Supervisor-Student Research Meetings: A Case Study on Choice of Tools and Practices in Computer Science

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ABSTRACT

Supervisory meetings are a crucial aspect of graduate studies and have a strong impact on the success of research and supervisor-student relations, yet there is little research on supporting this relationship and even less on understanding the nature of this collaboration and user requirements. Thus, we conducted an exploratory study on the choice and success of tools and practices used by supervisors and students for meetings, for the purpose of making informed design recommendations. Results of a series of five focus groups and three individual interviews yielded three themes on: 1) supervisory style diversity, 2) distributed cognition demands, and 3) feedback channel dissonance. Student-supervisor collaboration has many unexplored areas for design and as a first step our work highlights potential areas for supportive designs and future research.

Keywords: student-supervisor collaboration; supervisory meeting; tools and practices; exploratory study; thematic analysis

Index Terms: H.5.3 [Information Interfaces and Presentation (e.g., HCI)]: Group and Organization Interfaces—Computer-Supported Cooperative Work

1 INTRODUCTION

An important part of graduate research involves an inherently collaborative act of knowledge creation and problem solving between a student and his/her research supervisor. The type and nature of student-supervisor collaboration can vary significantly depending on many factors, including the culture of a community of practice and norms and expectations of the academic institution. The student-supervisor collaboration in applied sciences and engineering —and within our case study of computer science (CS)— is commonly characterized by face-to-face individual research meetings between a student and his/her research supervisor(s). This typically involves some variation of first setting a time and sharing required resources before the meeting, exchanging ideas during the meeting, and capturing the outcome of the communication after the meeting for future reference or action. The meetings are dispersed over different periods of time (e.g., one week or longer) and include the introduction of new information, as well as discussion of items already familiar to both parties. Students and supervisors are involved in multiple activities and responsibilities [12] that consume attention resources. Expectations of work habits and judgements of priorities and perceived value of research-related activities may not be made explicit. Additionally, students and supervisors' expertise and degree of involvement in the project are different; it is therefore not possible to always assume a common level of understanding between the two parties concerning the status of the research. These characteristics can increase the chance of ineffective meetings, and result in miscommunications and even conflict in a student-supervisor relationship.

To handle meetings and the relationship effectively, students and supervisors use a variety of tools (e.g., email, pen and paper, Evernote) as well as practices (e.g., sending an agenda 24-hours in advance). The choice of which tools to use is based on both awareness of existing tools and practices, as well as individual differences and personal preferences [8, 15]. We suspect that developing a process that works for both the supervisor and the student takes a lot of effort and happens implicitly over time, often by trial and error, potentially compromising the efficacy of the collaboration. The purpose of our study was to understand what drives the choice of tools and practices in student-supervisor relationships, and if and how current approaches are unsupported.

Despite the importance of supervisor-student collaboration on the progression of research and success of their relationship, there is little research on supervisor-student collaboration, nor on the tools and practices supporting this relationship. Existing research on group collaboration has investigated the affordances of a set of tools such as pen and paper or physical and virtual whiteboards [26]. We believe understanding the nature of collaboration and the reasons or factors for choosing a tool is equally as important. Our study builds on the body of research within HCI that endeavours to look beyond interactions between the user and a system, and to the specific contexts and activities or practices of individuals that shape or drive the interaction [13]. Thus, instead of focusing on the specific characteristics of tools, we set out to identify the major factors affecting supervisor-student collaboration by conducting an exploratory study with students and supervisors about the selection and evaluation of tools and practices for research collaboration. Our investigation also sought to understand the nature of the supervisor-student relationship (albeit, within the specific context of CS), and determine if profiles of supervisor-student collaboration could be derived from the tools and practices used. We believe developing such an understanding is the primary step for recommending future tool and practice design to support this collaboration. To clarify the scope of our study, we considered any digital (e.g., online scheduling software, social networking tools) or physical (e.g., whiteboards, notebooks) tools used to facilitate a meeting. In our study, practice refers to activities, processes, or habits of students and supervisors for research, information exchange, or collaboration such as keeping a personal or shared research blog, or sending meeting minutes.

