Supporting Intergenerational Groups in Computer-Supported Cooperative Work (CSCW)

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The workforce is aging as older workers reenter the workforce or delay retirement. One consequence is that work groups are increasingly becoming intergenerational. Because group work relies on many collaborative tools (e.g., email, shared calendars), it is essential to understand the special requirements that intergenerational groups may have for groupware. Can we design collaborative tools that leverage the differing abilities and contributions of older and younger people in groups? We focus on how best to support intergenerational groups, offering an analysis framework that combines ideas from small groups theory and activity theory. We consider design implications for CSCW and outline design principles for groupware that supports intergenerational groups. Finally, we discuss methodological issues that arise when studying intergenerational collaborative work.

Keywords

Intergenerational groups, computer-supported cooperative work, older workers.

1. Introduction

Our workforce is aging: the population in general is aging rapidly, life expectancy is increasing, and older workers are staying in or reentering the workforce. Demographic statistics from industrialized countries in Europe, North America, and Asia indicate that the populations of all of these countries are aging at a fast rate. At a global level, the proportion of the population over 65 years of age is reaching 15 % in many industrialized countries (twice the world level; Anderson & Hussey, 2000). In 2000, 13% of the US population was 65 years or older, by the year 2030 it is estimated that 22% of the US population will be 65 or older (Czaja & Hiltz, 2005). Similarly, the EU population is increasing from 15.4% in 1995 to 22.4% by 2025 (Eurostat Yearbook, 2001).

In the US, labor force participation of older workers has gradually increased over the last two decades and this growth is expected to continue (Wegman & McGee, 2004). More than 76 million baby boomers are looking for new and flexible ways to work as they move toward the traditional retirement phase of their lives. The Bureau of Labor Statistics predicts that the annual growth rate of workers 55 and older will be four times that of the overall work force through 2014 (Pethokoukis, 2006). The concept of older workers is increasingly becoming less defined and disparate, and, generally, the term older worker extends from 40 to 75 years of age (Stein & Rocco, 2001). Age 55 is widely regarded as the age at which employment problems become discernible. However, individuals are sometimes categorized as 'older workers' on the basis of their job status as midlife career changers, retirees returning to the labor force, dislocated workers, or displaced homemakers (Imel, 1991). It may be that becoming an older worker is more situational than chronological (Stein & Rocco, 2001).

As the workforce is evolving, so are the preferences, habits, and needs of workers. For example, older workers prefer jobs that are relatively more demanding of cognitive effort and less of physical effort (Uccello, 1998), and older workers are less likely to retire from jobs that are more demanding of cognitive than physical capabilities (Hayward et al., 1989). Herzog, House, and Morgan (1991) have suggested that retired people might continue working if the nature of their work and working conditions are sufficiently attractive and flexible. Discussing the economic impact of workforce aging, Cooke (2005) observed that technological change in many industries is making labor per se a less important input, relative to fixed capital. This is particularly meaningful in a so-called 'knowledge'

economy, where businesses are no longer reliant on people's physical labor power. In such a context, an older workforce is not necessarily a less productive one.

1.1. Intergenerational Groups

Group work and collaborative technology are increasingly common in the workplace as groups often increase productivity (e.g., Keen, 2003). As the workforce ages, one implication is that older workers will comprise a significant proportion of group membership. Moreover, the proliferation of technology in occupational settings implies that most such groups will be working with computers as part of their jobs (Czaja, 2001). In the workplace, collaborative technology (e.g., instant messaging, project managers, shared editors, decision-support tools, and databases) is used to support a variety of group tasks (e.g., communication, coordination, production, and group problem solving).

Intergenerational groups can be useful assets in satisfying increasing demands for corporate productivity and knowledge management (Herzog et. al., 1991). Organizations are learning that each generation brings different and valuable skills and knowledge to the workplace. Strategies that foster cross-generational sharing, learning, and performance are emerging (Lindenberger & Stoltz-Loike, 2005). There is an urgent need to consider the implications of these transformations in the workplace for the design of collaborative technology.

A complication for any group is the rapid evolution of technology and associated organizational structures. Market globalization and rapid technology evolution expose companies to greater competition and demands for staying up to date. Work in this new context implies not only production of goods and services but also continuous learning in the workplace; increasingly, work and learning are becoming equivalent (Tapscott, 1995). Workers, both older and younger, must be able to constantly enhance and relearn work-related knowledge, skills, and practices (Froman, 1994). The increasing demand for workers to adapt to change and novelty in the knowledge economy has led to a call for designing computer tools that foster continuous learning (Vicente, 2000).

