to complement and extend efforts to understand the real world, real time nature of help-giving. We present the findings of ethnographic studies of the cooperative character of assistance in two distinct contexts: one immediate, a library where in the ordinary sense of the word, parties are in the same vicinity or co-located, and one remote, a print service call centre where parties are geographically distributed. While different in character, these settings reveal some essential collaborative features of help-giving that maintain across immediate and remote sites, particularly the articulation work involved in translating vernacular descriptions into technical descriptions that enable problems to be identified and candidate solutions to be proposed.

Our studies of articulation work in both its ordinary and technical sense make visible some essential socially organized features of help-giving that the use of help systems relies upon. What the studies show then, are how help systems are "made at home" [23] and come to reside in essential ways in the social or collaborative organization of help-giving. In turn, they furnish domain knowledge that may be exploited by the designers of expert systems in the future. They shed further light on the "artful methods" [31] that help-giving relies upon for its practical achievement and in such detail open up new possibilities for designers to address the communicative asymmetries that inhabit remote help-giving.

2. IMMEDIATE HELP-GIVING

Libraries have long been a site of technological development. Over their history bibliographic and indexing systems have evolved from printed to card catalogues and to the widespread implementation of the Online Public Access Catalogue (OPAC) in the early 1970's. OPAC systems were not originally designed for public use but for the management of public actions with regards to library content. The development of a professional field of Library and Information Services transformed the use of OPAC systems to provide widespread public access to information. This is a trend that continues today through the ongoing development of the digital library in the 21st Century.

Some years ago an ethnographic study of help-giving in physical libraries was conducted on behalf of the British Library Research and Innovation Centre to inform the development of digital libraries [6]. Particular attention was paid to collaboration at a university library's help desk. The help desk was organized into two distinct sections: one dealt with the mundane "supermarket work" involved in checking books in and out, the other with search inquiries and the management of restricted access materials. Help desk staff were members of other work teams, such as registration, reservations, cataloguing etc., to which they returned in between help desk work. Staff worked in both sections on a rota basis and characterized their job as one of "helping" or "giving assistance" to users. They described "a lot of the work" as consisting of "finding out what people want", as "getting details out of people", as "trying to find what they are looking for", or more generally and formally, as "filtering work".

Filtering work is a major part of the day's work at the help desk and essential to the accomplishment of searching in the library. The work that staff and library users together engage in to articulate their information requirements is considered here in details of their collaborative talk. Following Lynch [18], methodological emphasis is placed on the work that talk accomplishes, rather than the talk itself, to elaborate the artful methods help desk staff and library users engage in to develop concrete understandings of information requirements.

Library users often turn to the help desk for assistance when they are experiencing difficulties in finding materials that might satisfy their information requirements. In 'formulating' [11] or linguistically constructing a search query at the help desk, library users initially provide a 'specifically vague' description [10] of their information requirements. Specifically vague descriptions have a prospective sense. What they mean will become clear as the speaker and listener proceeds and in that sense they are vague. They are specific in the sense that they announce in the case of help-giving a problem topic that will be 'worked up' through prospective revisions. The following sequence of naturally occurring talk at the help desk involves two users (Sarah and Lisa) and one member of staff (Sylvia). Their talk makes available the work involved in revising specifically vague descriptions and working them up into technical descriptions that resonate with the library catalogue.

Fieldwork Extract #1.

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1. Sarah: Could you tell us where market - what
was it - market intelligence?
2. Lisa: Yeah.
3. Sarah: Market intelligence …
4. Sylvia: Marketing is C floor. (Points to OPAC
located at help desk) Do you know how to use the
screens?
5. Lisa: Yeah but …
6. Sylvia: You need to find the classmark for the
book.
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The provision or elicitation of a specifically vague description is the first action in an unfolding course of articulation work. Here the library users say that they are looking for something on 'market intelligence'. This is a very vague description insofar as it covers many things and so just what is wanted is not at all clear but, at the same time, and without contradiction, it is also specific and directed as the information required is, in some yet to be articulated way, nonetheless understood to be connected to 'marketing'. Library users furnish help desk staff with such descriptions as a matter of course, thereby circumscribing the search area as a legitimate area of inquiry. Failure to provide a legitimate topic of inquiry may and does result in the termination

of assistance. Specifically vague descriptions also work, then, to provide for the undertaking of a search in collaboration with an expert. In order to find and retrieve information that satisfies the users' information requirements however, the connection between the search area (e.g., marketing) and the information requirement, which is (in part) in the user's head, needs to be further articulated:

Fieldwork Extract #2.

Sylvia leaves the help desk, leads the two users to a free OPAC terminal nearby and initiates a 'title' search.
7. Lisa: It's not a book.
8. Sarah: It's like information, information about these particular products and services. It's called market intelligence and leisure intelligence et cetera et cetera.
9. Sylvia: And is that the name of …
10. Sarah: That's the name – market intelligence and leisure intelligence. It's not a book as such. It's usually in the reference library.
11. Sylvia: Is, is it a serial?
12. Lisa: Yeah.
13. Sylvia: It's a serial. Sylvia initiates a 'serial' search on OPAC.