Studies suggest that the design of supportive systems for knowledge sharing would benefit from a focused investigation and a nuanced understanding of the context of the collaboration [4]. We therefore focused on the graduate level within a university department of CS. Through thematic analysis of the data collected from five focus-group interviews with supervisors and students and three individual interviews with supervisors, we developed three themes. Despite the limited population of our study, we found enough variation in the practices of our participants to suggest important implications for devising supportive tools and practices. In summary, our contributions include:

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- Evidence of individual differences in supervision style as a major factor on choice of tools and practices;
- The application of distributed cognition as a theoretical framework that allows holistic analysis of student-supervisor collaboration and their tool use;
- The call for two supportive systems: 1) a system or mechanism for mutual tracking and feedback on the research and relationship progress, and 2) a dedicated tools-and-practices awareness system for the discovery of ways to address the unsupported needs of student-supervisor collaboration.

2 Related Work

Research on Group Collaboration. Studies of group meetings suggest that a variety of factors impact group dynamics and the collaborative process [21, 24]. For example, seating arrangement [24] and table and group size [21] have been shown to impact the distribution of roles, coordination, and comprehension during collaborative face-to-face meetings. Various tools have been proposed and developed to account for such factors and to facilitate collocated meetings, including single display groupware [25], and note taking applications [5]. Additionally, tools have themselves been identified as a possible factor, with Verma et al. [26] studying the impact of input device affordances on collaboration and task outcome during meetings. While geographically-distributed research teams employ a variety of communication and collaboration tools to great effect, the technologies may also prove a source of stress if viewed as an additional task to manage or are not seen as appropriate platforms for conveying criticism or disagreement; Siemens [23] believes collaborators should balance their digital and non-digital tool use and plan accordingly at the onset of a research project; additionally, tools selected must support aspects of both the research and the researchers' relationship.

Research on Higher Education and IT. While pedagogical literature and higher education research agree that the supervisory relationship has a significant effect on successful experiences within academia and university attrition rates [16], there is little understanding surrounding the nature of supervisor-student relationships and collaboration, specifically how meetings are conducted, knowledge is shared, requests and recommendations are articulated, and tools and practices are used for idea exchange in meetings. In 2002, Marsh et al. [16], developed a survey instrument to assess satisfaction levels of PhD students across different universities in Australia after noting the lack of research on the quality of PhD student supervision; however, apart from a single item on the provision of university computer facilities, the Postgraduate Research Experience Questionnaire failed to explicitly address the respondents ratings and use of ICTs during their program of study. A 2004 review of the role and influence of information and communication technologies (ICTs) in graduate student supervision, indicated that technology can provide flexibility in the relationship between students and supervisors [17]. However, a 2012 survey of graduate students completing programs by distance found that they were less satisfied with their supervisory relationship than those who were not in online programs [7], leading the authors to speculate as to the exact effect the use of technology had on the relationship between students and supervisors. Based on our own literature searches, there has yet to be a comprehensive study of technological tool choice in the context of supervisor-student collaboration.

De Rezande et al. proposed a system for managing student-supervisor collaboration to support graduate thesis progression [6], however, the system was designed based on informal interviews and designers' assumptions. We think such a system could benefit from a richer study of the student-supervisor relationship. Reviews of educational technologies, like E-portfolios [14], also have focused on functionality and potential applications for graduate student supervision without closely examining if and how they are being used within a research context or relationship. The invisibility of supervision practice within the literature prevents inferences and thereby opportunities for improvement. Our qualitative formative study seeks a better understanding of users, and their practices, as a prerequisite to successful solutions and supportive systems.

3 Research Context and Methods

Methodology. We conducted joint supervisor-student focus groups, a student-only focus group, and individual interviews with supervisors. Each of the four focus group sessions comprised one faculty member and his/her students who were available to attend at the designated meeting time. Prior to undertaking our research, we were already familiar with the faculty members and some members of the research groups (one of us is a student in CS, and one has taken classes within the department); our experiences as members of research groups, as well as our impressions about supervisory styles and awareness of the possible diversity of participants personalities, preferences, and practices within just one research group contributed to our initial interest in the topic of study. The purpose of the joint focus groups was to highlight the variations and intragroup differences within one research group under a single supervisor. The aim of the student-only focus group was to reduce the potential influence of the supervision power dynamic on students' responses during the joint focus groups, while the individual interviews enabled supervisors to communicate their experiences more candidly while still providing a level of anonymity for their students. The student-only and the supervisor-only sessions provided an opportunity for us to member-check our findings from the joint focus groups.

Participants. We had 19 participants (7 Female) recruited from a CS department, including 13 students (8 MSc, 4 PhD, 1 undergrad), 2 postdocs, and 4 faculty supervisors for the joint focus groups; 4 of the students made up the student-only focus group and 3 (out of 4) supervisors participated in follow-up individual interviews.