In earlier work, we presented an extensive literature review, drawing from multiple disciplines, such as psychology of aging, adult learning and training, and collaborative technology in workplaces (Convertino et al., 2005). We discussed the complexity of intergenerational groups with respect to levels of analysis (member, group, and organization), types of resources exchanged among the coworkers, and stages of group development (formation, operations, metamorphosis).

1.2 Supporting Intergenerational Groups

Designing any successful collaborative technology is complex because the success of systems depends not only on their inherent qualities but also on a range of contextual factors (e.g., disparity of costs and benefits for different collaborators; Grudin, 1988). An additional layer of complexity is introduced when systems and interfaces are designed not for 'typical' young users, but for a broad array of 'diverse' users (Gregor et al., 2002). Human-computer interaction (HCI) researchers have demonstrated that older users have unique usability need*s* when interacting with computers (Meyer, Mead, Rogers, & Schneider-Hufschmidt, 1998). If we are to successfully design for intergenerational groups, we must to account for the specific resources and needs of both younger and older group members in a rapidly changing work setting.

One concern is the support of communication processes. The development of common ground among people from different generations may require more time and effort to due to differences in language, experience, relational style, work practices, social roles and stereotypes. A study of intergenerational relations at work showed that younger workers appreciated older workers' experience, but found it easier to communicate and socialize with people of their own age (Johansson, 2003). The younger workers were influenced by negative stereotypes about older workers; they were concerned that their older colleagues did not share the time pressure to develop a career quickly. Cross-age work groups, mentoring, and external social activities were found to be useful to encourage intergenerational cooperation.

Nonetheless, any additional costs for bridging cross-generational gaps may be counterbalanced by benefits in group performance and professional development: Mixed-age groups often offer more

advantages over homogeneous groups when the work requires problem solving, because of the complementary perspectives and contributions of different generations (Strauβ and Kuda, 2000). Successful collaborative technology would help in several ways, such as breaking the ice between younger and older workers, supporting reciprocal coaching, and enabling osmosis of knowledge and skills between domain-experts technology-novices (older workers) and technology-experts domain-novices (younger workers).

When we try to assess the implications of an older workforce for software design, a paradox emerges. While researchers have documented age-related declines (e.g., Salthouse, 1991), companies often attribute success to the efforts of experienced older workers. Because the dominant research model for aging studies has been *deficit*-centered (e.g., cognitive and motor declines), technology designers and HCI researchers have focused designing technologies that can compensate for the deficiencies of older users (Czaja, 2001; Rogers, 1999). These ameliorative approaches have been useful in addressing the specific needs of older users. However, by focusing only on deficits, such work has failed to consider the broader socio-technical challenges of older workers. For instance, there has been little design work directed at age-related concerns, such as skill obsolescence and professional development,.

We argue for a new focus on how best to leverage the unique assets and opportunities that both older and younger people bring to work *groups*. In the balance of this paper, we address (a) the challenges and opportunities for CSCW of intergenerational groups; (b) theory related to such groups; (c) principles of design for intergenerational CSCW groups; and (d) methodological issues in the study of these groups.

2. Challenges and opportunities for CSCW

There is a misalignment between traditional cognitive aging research and concrete evidence from the workplace. While researchers have documented age-related declines, companies have attributed their success to the efforts of their experienced older workers and are now trying to prevent the loss of experience these workers hold (e.g., Schaie, 2004; Shaw and Smith, 2003). We argue that this misalignment is due, at least in part, to lack of appropriate research methods and theoretical approaches

that account for the cognitive resources and abilities needed in a workplace. Most cognitive aging results have been obtained in well-controlled but relatively impoverished laboratory tasks and environments. Only recently have researchers started asking whether laboratory studies 'scale-up' to realistic work settings (Pew & Van Hemel, 2004).

Czaja and Sharit (2003) observe that traditional psychometric measures of cognition may have little relevance to the skills of older adults on everyday work tasks or on learning to use novel technology. Traditional research methods have failed to capture the complexity of work situations, placing heavy emphasis on processing speed and other measures of fluid intelligence. They also do not account for experience-based strategies that older people use to compensate for age-related declines in abilities (Czaja & Sharit, 2003). In practice, work environments do not require performance at maximum levels for short-term tasks, as is often the case with laboratory tasks. Rather, they require well-tuned strategies for monitoring and maintaining work performance at reasonable levels, and for improving efficiency and quality in the long term.

It is important to recognize that older adults in intergenerational groups can contribute useful social skills and problem solving abilities for the ill-structured problems a group may encounter. Sternberg and his colleagues argue that critical practical abilities are developed through performance in real life problems; these abilities are maintained or even increased in late adulthood (e.g., Torff & Sternberg, 1988). Similarly, Lee (1994) and Sinnott (1993) argue that ill-structured problems require post-formal thought, which develops hand in hand with social experience in the course of mature adulthood.