As the talk makes available, articulating the connection between the circumscribed search area and the information requirement in the users' heads consists of a course of 'categorization work' in and through which descriptions are elicited and made intelligible in terms of the online catalogue's organization. In accomplishing this work, help desk staff and users together orient to and employ OPAC search categories to elicit and furnish library-relevant descriptions of the information requirement. Thus, over the course of OPAC use it is concertedly established by staff and users that the information requirement is not a book but a serial, which provides a rather more specific sense of just what is being searched for: not just something in the area of marketing but a marketing serial.

In terms of articulation work, the use of OPAC consists of the collaborative formulation of 'preliminary information requirement' categories (e.g., 'books', 'serials', 'journals', 'maps', 'tourist guides', and the rest). As a routine matter of work-practice, preliminary information requirement categories are, in turn, used collaboratively as resources for articulating the information requirement in even finer detail and, at the same time in such detail, for purposes of working up potential categories of candidate solution:

Fieldwork Extract #3.

14. Lisa: It's a journal.
15. Sarah: It's not so much a journal but it does come out every few months.
Sylvia browses the 'serial' search retrieval list.
16. Sylvia: Is it marketing intelligence and planning? Is that the one? Sylvia points to an item on the retrieval list.
17. Sylvia: T6 – it's a journal.
18. Sarah: No. It's not a journal.
19. Sylvia: Do you want to check at that and find the journal itself? Sylvia points to the item's classmark on the OPAC screen.
20. Sarah: Been there.
21. Sylvia: But have you actually looked at the classmark?
22. Lisa: Yes.
23. Sarah: Yes.
24. Sylvia: You've looked at that and it's not what you're looking for?
25. Sarah: It's not what I'm looking for.
26. Sylvia: Right. But that's the title of the book you're looking for - marketing intelligence?
27. Sarah: Market intelligence, and its got a list of all the products and services - its basically a reference book - and it tells you about particular market products and services and what to look for.
28. Sylvia: You've checked in the reference area?
29. Lisa: Well, no.
30. Sylvia: Right.
Sylvia takes the users to the reference area, returning alone to the help desk some three or four minutes later.
30. Staff: What was it she wanted? What did she ask for?
31. Sylvia: Marketing intelligence.
32. Staff: Marketing intelligence?
33. Sylvia: Which is a joke [inaudible]. She didn't want that. I eventually got out of her that it was breweries, which we've got in the reference area.

Articulating the information requirement in even finer detail consists of establishing a more precise sense of just what is being searched for. In terms of articulation work, establishing a more precise sense of just what's being searched for consists of the joint formulation of more 'specific information requirement' categories. Although a marketing serial is being searched for, it is concertedly established in orienting to and working on the basis of preliminary information requirement categories that the information required is not in a 'journal' but a 'reference book'. With this information in hand, staff can act appropriately, in this case taking the users to the marketing section of the reference area in the library and thus to a finite collection of potentially relevant materials.

2.1 Some Salient Features

The formal notion of filtering work used by staff to characterize help-giving derives from academic studies of intermediated assistance in the library, and from the canonical work of Robert Taylor in particular [27]. Taylor noted in his studies that help-desk staff have developed "rather sophisticated methods of interrogating users". Furthermore,

> *"These methods are difficult to describe, indeed some believe they are indescribable … [Because] we are dealing here, of course, with a very subtle problem – how one person tries to find out what another person wants to know, when the latter cannot describe the need precisely … The negotiation of reference questions is one of the most complex acts of human communication. In this act, one person tries to describe for another person not something he knows, but rather something he doesn't know."*

We think there is some generality to help-desk staff's predicament. That is, that help-desk staff in other settings find themselves in a similar situation and that the situation of help-giving is often characterized by one person (the help-seeker) trying to describe not something they know but something they do not know. There is a practical need, then, for help desk staff to transform descriptions of things not known into descriptions of things known by the help-giver so that problems and solutions might be identified.

In the context of the library help desk, Taylor suggested that user descriptions are transformed by passing them through a series of cognitive filters to make them 'fit' the library catalogue. The

work of transformation is done to *translate* the vernacular descriptions of non-experts into technical descriptions and this too is a generic feature of help-giving in settings where specialized language-games [7], such as the Dewey Decimal Classification system used in libraries, are at work. Furthermore the work of filtering, whether cognitively [27] or technologically construed [31] is done through 'sophisticated' or 'artful' methods of interrogation. As a result of pursuing an explanatory programme of work [25] Taylor never specified what these methods consist of, however. Consequently, we cannot see in Taylor's account what they look like, or how they work to filter user descriptions and transform them into technical descriptions which afford the identification of candidate solutions to the problem to hand.

The study of help-giving in the library shows something of what those methods look like. They consist of furnishing specifically vague descriptions, which announce problem topics and warrant assistance. These descriptions are in turn prospectively revised and translated through a course of categorization work, which is concerned with the collaborative formulation of preliminary and specific information requirement categories. The production of these categories enables users and librarians alike to focus down on a manageable and sufficiently small collection of information in the library catalogue and from that point, to identify and extract information of personal relevance to the user.

It is through these methods that problems and solutions are articulated, both in an ordinary and technical sense. Ordinarily speaking, these methods enable staff and users to illuminate their information requirements in a way that resonates with the organization of the library catalogue and which thereby permits the identification of candidate solutions. Technically speaking these methods enable staff and users to coordinate their problem-solving activities. Through the formulation of specifically vague descriptions and subsequent categorization work, staff and users orchestrate the collaborative achievement of help-giving in the library.

