A MULTIDIMENSIONAL MODEL TO ANALYZE SOCIAL AND TECHNICAL FACTORS IN COMPUTER-MEDIATED COMMUNICATION

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Keywords: Computer-mediated communication, Computer-supported cooperative learning, Computer-supported Cooperative work.

Abstract: This paper proposes a multidimensional model to analyze problems in computer-mediated communication (CMC), which can serve as a framework to integrate existing CMC approaches and also offers guidelines for the selection, the design, and the social and organizational integration of CMC tools. The specific strength of the model is its clear distinction between social and technical factors influencing computer-mediated communication. A case study of groupware use is presented to demonstrate the usefulness of the model to analyze difficulties in CMC settings and decide whether to address a certain problem on a design level or a personal, social, or organizational level.

1 INTRODUCTION AND BACKGROUND

Numerous theories of computer-mediated communication (CMC) provide explanations of why communication processes succeed or fail. However, there is a lack of comprehensive models integrating different theoretical approaches. Furthermore, CMC theories predominantly focus on analyzing computer-mediated communication from a (mainly) psychological perspective, and less on the design of CMC tools from a software engineering perspective. This paper proposes a *multidimensional model of computer-mediated communication*, which can serve as a framework to integrate existing CMC approaches. Furthermore, implications for the selection, the design, and the integration of CMC tools into existing social and organizational structures can be drawn from the model.

The following paragraphs very briefly introduce some influential CMC theories.

For example, so-called "*cues filtered out" approaches* emphasize that computer-mediated communication is often text-based, and therefore nonverbal communication signs as well as social cues such as age, sex, ethnics, socioeconomic status, appearance etc. are lost or at least difficult to convey. While some authors (especially in early CMC research) take a deficit-oriented view of CMC as "impoverished" form of communication (e.g. Herrmann 1993), others emphasize that filtering out social cues might result in a more equal and honest interaction which is less inhibited e.g. by prejudices or social status (e.g. Sproull & Kiesler 1991, Hian et al. 2004, McKenna & Bargh 2000, Whitty & Gavin 2001). However, disinhibition and anonymity might also result in aggression, hostility and harassment (e.g. Burnett & Burkle 2004).

Media choice theories emphasize that different media are appropriate for different communication tasks and needs. Therefore, successful communication depends on an adequate media choice. For example, the Media Richness Theory (Daft & Lengel 1986) classifies different media according to their capability of conveying complex information: Richer media such as video conferencing or telephone should be chosen for highly complex or ambiguous communication tasks, while less rich media such as e-mail are more appropriate and efficient for simpler tasks.

Both cues-filtered-out approaches and media choice theories indicate that computer-mediated communication might be more anonymous and less personal than face-to-face interaction. Empirical studies often show that CMC is more task-oriented. CMC groups perform worse on tasks involving high levels of socio-emotional interaction, especially

Janneck M.
A MULTIDIMENSIONAL MODEL TO ANALYZE SOCIAL AND TECHNICAL FACTORS IN COMPUTER-MEDIATED COMMUNICATION.
DOI: 10.5220/0001834905210526
In *Proceedings of the Fifth International Conference on Web Information Systems and Technologies (WEBIST 2009)*, page
ISBN: 978-989-8111-81-4

under time pressure (e.g. Bordia 1997, Hian et al. 2004, Burnett 2000, Burnett & Burkle 2004, Birnie & Horvath 2002).

The different approaches highlight different aspects of CMC and possible causes for breakdowns and problems. However, when problems arise in computer-mediated communication situations, the specific causes are often difficult to figure out. Especially, it is often hard to distinguish between social and technical problems. As a result, people might try to solve social problems technically, and vice versa–a phenomenon that can also be observed in research on computer-supported communication and cooperation.

The multidimensional model presented here helps to analyze difficulties in computer-mediated communication by making a clear distinction between characteristics and behavior of the human communication partners on the one hand, and the media features and "behavior" on the other hand. The model is presented in the next section, followed by a *case study* illustrating its usefulness for analysis and design.

2 A MULTIDIMENSIONAL MODEL OF BREAKDOWNS IN COMPUTER-MEDIATED COMMUNICATION

The multidimensional model defines five factors influencing communication (see figure 1).