2.1 Problem scenario

We can make the challenges and opportunities of intergenerational groups more concrete with a problem *scenario* (Rosson & Carroll, 2002):

> *Bernard, a senior accountant with 30+ years of experience in his field, was recently laid off from Berkshire Auditing during downsizing because of his poor computer skills. Motivated to learn technological skills, he accepts a lower position with H&M Block to learn the latest tax auditing tools as part of job training. Bernard is paired up with Lucy, a young tax clerk with an accounting degree. Lucy illustrates how to use the AutoAccount software that scans all tax*

forms and sorts them according to tax return amount. Bernard acknowledges the efficiency of AutoAccount but has difficulty keeping track of all the steps. He is embarrassed to ask Lucy to slow down and so he tries to keep track of each step that Lucy explains in his notebook.

After two weeks of processing tax forms, Bernard notices that the software doesn't account for leased car deductions for small businesses, which would place them in a different tax bracket. He suggests printing hard copies of all tax forms and manually categorizing them. Lucy brushes off Bernard's suggestion, arguing that working by hand through the pile of forms will be inefficient.

Bernard is taken aback by Lucy's slighting remarks, and does not feel a part of the team. He complains to Lucy that she is only interested in following a program and not in processing tax returns. Lucy recognizes the truth in this and is frustrated that she is unable to leverage Bernard's experience to the fullest.

2.2. Challenges

Intergenerational groups require integration of heterogeneous perspectives, implying a larger cost for communication, coordination, and conflict resolution. Older and younger workers have different working styles: while young workers have a relatively carefree attitude towards their capacity to work ('just do it'), older workers make more effort to use economical work practices (Strauβ &Kuda, 2000). Different generations of workers use different 'languages,' hold differing work practices, and work with different paces. This poses a challenge for CSCW technology: creating an infrastructure for bridging the cross-generational gaps by supporting common ground building and coordination.

Bernard's out-of-date skills in the scenario exemplify a common situation older workers face due to rapid technological change. Issues of skill obsolescence and retraining are highly significant for older workers, as they are less likely than younger workers to have had exposure to technology (Czaja, 2001). Unfortunately, managers often mistakenly conclude that older workers lack interest in new technologies, perhaps bypassing them when training opportunities arise. Management studies have documented the attitudes that limit job options and training opportunities of older workers (Rhine, 1984). However, older adults do want to learn about new technologies (Rogers, 1999) and are quite capable of learning new skills, tasks, and procedures (Czaja, 2001).

Moreover, negative stereotypes held by younger and older workers may impede productive collaboration. Finkelstein et al. (2000) found that in simulated employment settings, younger workers tended to rate older workers less favorably than younger workers when they were not provided with

job-relevant information about the workers. There is also evidence, albeit less so, that older workers are likely to have younger managers, which may create tension - older workers view their younger superiors as a threat (Steinberg, 2001).

Different training strategies are required to promote professional development in older and younger workers. Traditional training methods used with younger workers, such as lectures, are less effective for older learners than group discussions and problem solving, in part because the latter more closely emulates real-life work processes, and in part because they may mitigate the anxiety many older adults feel about returning to a learning situation (Knowles, 1984). Meyer and Poon (2001) showed that older adults can learn new skills and strategies when they receive well-designed training. There is agreement that adult learners are 'problem' oriented. Problems lead to learning, and perplexity leads to reflective thinking (Dewey, 1993): adults learn from solving perplexing situations problems. Two characteristics that distinguish older from younger learners are greater individual variability and changes in the motivation to learn (Long, 1991). Older adults are more diverse than younger colleagues on physiological, psychological, and sociological variables (Czaja, 2001; Hertzog & Light, 2004).

2.3. Opportunities

Fortunately, the intergenerational heterogeneity of perspectives and contributions has positive implications as well. In some situations, mixed-age groups perform better than homogeneous groups. Mixed-age groups offer more advantages when the work requires problem solving and idea generation. They can act as collective agents that integrate different social orientations; they can also protect against one-sided work conditions and performance requirements (Strauβ and Kuda, 2000).

The personal job experience of older workers provides special benefits for their groups, such as ability to recognize and react to irregularities in work procedures (Strauβ & Kuda, 2000). Identifying exceptions (e.g., the tax anomaly noted by Bernard in the scenario) often depends on intuition and tacit knowledge (Torff & Sternberg, 1998). Such experience-based knowledge is acquired through practice, not formal learning. Experiential knowledge requires considerable time to become useful as practical, action-oriented knowledge (Strauβ & Kuda, 2000). Younger workers tend to rely more on knowledge they are 'taught' during job training activities (e.g., as Lucy did when she assumed that exceptions

should be noted and handled at the end of the process). The combination of tacit experience-based knowledge of older workers and the explicit more formal knowledge of younger workers can be seen an opportunity—modules of complementary organizational memory that could be accessed and augmented through a CSCW system (e.g., Bannon & Kuutti, 1996).