It is also worth noting that in the course of accomplishing help-giving, the OPAC system is used in ways it was not designed for. As in other settings [e.g., 12], OPAC (which has been designed as a single user system) is intentionally employed by staff and library users as a collaborative resource that may be exploited to articulate problems and solutions. While intentional this is an improvised or serendipitous use. It is also critical as it provides a shared object which staff and users mutually orient to and exploit to order their interactions and work up increasingly more precise information requirement categories to resolve the practical troubles to hand [5].

3. REMOTE HELP-GIVING

In the second ethnographic study we examine the work of remote technical troubleshooting of office devices. The study took place in one of the call centres of a large printer manufacturing company. The call centre in question is the first point of contact for all of the company's customers and technical support in most European countries. Calls are allocated to particular troubleshooters with appropriate language skills and product experience. The troubleshooters use a range of online resources to support their troubleshooting, the most central being a knowledge base, containing a range of cases and solutions for the devices, and a call management system (CMS) with the customer's records for handling the details of the call. Different levels of compulsion are associated with different technical resources, for example troubleshooters must use the CMS to manage the customer's record, whereas they should but do not always use the knowledge base. The following extracts, taken from a single call, show routine features of troubleshooting.[1]

Fieldwork Extract #4.

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Troubleshooter: OK, and what's the problem you're
having with the machine?
Customer: I'm getting poor quality prints - sort
of smudges on them.
Troubleshooter accesses knowledge base and selects
'image quality'.
Troubleshooter: When it's printing?
Customer: Yes.
Troubleshooter: OK, do you get this when it's
copying?
Troubleshooter: So you get it printing and copying
and they're like smudges?
Troubleshooter selects 'smears and smudges' in
knowledge base.
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The troubleshooter asks the customer to describe the problem with their machine. As in the library, the customer does not fully articulate the problem in their initial formulation. Rather, their initial problem description is partial, symptomatic and vernacular. For the troubleshooter to be able to help the customer, they need to collaboratively work up an articulation of the device problem such that they can reach a point where candidate solutions can be identified and put into practice. The sequence of articulation work that follows the initial formulation is designed to reformulate and develop the customer's report of the problem into a more specific and technical understanding for which solutions can be seen as relevant. The troubleshooter sets about transforming the customer's description to fit the knowledge base.

Cases in the knowledge base can either be found by keyword search or by using the side-bars which link to various categories of problem type. In this case the trouble-shooter uses the side-bars and chooses the category 'image quality', which is later refined with the more specific category of 'smears and smudges'. Troubleshooters mediate between the customer and the technology, by which we mean both the knowledge base itself and the more general technical understandings of the ailing device required for printer repair, transforming customers' accounts of their problems into suitable technical understandings for which solutions can be derived. In part this involves translating customers' language into the terms of the knowledge base but this work goes beyond that, transforming these initial understandings into the language of the troubleshooting domain.

Fieldwork Extract #5.

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Troubleshooter: OK, now do you get that whether
you use the document feeder or whether you place
the original on the glass or from both?
Troubleshooter: OK, you just need to put a copy on
the glass just to see if you actually get it on
the glass as well and if you could just - do you
have the image counts of your xerographic and your
fuser modules
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[1] For legal reasons only the troubleshooter's side of the call was recorded on audio. The customer side was recorded in the ethnographer's field notes. Consequently, the customer's talk is not verbatim and some customer turns are not recorded. Where customer turns were not recorded, a series of troubleshooter turns are shown.

Troubleshooter: You know your image counts, which is the amount in thousands of copies that the xerographic and fuser module have done, check them just to see if they're running over their copy limit and causing that problem for you.
Troubleshooter: Of course, yeah, take your time, that's fine.
48 second pause.
Customer: Where do I find them?
Troubleshooter describes how to use the menus to find the counts and customer goes to find them. 70 second pause.

As with the library study the customer does not come with a ready understanding of what exactly is wrong. Rather, initial descriptions are worked up into a more precise understanding of what constitutes the problem. This is done though a process of reformulation and questioning to delve deeper into the problem and its features (e.g., just when does it occur?). This 'working up' often requires the customer to perform some actions on the machine, such as doing tests or taking readings, and relaying the results. The troubleshooter here asks the customer to test whether the problem occurs when making copies as well as when printing and asks the customer to locate additional information, stored on the machine, which will help with the diagnosis of the problem.

Just as the troubleshooter mediates between the customer and the knowledge base, the customer must mediate between the troubleshooter and the machine in the exploration of the problem and its rectification. Since the device is not mutually available or shared, the troubleshooter is dependent on the user carrying out diagnostic actions on the machine and feeding back the results to identify candidate problems and their solution. This involves articulation work in both its ordinary and its technical guises. In the ordinary sense articulation work here focuses on transforming the technical language and concepts of the knowledge base and printer repair so that they become understandable for the customer. The troubleshooter for example begins by asking the customer for "the image counts of your xerographic and your fuser modules" and then explains what this means and where to find them. Technically, there is the necessity to coordinate the customer's and troubleshooter's actions to find such information. To do this the troubleshooter needs to provide the customer with intelligible instructions and the customer has to follow them, despite their being remotely located.