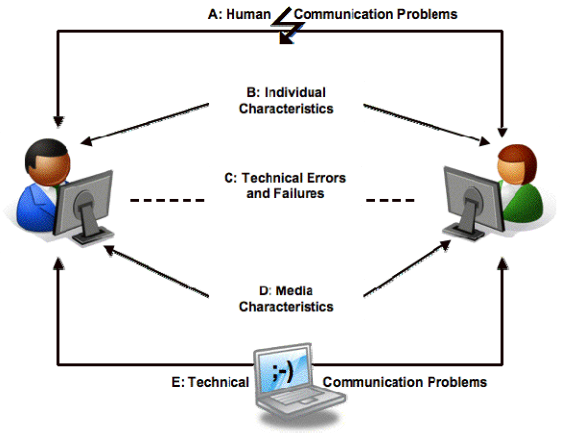

Figure 1: A multi-dimensional model of factors influencing computer-mediated communication.

A. Human Communication Problems:
Naturally, just like in face-to-face interaction, problems and misunderstandings might occur in computer-mediated communication, which have social or personal reasons and have nothing to do with the communication media used. They are of little interest for developers of CMC tools because they cannot be influenced or reduced by media design. Nevertheless, the literature describes repeated attempts to solve or avoid social problems through technology, for example, when trying to compensate a lack of trust among interaction partners by sophisticated access controls (e.g. Sikkel 1997, Sohlenkamp et al. 2000). Notwithstanding, understanding and distinguishing human communication problems from truly CMC-related problems is crucial to identify and address actual design challenges and also to devise accompanying measures to support and moderate media use.

B. Individual Characteristics:
The individual characteristics and experiences of the people involved in the interaction will obviously influence communication in a decisive way. As this is also true for face-to-face interaction, CMC is additionally influenced by the communicators' technical skills (e.g. using browsers or e-mail), media competencies (e.g. making appropriate media choices), or *mental models*, i.e. users' conceptions and beliefs regarding configuration and functioning of a software system which influence software use.

C. Technical Errors and Failures:
Data loss, e.g. due to software bugs or network problems, is a source of problems which can be compared to transmission errors as described by the 'classical' mathematical theory of communication by Shannon & Weaver (1949). Technical errors may result in a partial or complete message loss. Data loss is especially problematic if it goes unnoticed by sender and recipient of the information, e.g. if an e-mail is lost without an error prompt. Web applications might provide insufficient feedback when information is displayed differently to several recipients, e.g. because of individual customizations or access rights: As a result, the sender might not know if and how his message was displayed. Technical problems also include system incompatibilities (e.g. different operating systems, data formats etc.). Technical failures are often hard to understand or avoid, even for experienced users.

D. Media Characteristics:
As described by media choice theories, difficulties may arise if CMC tools are not suitable for the underlying communication needs: Media characteristics influence communication success. For example, scheduling an appointment with several participants will likely be much more

complicated and time-consuming when asynchronous technology such as e-mail is used, compared to i.e. telephone or chat, because immediate feedback or enquiries are not possible. For the design of communication technology this means that it should be appropriate for the task: All-embracing tools catering for diverse communication needs might have to be viewed critical. For example, it is questionable whether technology can convey high as well as low levels of social presence.

E. Technical Communication Problems:
Technical communication problems might arise in situations when the technology itself assumes the role of a communicator, or communication processes are automated by the technology, respectively. Maass & Oberquelle (1992) call this an "agent perspective" in software development: The computer assumes the role of an equal partner who is able to interpret and react to user behavior in an adequate way. They criticize that such system behavior is seldom transparent for users. Furthermore, an anthropomorphic presentation of technology might raise unrealistic expectations among users regarding the computer's actual communication skills.

In computer-mediated communication there is a broad spectrum of autonomous communication acts reaching from simple automatisms to complex interpretations. One example is inferring users' emotional states by interpreting certain emotional keywords in the texts (Perry & Donath 2004). Another example is the e-mail recovery function offered by some e-mail clients, allowing users to call back (still unread) e-mails under certain circumstances. However, recipients using different e-mail clients usually receive a strange automatic reply, offering neither an excuse nor request for confidentiality etc. like one would expect from a human sender. Still, by offering such a function the notion of a competent communicator is evoked, who is able to handle a possibly embarrassing or awkward situation. The following anecdote might illustrate this: A colleague receiving such an e-mail reading "Mrs. X wants to call back this e-mail" wrote back, amused: "But Mr. Y doesn't want to give that e-mail back!"

3 PRACTICAL IMPLICATIONS: A CASE STUDY

The following sections illustrate how the multidimensional model can be used to analyze CMC problems and derive design implications, using a case study of an educational groupware system, which was evaluated by means of an online survey with more than 1500 users.