Intergenerational groups also provide opportunities for professional development and knowledge transfer. Apprenticeship in such groups is unlikely to be unidirectional—while Bernard is learning from Lucy about technology and new work practices, there is also a transfer of domain knowledge, skill, and experience, implicitly or explicitly, from Bernard to Lucy. Bernard and Lucy have higher levels of competence in different knowledge domains, skill sets, and experiences, and therefore, a process of osmosis is created during apprenticeship in context of each one's *zone of proximal development* (Vygotsky, 1978).

Oral history, especially personal experience, is a rich medium for conveying tacit knowledge. Storytelling is known to be effective in workplaces. NASA (National Aeronautics and Space Administration), for example, has made extensive use of storytelling by using an online magazine to capture project managers' stories (De Long, 2002). The stories convert tacit knowledge to explicit knowledge, and are an effective method for assimilating new learning. Sharing stories, narratives, and experiences are a way of sharing tacit knowledge because they are an evocative and informal way of communication.

3. A theoretical framework for intergenerational groups

Instead of creating problems for productivity, older workers are now viewed as an asset that should be valued by groups and organizations (e.g., Stein & Rocco, 2001). Intergenerational groups provide an excellent context for older workers to share and apply their technical, planning, organizational, and social skills (Strauβ & Kuda, 2000). To further analyze how intergenerational groups can be supported by CSCW systems, we need a frame of reference that is grounded in existing models, theories, and frameworks.

We have integrated two theoretical perspectives to help us take into account the notions of both group *and* work. In particular, we draw from *Theory of Small Groups* (hereafter, TSG; Arrow et al., 2000) to articulate socio-psychological phenomena related to groups. We look to *Activity Theory* (Bertelsen & Bodker 2003) to understand work from a socio-cultural perspective. Each theory is insufficient on its own to address the problem of supporting intergenerational groups in CSCW, but combine well to provide a more comprehensive framework: TSG explains group phenomena in the foreground and treats work as a background process, whereas activity theory emphasizes work activity and considers group processes per se as background.

Our framework adopts the concepts of activity and artifact from activity theory (Bertelsen and Bodker, 2003; Bodker, 1991; Vygotsky, 1978). An *activity* is a rich human endeavor where practices and artifacts define one another in a historical context. *Artifacts* have a social origin (i.e., they are generated and transformed through social interaction); they mediate a group's thought and action and help to develop and compose the culture of a group. We distinguish three classes of artifacts in group work:

- *Knowledge and experience*. While performing group work, knowledge and experience are generated and exchanged among group members (e.g., members learn from each others' skills).
- *Social relationships*. Social relationships, norms, and roles are created, sustained, and transformed during group work (e.g., members create affiliation in the group).
- *Work products*. A group achieves its production function by generating and exchanging work products (e.g., reports).

We do not claim that these classes of artifacts are exhaustive in describing group work, yet they represent fundamental outcomes of group activities. A group can be defined in terms of *functions* that refer to the purpose and roles of a group (McGrath, 1991). By relating functions to the three types of artifacts generated and used in cooperative work, we propose the following three function-related themes:

- *Sharing and managing knowledge and experience*. Knowledge and experience needs to be shared and managed in group activities.
- *Social group dynamics*. The creation, sustenance, and transformation of social relationships form the basis for social group dynamics.

- *Performance and productivity*. Work products are outcomes of group performance and productivity.

These three themes suggest a synthesis of the resources that workers contribute to their coworkers, groups and organizations. For example, older workers have (a) domain knowledge and practical expertise in dealing with ill-defined situations; (b) experience in working with others, negotiating, integrating differences and resolving conflicts among colleagues; and (c) long-term planning skills and economical work strategies. Indeed the literature on work and organization has called for increased attention to a crisis caused by the aging of workforce: irreplaceable loss of knowledge, experience, skills and wisdom, and a consequential loss in productivity and effectiveness (Shaw & Smith, 2003).