Fieldwork Extract #6.
Troubleshooter: Hi, that's from your fuser module (writes down count).
Troubleshooter: OK could you - do you know where the xerographic module is in the machine?
Troubleshooter: OK, I'll tell you exactly where it is as there's something I want you to try, just to see if this will rectify the problem for you - if you open the front door of the machine …
The proposed solution does not work and an engineer is called out.

Once the troubleshooter has enough information about a potential problem she describes a candidate solution for the customer to try. Whereas the librarian can go with the customer to the shelves to identify the relevant material and solve the problem, the troubleshooter must verbally instruct customers in the actions that need to be carried out to clarify the problem and remedy it.

3.1 Some Salient Features

Naturally, customers often lack technical knowledge of the machines they use and have a limited understanding of how one might get from the observed features of a problem to some sort of solution. Customers know what the problem is insomuch as it manifests itself to them: they know what they were doing at the time; they can hear funny sounds, see funny print outs, and so on. However, customers rarely know what the observable features of a problem mean in terms of a technical specification from which candidate solutions can begin to be determined. As with the library study, initial formulations are a starting point for further exploration. Exactly what constitutes a problem formulation which will be adequate for the troubleshooters is not something the customers can know in advance, and like the library help-desk staff, troubleshooters have to translate advice-seekers' formulations into the language of the expert domain and the constraints of the expert technology.

In the example presented here the troubleshooter, like the librarian, employs categories to define the problem in the knowledge base. It is not always the case that troubleshooters engage in such explicit categorization work. Whereas the categorization work is an integral part of the problem solving in the library study, in the troubleshooting study this categorization work is opaque to the customer. Although both the librarian and the troubleshooter mediate between the customer and technology, a difference between the two studies arises from the *how* the technology is used in remote help-giving. That is, in how articulation work takes place around the resources available. We can see how the library catalogue was used as a tool to support articulation work, where both the customer and the librarian mutually orient to the categories (e.g., book, journal, etc,) provided by the technology. By coordinating their actions and interactions around the catalogue they are able to better specify the information request.

In the troubleshooting study the technology is *not* a shared resource, however. It is only shared insomuch as it is made available to the customer by the troubleshooter and, both in this call and more generally, troubleshooters tend not to make the use of the knowledge base apparent to the customer. Rather, troubleshooters weave the use of the knowledge base seamlessly into the interaction: asking common questions before they arise; searching while the customer is talking, and so on. Thus the knowledge base cannot be used as a tool to explicitly support articulation work and the customer cannot refute the troubleshooter's translations as used in the knowledge base except where they are offered up to him. The knowledge base still shapes the interaction but is no longer used as a shared resource around which the interaction can directly focus then, and it becomes the troubleshooter's burden to articulate the problem in technical terms, identify candidate solutions from experience or by finding them in the knowledge base, and to direct the user to effect them.

Furthermore, in the library the librarian undertook the search with the users, both using OPAC and going to the shelves with them. In a remote context the customer must undertake the troubleshooter requests themselves, however. Although the librarian may try to get the customer to do the work themselves, if direction is not enough they can *show* the customer what to do. The trouble-shooter must rely on talk, describing and explaining to the customer any required actions. Just as the distributed environment means that showing is not possible, the trouble-shooter can only know what the customer is doing through the customers' feedback. Both of these features impact on the coordination of actions required to fix the ailing device.

Instructions are situated in the ongoing actions of the customer as far as is possible, considering the limited feedback: being tailored to what customers report they are doing now and modified on-the-fly to make them relevant to what customer say they can see. Customers and troubleshooters must work together to coordinate the giving and carrying out of instructions and do so without recourse to a shared object to order interaction around.

4. COMMON METHODS OF ARTICULATION

The studies suggest a number of characteristic methods are involved in the seeking out of expert advice, the production of that advice, and people's engagement with it, that seem to be sufficiently regular components in both immediate and remote situations for them to be worth attending to in the design of systems to support help-giving activities.

4.1 Initial Formulations

The non-expert seeking help has a problem and knows to some extent what the problem 'looks like' from their own point of view. However, when entering the help-giving situation they have no way of knowing how best to articulate this for the provision of expert help. The non-expert will need to provide some kind of articulation of the problem but this, by its very placement within a sequence of the help-seeking and help-giving interaction, is a prospectively revisable formulation where just what will be adequate has yet to be worked out. While experts have access to a broad range of resources of prospective relevance to any particular case, it is only through the provision of an initial problem formulation, which provides a lay or vernacular description of the problem, that experts establish a concrete sense of to how to bring those resources to bear on the problem. Insofar as expert knowledge and resources apply to particular configurations of problems the expert has to find ways of reconfiguring the initial problem formulation so that it becomes an accountable occurrence of 'just such a case'. For the expert too, initial formulations are prospectively revisable and their use relies on 'getting further the details out of people'.

Just what an adequate revision might look like can only be worked out through cooperative interaction. Both the help-seeker and help-giver are therefore tied to utilizing the kinds of interactional methods available for arriving at an adequate revision, e.g. initial problem formulations, questions and answers, ratifications, counter-formulations, and so on. There is, in that case, an expectation that specificity and relevance will be absent at the beginning of non-expert/expert interaction and that subsequent interaction will need to work to embellish the problem situation and make it concretely specific.