3.1 Software and use Context

The software *CommSy* is a web-based groupware system to support communication and coordination in working and learning groups, comparable to e.g. *BSCW* (e..g. Klöckner 2002), *phpBB* (e.g. Stefanov et al. 2005), or *Moodle* (e.g. Cole & Foster 2007). It supports communication (for example with news and discussion forums) and the exchange of working materials (with e.g. file uploads and online documents) and also offers project management functions (e.g. a shared calendar and to-do lists).

The groupware consists of so-called *workspaces*:

- *Project Workspaces* are designed for use in closed groups of approximately 10 to 30 members (e.g. student groups). To support group activities, the software offers groupware functionalities, such as announcement of news or events, discussion forums, personal homepages for the presentation of members to the group and materials that can be written in a cooperative way, collected and classified by the users.
- *Community Workspaces* incorporate project workspaces into a larger structure supporting not only small groups, but a community of users (e.g. all members of a school or university) over a longer period of time, similar to an intranet structure.

CommSy was developed for use in educational settings, both secondary and undergraduate education. It has been used in a variety of teaching fields, including history, languages, economics, and informatics. Furthermore, the groupware is also used in the public and private sector, for example in public administration or business networks. *CommSy* is Open Source software distributed under the GNU General Public License. A description of the software, the development process and its use contexts is given e.g. by Bleek & Finck (2005), Janneck et al. (2006), Pape et al. (2002).

3.2 Analyzing Problems in Computer-mediated Communication

Throughout the last five years, the use of the groupware in secondary and post-secondary education has been regularly evaluated by means of an online survey with several thousand respondents (Janneck 2007). In this paper, we specifically refer to the latest survey, which was conducted in the

spring of 2008. 1538 users participated in the survey, mainly university students and teachers (63%). 32% were secondary school students or teachers, 5% from other use contexts (e.g. business networks). 64% were female, 36% male.

The survey covered usage preferences and characteristics such as frequency and most-used features, usefulness, usage problems, and usability measures. In this study, we focus on *usage problems*. Users were asked to report all problems they had encountered while using the software. They were able choose from a list of possible usage problems, which were known to occur from prior evaluations, as well as add and describe all other problems they had encountered. A total of 1120 problems were reported (multiple answers were possible). The responses were then categorized according to the five dimensions described above. Figure 2 shows the distribution.

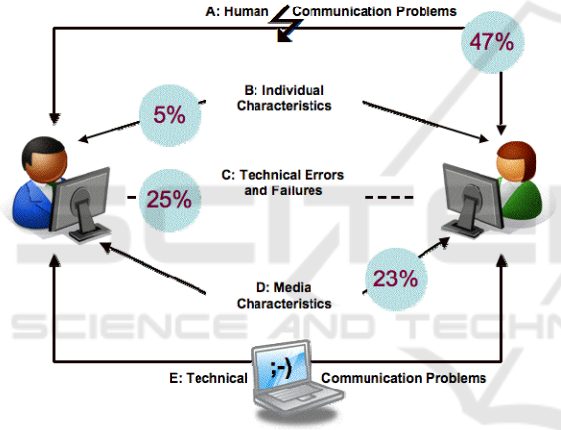

Figure 2: Distribution of usage problems regarding the five levels of the model.

Most frequently, users complained about a lack of interest and active participation by other users (22% of all mentions), problems regarding collaborative structuring and editing content (13%), and to a lesser extent, an insufficient introduction to use (8%) and a lack of incentives for use (4%). These problems can be attributed to an insufficient moderation of use and, thus, located on the dimension of *Human Communication Problems (A)*– the largest category with a total of 47% of mentions.

Technical Errors and Failures (C) constitute the second largest category with a total of 25% of mentions. This is made up by software bugs/incompatibilities, especially with the browser (14%), and long response times (11%).

Media Characteristics (D) make up a comparable share of mentions (23%), summing up functions not suitable for the use context (e.g. lack of synchronous communication tools). Furthermore, there were deficits in supporting *awareness* (see section 3.3).

Problems arising from *Individual Characteristics (B)* were hardly mentioned (5%), which might be due to the self-report data. Some users mentioned difficulties regarding the metaphors and terms used in the software. For example, some users tried to use the so-called "clipboard" (which is used to copy posts within the groupware workspace) to save files to their desktop, inferring from the usage of the familiar Windows clipboard. Furthermore, especially teachers reported that some participants were reluctant to participate in computer-mediated communication.