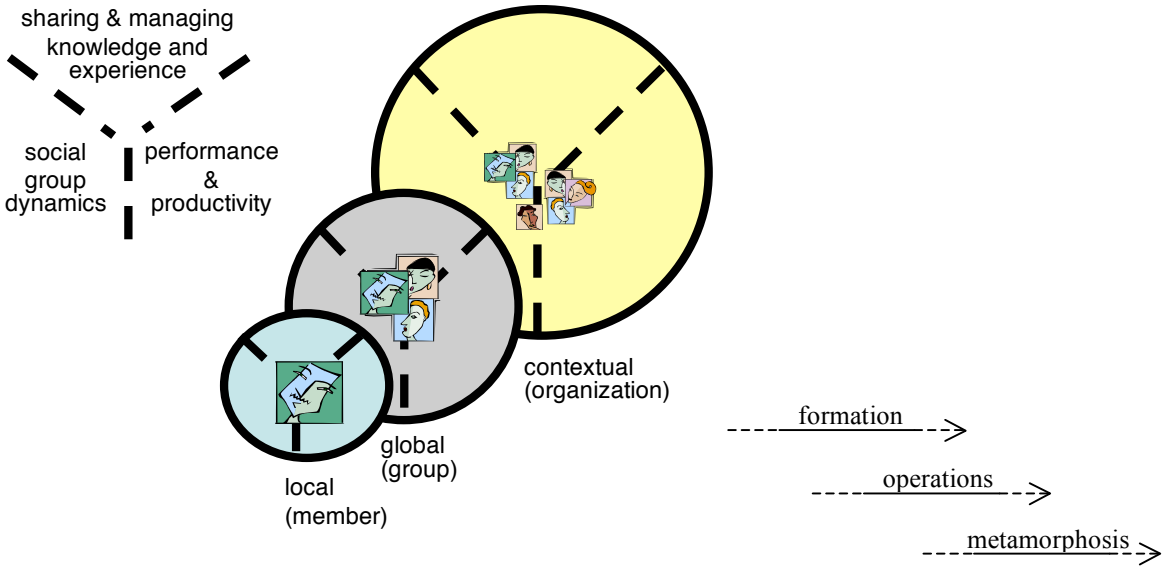

Figure 1. Framework for analyzing the complexity inherent in intergenerational groups.

A group is an open and complex system; as a system a group interacts with smaller sub-systems (individual members) embedded within it, as well as with the larger super-system (organization) that contains it. Drawing from system theory, Arrow and her colleagues suggest that causality and group behavior can be articulated with respect to three levels of causal dynamics: local, global, and

contextual (Arrow et al., 2000; this is conveyed by Figure 1 as three distinct circles). Each causal dynamic implies a different level of analysis:

- *Local level of analysis*. This represents activities of a group's members.
- *Global level of analysis.* This represents evolution of group-level variables that are driven by and shape local dynamics.
- *Contextual level of analysis*. This represents the group's organizational context that will shape and constrain both local and, in turn, global dynamics.

By articulating the dynamics at different levels of analysis, we can systematically investigate multiple causes and effects that may influence intergenerational groups. For example, an older worker may build stable social interactions with colleagues; at a global level, this may result in increased social integration and group stability. However, studies have shown that at the organizational level, supervisors may perpetuate negative perceptions of mature workers by reserving opportunities for career advancement for younger employees; this can have a strong impact at both the global (introducing conflict in the group) and local level (reinforcing age-related stereotypes in the different members; e.g., Parkinson, 2002).

From a developmental perspective, groups can be seen as living systems with their own life cycle. Groups strive to keep living, maintain boundaries, and set their own course over time (Sinnott, 1993). The structure and behavior of groups change over time, resulting in patterns and phases of development. The sources of development lie both within and around a system. TSG characterizes the life cycle of groups as three relatively sequential modes:

- *Formation*. Process by which a group emerges.
- *Operation*. Most of the group's existence in completing group activities.
- *Metamorphosis*. Process that dissolves the group or changes it to a new group.

The theoretical framework summarized here informs the design of collaborative systems in several ways. The *themes*, *levels of analysis*, and *modes of group life* represent three dimensions that we propose to use for systematic analysis of design requirements and potential design solutions. Each dimension can be viewed as conceptually dissecting the design space with respect to a different criterion (themes, levels of analysis, modes of group life). Thus, the framework guides us to distinguish

and evaluate different types of design tradeoffs, and to articulate design rationale for intergenerational groups.

4. CSCW Design: Principles and implications

Although empirical accounts of intergenerational groups largely do not appear in HCI and CSCW, this does not preclude us from leveraging foundations from other disciplines, such as adult learning and training. Therefore, to construct the design space as a theory-based approach to design, we take a synthetic approach. The design principles offered here are guided by the challenges, opportunities, and theoretical framework presented thus far, with the goal of illustrating how our analysis can inform design.