While there is a working expectation that problem descriptions will need to be reformulated in appropriate terms, it should also be noted that initial formulations are also systematically designed to circumscribe what a reformulation might consist of. Such formulations do not allow for any possible kind of reconstitution. Instead they are designed to specify what relevant expert support might look like. One doesn't say one is looking for a book on marketing to be probed as to what kind of period in religious history one is looking for. Nor does one say one has a problem with a paper jam in your photocopier only to be asked by the expert what happens when you send a fax, at least in the first instance, without seeking some further account for the relevance of being asked that. Thus, whilst initial problem formulations may be oriented to as revisable, they are also oriented to as something that delimits how the subsequent interaction may proceed.

4.2 Translating Vernacular Descriptions

One of the most striking ways in which both the immediate and remote expert/non-expert interactions described above share characteristics is in the ways in which they turn upon the cooperative work of transforming descriptions to make them fit the expert resources available. In both cases a key feature of the work of experts is the use of online resources. An important part of what is understood to be a facet of expertise is the privileged and ready access to a body of technical understandings, which are invariably couched in technical terminology. A constituent part of expert work then, when confronted with the non-expert articulation of problems, consists in the translation of vernacular descriptions of problems into terms that resonate with the experts' domain.

Technical resources, such as the library catalogue and trouble-shooting knowledge base, constrain what can be considered to be a relevant problem formulation. Experts exploit technical resources to formulate the problem such that an appropriate answer might be located. Technical resources also shape ongoing interaction, since what comes next and how it should be formulated is a function of using technical resources in the first place. For example, the OPAC search categories of books, serials, journals, etc., are used as a resource in the unfolding course of categorization work to manageably reduce and elaborate the problem space. Similarly with the knowledge base, options between cases for printing only, copying only, printing and copying, are explored between expert and customer through the performance of various tests to shape formulations of the problem and to identify candidate solutions.

A major difference between the two settings arises from the distributed nature of the troubleshooting setting. Whereas in the library the librarian and customers use the OPAC system together to co-produce the information request, in the troubleshooting situation the knowledge base is not mutually available. Thus the participants in the library interaction have an additional resource for reaching a shared understanding of the problem. Library users can react directly to the librarian's actions on the OPAC system - when the librarian began a title search, for example, they could immediately correct her understanding by saying that it was not a book. This is not possible in the troubleshooting session unless the troubleshooter makes explicit the selections that he or she is making in the knowledge base. This is done to some extent by offering up technical translations for the customer to confirm through testing, but not in the fine detail and to the practical effect that occurs when resources are immediately shared.

4.3 Reformulating and Refining Descriptions of the Problem

A concomitant feature of non-expert/expert interactions that arises from the prospectively revisable character of initial formulations and the quest for articulations open to some order of technical translation, is the need for the expert and non-expert to work together through a sequence of reformulations and refinements of the problem. From the point of view of the expert there is a need to arrive at the point where the problem can be seen to be

potentially a case of X or Y or Z such that an appropriate solution might present itself.

In the library the problematic information request is to some extent in the user's head and the librarian must use their expertise to tease this out. Neither is the problem fully formulated, in large in part because the user does not have the technical expertise to phrase their request in a way which fits with the information resources and technical organization of the library. Furthermore, it is often the case in libraries that users are not at all sure just what would constitute a resolution of their problem. To this extent then there is a close similarity with the troubleshooting situation, in that customers often do not know just what will constitute a resolution of their problem, except in the broadest sense of getting the machine working again. Thus in both situations the help-seeker is only likely to have a partial understanding of the problem and both parties are therefore obliged to reformulate and thereby refine problem descriptions until they can reach a shared understanding that illuminates the problem.

In both cases of help giving the problem is not directly available to the expert and must be uncovered through a course of categorization work that prompts reformulation and refinement of the problem and reconciles vernacular descriptions with technical resources and expertise that provide for its resolution. The reformulation and refinement of problem statements is unavoidable in both immediate and remote situations. Even if the troubleshooting expert were collocated with the device and the user, reformulation and refinement would still play their part in resolving the problem. Imagine, for example, when you take your car to the garage with some problem or another, there is still a cooperative process of describing the symptoms of the problem, the noises, effects, locations, conditions under which they occur, etc. In such a way you and the mechanic together reformulate, refine and illuminate the problem and identify candidate solutions.

4.4 Using Instructions to Articulate Candidate Solutions

In the course of developing a sufficient understanding of the problem, candidate solutions may be identified. The trajectory of finding (or not, as the case may be,) a solution is not linear. There are actions that might have to be undertaken by either party as intermediary steps towards refining the problem space or enacting a solution, and attempting candidate solutions can lead to refinement even where the solution is not the appropriate one. In this sense articulation work is about defining the status of the current situation within a hypothetical trajectory towards resolving the problem.

As part of this offering of solutions, the expert's production of demonstrably good advice is a feature shared across the settings. A key feature of non-expert/expert interaction is that the expert status of the help-giver is established and maintained in and through interaction. The help-giver's expert status does not rely on *a priori* considerations but on their demonstration of expertise 'here and now' in the ongoing, unfolding course of the interaction. In other words, the actions of experts are accountable to non-experts and experts must provide ways for non-experts to be able to see that what they are being asked to do (e.g., categorize the information problem in terms of the library catalogue or carry out particular tests on a printer) is reasonable.