Technical Communication Problems (E) were irrelevant in the case study, because the groupware offers hardly any automatic or interpretative functions.

This problem analysis is exemplary and shows an individual profile, which cannot be generalized to other software tools or even other user groups of the same system. Nevertheless, it is an interesting result that the bulk of usage problems that were reported can be attributed to personal and social factors, and cannot be tackled by the software design. Instead, they would have to be addressed by measures to better support and supervise software use. Second come seemingly "trivial" technical problems. Problems requiring conceptual changes in the software design only come in third. Thus, a strategy relying primarily on changes to the software design and functionalities would presumably be rather ineffective in this particular case.

3.3 Implications for Shaping CMC Tools and Processes

After using the multidimensional model to analyze problems in CMC settings, the following section highlights how it can be used to draw conclusions for the design of CMC tools and computer-mediated interaction processes. The model helps to distinguish whether to address a certain problem on a design level or a personal, social, or organizational level.

A. Human Communication Problems:
Clarify whether the difficulties that can be observed are actually due to the technology or rather due to difficulties in social interaction processes, which can't be addressed by the software design.
→ In the case study, the most frequent problems could be traced back to deficits regarding the didactical integration of the tool into the course

design. Those problems might be addressed by providing better occasions for use or agreeing upon common rules for usage (e.g. frequency of use).

B. Individual Characteristics:
The current state of knowledge and the experiences of the (prospective) user group should be analyzed and taken into account when selecting or designing CMC media (e.g., simple tools might be more appropriate for an inexperienced user group). Training and support measures must be adapted to users' experience and needs.

→ *In the case study, teachers who observe reluctance among students to communicate online might try to establish a playful approach to CMC, e.g. by letting students communicate informally before using the tool in class.*

C. Technical Errors and Failures:
Of course, data loss due to technical errors must be reduced to a minimum. Furthermore, especially with communication technology it is important to provide transparent error handling processes, allowing the user to understand what problems occurred and whether the message transmission was impaired.

→ *Regarding the case study, users should receive information about frequent browser or software incompatibilities.*

D. Media Characteristics:
Check whether the CMC tool/software is appropriate for the users' purposes and tasks and whether the tool has a coherent overall design (rather than integrating contradictory functions or concepts of use).

→ *In the case study, the analysis revealed a lack of awareness (e.g. Gutwin & Greenberg 1999, Dourish & Bellotti 1992) functions (e.g. a "who is online" display or access statistics), which can be addressed by the software design (Janneck 2007, 2009).*

E. Technical Communication Problems:
Check if and to what extent the CMC tools influence the human communication process (e.g. by automatic functions) and whether this is actually necessary and appropriate in the respective context. Make sure users get transparent feedback if (and how) the communication content or process is altered by the software.
→ *In the case study there is no need for action in this regard.*

4 CONCLUSIONS

This paper presented a *multidimensional model* to analyze problems in computer-mediated communication (CMC) regarding to five levels of potential difficulties and demonstrated its use for the analysis of CMC situations by means of a case study. Likewise, practical implications for the design of CMC tools and the social and organizational frame were exemplarily shown.

Those implications and recommendations support and refine existing design guidelines such as the Dialogue Principles established in the DIN EN ISO 9241-110 (2006) or guidelines referring more specifically to the design of communication and cooperation software (e.g. Dieberger et al. 2000, Erickson 2003), as well as basic psychological principles of human-computer interaction such as the use of metaphors in design. The specific contribution of the model presented here is to distinguish clearly between technical and social factors influencing CMC.

Methodically, empirical and explorative evaluation approaches (such as surveys, interviews, or usability tests) should be chosen to grasp the users' subjective views and experiences. For that reason, evaluations shouldn't rely solely on expert or inspection methods (e.g. usability walkthroughs or heuristic evaluations).

From a research perspective the model helps to clarify and understand the different factors influencing CMC and the success or failure of interaction processes. Nevertheless, it has to be noted clearly that the model cannot be seen as a full-flegded 'theory'. It serves as a frame, which can integrate existing CMC and, generally, communication theories on the different levels. Furthermore, it adds to those mainly psychological analysis models the perspective of systems and sociotechnical design.

For further refinement and substantiation of the model, more empirical work is needed. Thus, a next step will be to study other CMC tools, settings, and user groups and compare them regarding the distribution of problem dimensions to see if the model continues to serve as a useful analytic tool or whether new categories emerge from the empirical material. Furthermore, potential interactions and interdependencies between the different levels described by the model will have to be investigated and discussed.

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