1. Support meaningful work activity for all group members, younger and older.

A system design should support work activity that has meaning to *all* the group participants. A lesson learned by adult development researchers is that in order to support older adults we need to successfully handle the broad individual variability characterizing older adults. There is a generational gap between younger and older workers consisting of different values, motivations, and expectations that the design needs to bridge. Groupware intervention is likely to fail if it does not account for different motivational factors and objectives of collaborators (e.g., Grudin, 1994). Motivation stems directly from the meaningfulness of the group activity. For example, adult learning researchers have emphasized that learning opportunities for adults should promote participation, choice, reuse of experience, and critical thinking (e.g., Knowles, 1984; Marsick, 1987; Brookfield, 1987).

2. Consider tradeoffs in design features across individual, global, and contextual levels of analysis.

The levels of analysis in our framework help to specify the unit of work that is being supported, and how different work units relate to each other. This is merely an analytic strategy to distinguish and understand specific factors affecting group work. Group phenomena occur at all three levels of analysis, and group dynamics at one level of analysis affect dynamics at the other levels.

Distinguishing the levels of analysis helps us to elicit appropriate requirements and to assess the costs and benefits of design features at each level of analysis. Design features satisfying user requirements at

a particular level of analysis may not be beneficial over time with respect to other levels of analysis. For example, computer mediated communication can satisfy the need for increased collaboration between the group members (global level), but may lead to the formation of cliques (individuals and subgroups). The formation of cliques satisfies an individual member's needs for affiliation and interpersonal relationships, but cliques may split the group into warring factions where the conflict reaches too high and the group, as a result, may not survive as an intact system (Arrow et al., 2000).

3. Consider tradeoffs in design features with respect to sharing and managing knowledge, social dynamics, and performance and productivity concerns (i.e., themes).

The themes refer to different products/artifacts generated and exchanged during the work activity and to different group functions. The three themes are mutually dependent, and designing for a thematic feature will often entail tradeoffs in other themes.

We suggest that designers should carefully consider costs and benefits with respect to function-based themes and between-themes tradeoffs. For example, a design that gives precedence to social group dynamics (e.g., providing multiple communication tools) may lead to performance and productivity costs, if group members spend more time in communication and less time doing productive work (e.g., Kraut, 2003, p. 339). On the contrary, if the design gives priority to performance and productivity (e.g., providing tools exclusively supporting task execution), there may be costs in sharing knowledge and developing social relationships.

Failure to consider tradeoffs among themes may result in expensive design failures. Designers should develop a value system capturing the needs of their application domain to help in judging the appropriate distribution of design support for the functional themes. For example, the observation that types of tasks (routine vs. problem-solving) interact with types of groups (homogeneous vs. heterogeneous) (Strauβ and Kuda, 2000) would lead to at least two different design arrangements with respect to the three themes. For routine tasks, precedence would be generally given to the performance and productivity theme, as opposed to social group dynamics theme for tasks requiring problem solving and creativity (e.g., brainstorming would require efficient technology for communication). In

general, for each arrangement, the distribution of design support will probably be unequal among the themes, yet be amenable to the *primary* goal of the group.

4. Consider the developmental characteristics of intergenerational groups as they move through the group life cycle (formation, operation, and metamorphosis).

As a group evolves through formation, operation, and metamorphosis, it tends to become more complex—which means that the number and variety of regularities in structure and behavior proliferate (Arrow et al., 2000). Intergenerational groups seem likely to increase this level of complexity to a greater extent than same-generation groups. Groups that are diverse —for example, intergenerational— prolong the formation phase of in a group. In the long run, diversity increases the flexibility and life path multiplicity (Arrow et al., 2000), because there is a larger range of possibilities available for group development. Given the greater ambiguity due to group complexity, a promising approach for CSCW designers is to design systems that afford evolution of the technology with the group and the activity performed by the group (cf. 'dynamic flexibility' in Dourish & Edwards, 2000; 'design for worker adaptation' in Vicente, 2000).

5. Methodological issues

5.1. From theory to research methodology

The use of work-as-activity and groups-as-complex-systems as pivotal concepts in our theoretical approach has implications for research methodology. The study of *work-as-activity* requires research methods that capture the long-term and distributed nature of an activity. These should inform on the *development* of the group. Measuring how well the three functional *themes* are supported requires measures that are appropriate to each group (e.g., measures of knowledge sharing, measures of trust and social support, measures of productivity and efficiency). Moreover, the study of elusive and unspoken phenomena, such as tacit knowledge, shared practices, and norms, will benefit from mixed method approaches that collect qualitative and quantitative data, and that use triangulation across different methods. Finally, the study of working groups at multiple *levels of analysis* (local, global, and contextual) requires the measurement of variables typical of each level. In CSCW research, dependent and control variables capture various responses measured at the levels of individual workers, groups,

and organization. While in traditional group research emphasis is usually placed on the attributes of the group, in CSCW the independent variables and potential manipulations often pertain to features of the technology supporting the group or the socio-technical context.