There is, however, a key difference between the interactional production of candidate solutions in the two settings, which revolves around the relationship between the parties to the interaction and the resources around which help-giving takes place. In the library setting participants and resources are all collocated and we can see that the preferred method of conveying candidate solutions by instruction, where simple directions are not enough, is to demonstrate what needs to be done. The valuable interactional resource of being able to show what needs to be done in addition to telling is lost in the remote situation, however. Instead the expert has put into words all the actions that he or she wishes the help-seeker to undertake. It is notable that spatial actions, such as those connected to testing particular parts of a printer, are particularly difficult to describe in the absence of gestural resources to inform their direction. Gestural resources are not shared in the remote situation and must also be translated into talk. Furthermore, feedback from the customer is only available though talk, resulting in less fine grained and effective interaction. Consequently, situating instructions that provide for the articulation of problems and identification of candidate solutions in ongoing activity becomes much more difficult and is hampered by the communication equipment employed.

The communication equipment is important, as it is through this that interaction is mediated. In addition to the ailing device and knowledge base, customer and troubleshooter must negotiate the communication equipment, in this case the phone. Such equipment is often inconveniently located or may be difficult to use whilst carrying out actions on the copier itself. Office copy devices are often situated in shared locations, whilst phones are often private devices and not necessarily located conveniently for the device. This arrangement compels the customer to move back and forth between the device and the phone or to rely on the assistance of another party through which the instructions can be relayed. Consequently instructions providing for the illumination and resolution of problems cannot be so precisely situated in the ongoing interaction. The communicative asymmetry built into remote help-giving therefore adversely effects feedback and shared understanding.

5. SALIENCE TO DESIGN

The studies of help-giving in immediate and remote locations add to the body of domain knowledge that is beginning to accrue around the topic and provides further resources for designers to consider the development of future help-giving systems. Whether assisted or 'self-help' systems are at stake our studies suggest that it is important to factor in the artful methods that people ordinarily exploit when seeking help and whereby problems and solutions are articulated. As Yamauchi et al. [31] put it,

> *"Why should we not design technology by drawing on the actual, artful methods by which practitioners use information in their work?"*

We might go further and ask why not design systems that resonate with the artful methods by which practitioners conduct their activities? To this end we think that the development of remote help-giving systems, particularly those that involve experts, may be usefully advanced through the design of computer-based mechanisms that support articulation work. Such mechanisms might enable participants – experts and non-experts alike – to work up initial formulations of the problem and translate them into technical objects providing for resolution through the

reformulation and refinement of vernacular descriptions and instructed action. We also think that in this respect there is much to be learnt from help-giving in immediate situations for the design of help systems in remote contexts. Of particular note is the sharing of resources, which effective articulation work relies upon and methodically exploits. Support for the more effective articulation of problems and solutions between remote participants might usefully exploit advances in ubiquitous computing and mixed reality systems to support interaction and it is towards unpacking ways in which this might be achieved that we now turn.

5.1 Potential Support for Articulation Work

The role of resource sharing has been described in the studies as central to the support of effective articulation work. In view of this we believe that these studies are particularly relevant to the development of computer support for the remote troubleshooting of devices with embedded computing capabilities (be they printers, washing machines, vehicles, etc), where such features can benefit from the support of technology that is only now starting to be widely available. To this end we wish to consider two essential modes of support: one which exploits the sensing capabilities of ubiquitous computing to support the work of formulating and translating problem descriptions, and the other which exploits the gestural capabilities of mixed reality systems to support the work of instruction that inhabits help-giving.

5.1.1 Supporting Formulation and Translation

One of the essential features of remote troubleshooting at the current point in time is the asymmetrical character of the problem situation. Remote experts simply do not have shared access to the local user or worker's situation, the device, and the problem that is being encountered. One way in which the working up and translation of the problem might be supported is through the development of better means of capturing information relevant to understanding the problem. What we are suggesting then is that there is a need to give serious attention to how to capture and record information at the site of the problem.

Devices with embedded computing capabilities already log a vast array of information. The desktop PC or laptop records system events and make them available to inspection and devices such as printers go beyond this to exploit a range of sensors to display functions to users. The future development of mechanical devices that exploit embedded computing capabilities might extend this approach by further augmenting data capture through the use of a range of ubiquitous computing sensors [21]. Motion, sound, weight, heat, light and a host other physical attributes may be exploited to further enhance what machines log and make it available to remote experts.

These advances may be exploited alongside the network capabilities of many modern devices to make recorded information available to remote parties. Modern office devices, for example, are networked and in principle the information they record may be relayed to remote experts to support troubleshooting, providing a degree of shared access to problematic system events and recent user actions. Such devices also come with medium-sized high quality screens with graphical user interfaces. These features of modern office equipment make it possible to use the ailing device itself as a shared resource, as it is rare indeed that the whole device fails and in such cases there is little the user themselves, even with the support of a remote troubleshooter, can do to repair it. Thus on-device screens may be exploited to add a shared visual layer augmenting formulation and translation [20] and may even permit the remote troubleshooter to show the local worker how to perform diagnostic actions.

Augmenting both the artefact and the communication channel through ubiquitous computing enables a degree of sharing that is not available via the phone. Such an approach may allow the remote expert to see for him or herself changes in the status of the artefact and to understand what the user has done before the call for help and during it. For example, let us say door A of the printer is closed and must be opened to inspect some part. The remote expert might exploit the graphical user interface to show the local worker where the door is on the machine and, in exploiting in-built motion sensors, the artefact may in turn inform the remote expert that door A is now open. Further sensors on the various parts on the machine may subsequently inform the remote expert that some test or another has been carried out by the local worker. The principle at work here, then, is one of extending current technological capabilities to make the machine itself into a shared resource supporting the articulation and resolution of problems.

5.1.2 Supporting Instructed Action

Just as remote experts do not have shared access to the problem situation then so too local workers do not share access to the remote expert's situation. Consequently, a great deal of effort goes into articulating instructions. While sensors and shared interfaces to the machine may go some way towards supporting instructed action this is, in many respects, an indirect form of interaction and the possibility exists to support more immediate collaboration. What we are suggesting here is that there is a need to consider how emerging technologies might be exploited to augment direct interaction between remote parties.

Significant effort is currently being invested in the extension of media spaces to support interaction between remote parties and has seen the emergence of systems that support gesture-based interaction. These kinds of development are particular suited to instructed action, where verbal actions are paired with physical actions, such as pointing; to articulate what it is that needs to be done. Current efforts are concerned to support the 'projectability' [16] of gesture across geographically distributed sites. Support for gesturing is being pursued through the development of two distinct kinds of system: linked systems, e.g. [9] which seek to support gesture by exploiting video to overlay remote gesture onto the local worker's ecology, and mediated systems, e.g. [16], which seek to embed remote gestures in the local worker's ecology through the use of computational devices, such as robots.

Current incarnations of linked and mediated systems have their limitations, suffering from the 'distorting' effect of technological arrangements on gesture which 'fractures' the intelligibility of gesture [17]. A new generation of linked system resolves this by exploiting mixed reality not only to project gesture into the local worker's task space but also, to align the orientations of participants and promote awareness and coordination [14]. While this type of system is still in its experimental stages it raises the distinct possibility of supporting more immediate forms of interaction between geographically distributed parties. This might be achieved by exploiting and extending the capabilities of 3rd

Generation mobile telephony to augment verbal communication with its immediate gestural counterpart.

Developments such as [26] provide a practical illustration of the potential to exploit mobile phones as projectors and 'photon vacuum' [29] technology opens up the possibility of developing more flexible displays that support the fluid nature of gestural interaction. Coupled with the sensor-based augmentation of devices this kind of arrangement offers the real potential to enhance articulation work between remote parties, providing a shared object and means of establishing a mutual orientation to that object through which they may order and conduct interaction. Advances such as this offer the opportunity, then, to reduce if not resolve the communicative asymmetry that inhabits remote troubleshooting. In turn, the development of computer support to enhance the artful methods of interaction involved in remote help-giving may enhance the enterprise and make it more effective.

6. CONCLUSION

Our studies of help-giving in immediate and remote contexts have shown that the use of help systems is embedded in articulation work and distinct methods for its accomplishment. The study of immediate help-giving in the library highlights how articulation work takes place around the use of the *library catalogue as a shared resource*. Furthermore, shared access to the library itself facilitates the coordination of problem-solving activities, in that the librarian can physically direct the user in effecting a solution. The lack of shared access to both help system and device in the remote technical troubleshooting example affects both the articulation of the information request and the work necessary to coordinate action in the attempt to solve the problem.

Recent technological developments, particularly in the field of ubiquitous computing, are starting to offer the opportunity of augmenting direct interactions between remote parties, however. Within the present work, we aim to contribute to the research effort in this emerging domain by providing indications of how central aspects of help-giving can be technologically augmented to facilitate articulation work. Key to the achievement is the development of computer support that resonates with the methodical ways in which problems and solutions are articulated and help-giving 'gets done'.

7. REFERENCES

[1] Bateman, D., Good, A., Procter, R., Slack, R., Hartswood, M. and Voß, A. (2004) "The work of advice giving in a poisons information setting", *Toxicology*, vol. 202 (1), pp. 125-126.

[2] Bobrow, D. and Whalen, J. (2002) "Sharing in practice: the Eureka story", *Reflections*, vol. 4 (2), pp. 47-59.

[3] Bowers, J. and Martin, D. (2000) "Machinery in the new factories", *Proceedings of the 2000 ACM Conference on Computer Supported Cooperative Work*, pp. 49-58, Philadelphia: ACM.

[4] Button, G. and Harper, R. (1996) "The relevance of 'work-practice' for design", *Computer Supported Cooperative Work: The Journal of Collaborative Computing*, vol. 4 (4), pp. 263-280.

[5] Crabtree, A., Twidale, M., O'Brien, J. and Nichols, D. (1997) "Talking in the library: implications for the design of digital libraries", *Proceedings of the 2nd ACM International Conference on Digital Libraries*, pp. 221-228, Philadelphia, Pennsylvania: ACM.

[6] Crabtree, A., O'Brien, J., Nichols, D., Rouncefield, M. and Twidale, M. (2000) "Ethnomethodologically informed ethnography and information systems design", *Journal of the American Society for Information Science*, vol. 51 (7), pp. 666-682.

[7] Ehn, P. (1988) "Language-games: a Wittgensteinian alternative", *Work-Oriented Design of Computer Artefacts*, pp. 103-122, Stockholm, Sweden: Arbetslivscentrum.