5.2. Development and research design

'The use of technology can be conceptualized as the development of skilled behavioral repertoires over time' (Hertzog and Light, 2004, p.101). In order to evaluate how skills develop, *assessment of change over time* is a critical element in understanding how much and what type of training conditions are more effective and efficient in promoting the use of new technology. Aging research has already acknowledged the need for research methods that gauge changes on numerous dimensions (e.g., physiological, behavioral, cognitive, and social changes; Hertzog & Light, 2004). Our emphasis on intergenerational groups requires the research design also to account for development at the *group* level. Research on groups has shown that patterns of continuity and change over time can be identified at both the group and member level. These patterns are often operationalized as stages and transitions in the skills and abilities of the group and its members.

Because development occurs over time, *repeated measures experimental designs* and *longitudinal designs* are useful strategies for studying development in intergenerational groups supported by technology. *Longitudinal studies* that use a *time-series design* are a useful solution for conducting initial, exploratory research of intergenerational groups functioning in the workplace and interacting with existing technology. Multivariate time-series observations on the critical variables of interest and accounting for relevant covariates can strengthen this approach (Hertzog & Light, 2004). Time-series designs can be used to: (a) quantitatively assess group development through global variables, such as group performance, cohesiveness, conflict and consensus (Arrow et al., 2000); (b) qualitatively examine of individual cases and their relationships by identifying similarities, differences, and dependencies between cases, and considering how the observed patterns relate to the technological intervention (Miles & Huberman, 1994).

When possible, detailed studies should be conducted using experimental designs in the laboratory and workplace, but *quasi-experimental designs* may be useful alternatives to consider in the workplace setting, particularly *interrupted time-series* designs. Such designs can be used to establish time-related trends on relevant variables before the introduction of new design features, and to learn about changes in level, speed of change, or variability after the introduction of these features. This type of research design is appropriate for several reasons: the key role of individual differences in mixed-age groups, the even greater heterogeneity among older workers than younger age groups, and the limited number of intergenerational groups that may be available for study (i.e., 'small N large P' problem).

5.3. Skill transfer and situation-dependence

An important research problem related to development in intergenerational groups is how well the system supports the *transfer of skills* and strategic knowledge across projects and groups. The aging literature suggests that younger and older workers may acquire and transfer skills at different speeds and in different ways (e.g., Charness et al., 2001). In order to design collaborative technology that optimizes development and performance in intergenerational groups we need to understand how skills are transferred by different group members. However, in order to make meaningful comparisons between younger and older workers with respect to skill transfer, we need to ensure that both have reached the same level of mastery on the target skills (i.e., older workers probably need more sessions of training to reach the same level of mastery as younger workers).

Moreover, careful attention should be given to relevant *co-variables* and *interactions*. *Age* effects on the ability of transferring skills should be separated from the effects of *situation-dependence*: skills acquired within a specific group, task, and work setting are less likely to transfer to different groups, tasks or work settings, without explicit instruction to make such a transfer. It would be important to determine if age interacts with situation-dependence when transferring to new group situations. Perhaps older workers would need extra instruction brushing up on the skills targeted for transfer.

5.4. Cohort effects and individual differences

Cohort effects and aging effects are often confounded when adults of different ages are compared in cross-sectional studies. Schaie and colleagues have used longitudinal studies to investigate age and cohort effects separately. The differences between cohorts often result from changes over time in the profiles of abilities valued by the society (e.g., Schaie, 1996). Societies with different histories of schooling, media adoption, and information technology may yield cohort effects among generations of technology users.

Various sources of *individual differences* pose another methodological challenge to researchers on aging and technology, because it is difficult to delineate the profile of 'the average person' who uses technology (Hertzog & Light, 2004, p.98). It is difficult to isolate or separate the effects of age from the effects of other individual differences, such as gender, work experience, and socio-economic status, on work performance. The issue of subpopulation selection has critical importance for selecting the appropriate research design.

If larger samples are impractical, researchers can select samples that are homogeneous on influential variables. Traditional evaluation studies of technological interventions are cast in an experimental model that assesses the results of the technological intervention though analysis of variance (comparing mean responses). However, research on human abilities, cognitive aging, and educational psychology, has shown that the interventions may be differentially effective for individuals varying along some dimension (Baltes, Reese, & Nesselroade, 1988). This suggests that *mixed-method approaches* are preferable when a relationship between response variables and individual differences may affect the results.