[8] Fischer, G. and Reeves, B. (1992) "Beyond intelligent interfaces: exploring, analyzing, and creating success models of cooperative problem solving", *Applied Intelligence*, vol.1 (4), pp. 311-32.

[9] Fussell, S., Setlock, L., Yang, J., Ou, J., Mauer, E. and Kramer, A. (2004) "Gestures over video streams to support remote collaboration on physical tasks, *Human-Computer Interaction*, vol. 19 (4), pp. 273-309.

[10] Garfinkel, H. (1967) "Studies of the routine grounds of everyday activities", *Studies in Ethnomethodology*, pp. 35-75, Englewood Cliffs, New Jersey: Prentice-Hall.

[11] Garfinkel, H. and Sacks, H. (1970) "On formal structures of practical action", *Theoretical Sociology: Perspectives and Developments* (eds. M^{c}Kinney, J.C. and Tiryakian, E.), pp. 160-193, New York: Apple-Century-Crofts.

[12] Greatbatch, D., Heath, C., Luff, P. and Campion, P. (1993) "Interpersonal communication and human computer interaction", *Interacting with Computers*, vol. 5, pp. 193-216.

[13] Halverson, C., Erickson, T. and Ackerman, M. (2004) "Behind the help desk: evolution of a knowledge management system in a large organization", *Proceedings of the 2004 ACM Conference on Computer Supported Cooperative Work*, pp. 304-313, Chicago: ACM.

[14] Kirk, D., Crabtree, A. and Rodden, T. (2005) "Ways of the hands", *Proceedings of the 9th European Conference on Computer Supported Cooperative Work*, pp. 1-21, Paris, France: Springer.

[15] Kristoffersen, S., O'Brien, J., Rouncefield, M. and Hughes, J. (1996) "When MAVIS met IRIS: ending the love affair with organizational memory", *Proceedings of the 19th Information Systems Research Seminar in Scandinavia*, pp. 29-53, Gothenburg: IRIS.

[16] Kuzouka, H., Kosaka, J., Yamazaki, K., Suga, S., Yamazaki, A., Luff, P. and Heath, C. (2004) "Mediating dual ecologies", *Proceedings of the 1998 ACM Conference on Computer Supported Cooperative Work*, pp. 477-486, Chicago: ACM.

[17] Luff, P., Heath, C., Kuzouka, H., Hindmarsh, J., Yamazaki, K. and Oyama, S. (2003) "Fractured ecologies: creating environments for collaboration", *Human-Computer Interaction*, vol. 18 (1), p. 51–84.

[18] Lynch, M. (1993) "Molecular sociology", *Scientific Practice and Ordinary Action: Ethnomethodological and Social Studies of Science*, pp. 203-264, Cambridge: CUP.

[19] McDonald, D. and Ackerman, M. (1998) "Just talk to me: a field study of expertise location", *Proceedings of the 1998 ACM Conference on Computer Supported Cooperative Work*, pp. 315-324, Seattle: ACM.

[20] O'Neill, J., Castellani, S., Grasso, A., Roulland, F, and Tolmie, P. (2005) "Representations can be good enough", *Proceedings of the 9th European Conference on Computer Supported Cooperative Work*, pp. 267-286, Paris: Springer.

[21] Pfeifer, T., Olariu, S and Fersha, A. (eds.) (2005) "Wireless sensor networks and their applications", special issue of *Computer Communications*, vol. 28, Amsterdam: Elsevier.

[22] Psathas, G. (1991) "Direction-giving in interaction", *Talk and Social Structure*, (ed. Boden), pp. 195-216, Cambridge: Polity Press.

[23] Sacks, H. (1992) "A single instance of a phone-call opening", *Lectures on Conversation* (ed. Jefferson, G.), Volume II, pp. 542-553, Oxford: Blackwell.

[24] Schmidt, K. and Bannon, L. (1992) "Taking CSCW seriously: supporting articulation work", *Computer Supported Cooperative Work: The Journal of Collaborative Computing*, vol. 1 (1), pp. 7-40.

[25] Shapiro, D. (1994) "The limits of ethnography: combining social sciences for CSCW", *Proceedings of the 1994 ACM Conference on Computer Supported Cooperative Work*, pp. 417- 428, Chapel Hill, North Carolina: ACM.

[26] Siemens Cell Phone with Built-in Projector, www.siemens.com/index.jsp?sdc_p=ft4mlsu20o1255774ni1255502pFEcz3&sdc_sid=9480990992&

[27] Taylor, R. (1968) "Question-negotiation and information seeking in libraries", *College & Research Libraries*, vol. 29 (3), pp. 178-94.

[28] Twidale, M. and Ruhleder, K. (2004) "Where am I and who am I? Issues in collaborative technical help", *Proceedings of the 2004 ACM Conference on Computer Supported Cooperative Work*, pp. 378-387, Chicago: ACM.

[29] Upstream Engineering, www.upstream.fi/index.html

[30] Walsh, J. and Ungson, G. (1991) "Organizational memory", *Academy of Management Review*, vol. 16 (1), pp. 57-91.

[31] Yamauchi, Y., Whalen, J. and Bobrow, D. (2003) "Information use of service technicians in difficult cases", *Proceedings of the 2003 ACM SIGCHI Conference on Human Factors in Computing Systems*, pp. 81-88, Florida: ACM.