6. Discussion and conclusion

6.1. Extending prior work

In our prior work (Convertino et al., 2005) we identified design requirements for supporting older workers in CSCW, using design micro-scenarios to illustrate envisioned computer-supported interactions that might support important aspects of intergenerational collaboration. These design

proposals included these specific ideas: (a) an asynchronous communication backchannel used to support common ground and coordination; (b) desktop sharing and storytelling tools used to support tacit-knowledge transfer; (c) notifications and visualizations of collaborators' activity used to leverage older workers' sensitivity to exceptions; and (d) annotations that tracked who contributed what work outcome, thus increasing visibility and associated reward of work outcomes. These design ideas were not intended to be exhaustive. Rather we hoped establish initial ground for design work, and initiate a theory-based discussion of how to better support collaboration among intergenerational work group members.

In this paper, our contribution has been threefold. First we have described a synthetic framework drawing from an interdisciplinary research base, to view the problem of designing groupware for intergenerational teams from a theoretical lens. Second, we have proposed a set of high-level design principles suggested by this framework and the design opportunities and challenges discussed. Third, we have raised a number of methodological issues that must be considered in the research on intergenerational groups. Thus our remaining remarks are organized around these three contributions: theory, design, and research methods.

6.2. Theory, design, and method

Our *theoretical approach* builds on analytic constructs from TSG to describe and explain complex group phenomena, and from activity theory to explain work as a socio-technical production process. The rationale for this composite approach is to increase the *explanatory power* of existing conceptual models in CSCW and, as a result, promote broader understanding of intergenerational groups and theory-based design of collaborative tools. TSG and activity theory provide different conceptual tools that help explain distinct aspects of intergenerational computer-supported cooperative work. This suggests that our approach should satisfy the principle of Occam's Razor – the concepts of our explanation are not multiplied unnecessarily.

A conundrum of design is to resolve the tension *between tradition* and *transcendence*, as design is always bound by tradition (current work practice) and, at the same time, committed to transcending

tradition in order to add new value. In intergenerational groups, CSCW designers will need to address the old tension between tradition or transcendence. In addition, they also need to design solutions that are compatible with and coordinate among various skills and work practices from different generations.

Participatory design is a useful approach for eliciting requirements and designing CSCW tools. We argue that *participatory design* would lead to richer results *with intergenerational groups* than with same-generation groups. Designing for intergenerational groups requires designers to *bridge across different eras of artifacts, work practices, and skills*. The gap between skills and practices of younger and older workers—which is a consequence of the evolution of technology and work—encompasses a broad spectrum of experiences useful to design that to date have largely been either accessible to designers only or have remained unexploited due to design processes that focus on future designs that will replace present ones but fails to learn from past knowledge, skills and artifacts.

Finally, teams composed of age-diverse members have *implications for research methods*. TSG suggests that the *effect of group composition*, task structure, and tools (or resources) on the generic group functions (production, group well-being, and member support) can be viewed as a degree of 'fit' among these three elements (McGrath et al., 1993). Given the special role of group members (actors) and the higher variability in the composition of diverse groups, we argue that *the specific mix of attributes* (number and proportions) characterizing the members of a group is an important methodological matter when interpreting measures of group functions (e.g., production).

While it is relatively common to consider the role of gender or ethnicity as a diversity issue for groups (Parkinson, 2002), little research is available about the effects of varying age mixes on group functions. The issue of age composition is complex because age diversity carries with itself other dimensions of diversity, such as personality, educational background, work experience, social status, seniority, work function and division, and level in the organization. Moreover, age is a continuous variable, and the concepts of 'older worker' and 'younger workers' refer to two age intervals that have never been clearly defined and separated.

6.3. Concluding remarks

In this paper, we have argued that the field of CSCW must enhance its understanding of intergenerational groups, a major frontier for the design of future collaborative systems. Designing systems for mixed-age groups is complex and represents a part of a larger challenge of designing for workplace settings that are becoming increasingly diverse (Parkinson, 2002). Designers need to account for the implications of major transformations occurring in the workplace and workforce: demographic, technological, and organizational changes.

We outlined a theoretical approach to explain of both group *and* work phenomena by leveraging constructs from TSG and activity theory. *Themes*, *levels of analysis*, and *modes of group life* are dimensions that we propose for dissecting and analyzing the design space. Working from this framework, we developed high-level design guidelines and explored specific design features that might future work.

An obvious next step is to conduct field and laboratory studies to empirically inform the design process. We think *participatory design* with intergenerational groups is a fertile approach for design. This will prompt designers to bridge across different eras of artifacts, work practices, and skills by both interacting with and involving older and younger workers as stakeholders in the design process.

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