Data Gathering. Because of faculty members' limited time and the difficulty of recruiting entire research groups with a general call-for-participation, we contacted six faculty members and research groups we were familiar with; we interviewed the four research groups that responded to our email. Having all participants from one department ensured that our participants came from the same academic environment and culture of CS.

For the student-only focus group, we contacted six of the students from the initial series of focus groups in order to follow up on information that they had previously shared with us. We also specifically selected students to achieve representation of at least one person from each of the four research groups and variability of both stage of research and particular supervision arrangement (e.g. co-supervision). Based on availabilities, our focus group ended up including four students. Owing to scheduling conflicts and the challenge of finding a time to meet with all supervisors at once, we individually interviewed 3 faculty supervisors who agreed to participate in our second interview.

Each focus group lasted about one hour. Two of the three authors were present and responsible for jointly conducting all of the focus groups and individual interviews. Interviews were semi-structured; discussion topics were provided to the participants in advance over e-mail and were again provided in hard-copy or by projection on a shared screen during the session. During the interview, participants were encouraged to talk about any experiences with past and current supervisors, as well as personal approaches to research and collaboration, with a particular focus on what tools and practices they used, their reasons and their degree of success. Individual interviews with supervisors were held in their offices and each took about 45 minutes. Audio files for joint focus groups were transcribed (in excerpts included here, supervisor participants and students are anonymized as Sp-G#, and St#G#, respectively, according

to which research group they belonged to). We took notes by hand during the student-only focus group session and the supervisor-only interviews because of the increased sensitivity of the data.

Analysis. We used Braun and Clarke's approach to thematic analysis [3] for our qualitative dataset, which consisted of transcripts of the four joint supervisor-student focus group interviews. Thematic analysis is a research method for identifying and reporting patterns, or themes, from datasets. It differs from other approaches to qualitative analysis (for example, grounded theory) in that the findings do not need to confirm or comply with any one theoretical framework; thematic analysis is thus flexible to accommodate both essentialist (i.e. what people are actually doing) and constructionist (i.e. how people interpret and attribute meaning to their actions) analyses of practices. Our analysis sought to initially identify patterns of reported behaviour for the purpose of research collaboration, as well as evaluate their perceived effectiveness and determine which practices were either commonly shared amongst participants or unique to individuals within a supervisory relationship.

Two of the authors individually coded our transcripts by applying descriptive keywords or phrases to longer excerpts; we then reviewed codes together to discuss any deviations in our agreement on and applications of codes and refined our annotations. Excerpts annotated in the same way were collected together, and along with sets of codes that frequently co-occurred within the data, were identified as potential patterns and used to develop initial themes. Themes were later reviewed in light of the coded extracts to ensure they accurately reflected the intent of that stage of analysis. Because of the interpretive nature of this approach to analysis, we also conducted member-checking of our findings during additional interviews with the four participants of the student-only focus group and three supervisors to refine our findings and confirm that we had developed a thematic map that was representative of and consistent with the data.

4 RESULTS

We present the results of our study in three themes. As previously stated, we focused on understanding the factors that impact choice and success of tools instead of describing specific tools and their affordances in detail. We saw a variety of tool use within our case study including wikis, weblogs, physical notebooks, digital text files, Evernote, laptops, mobile devices, projectors, whiteboards, email, online calendars, and Twitter and Facebook for microupdates. Major practices included sharing a public calendar to schedule meetings, booking all regular meetings at the start of term as a 'placeholder', daily collocated or online microupdates in the research group, sending an agenda and meeting minutes, compiling meeting notes immediately after meetings, and keeping a digital or physical repository of meeting notes, like a wiki. In the first two themes, we discuss factors impacting choice and success of tools, as well as the reciprocal nature of the connection between tools used and the supervisory relationship dynamic. Theme 3 indicates that awareness of tools and practices is an important yet unsupported area of student-supervisor collaboration. Member-checking with participants confirmed and further refined the three themes.

4.1 Theme 1: Supervisory Style Diversity

A major theme developed from the data was the significance of the supervisor, and their supervision style, for determining and driving the supervisor-student relationship dynamic and choice and success of tools.

There was a large spread of individual differences among supervisors; each supervisor has his/her own preferences and personal practices already in place. The flexibility and capacity to adapt to student needs can vary between supervisors; the relative rigidness of a relationship is in turn exacerbated by each supervisor's time constraints, availabilities on campus, and concurrent supervisory responsibilities such as their current number of students.

Both supervisors and students in our study situated these individual differences in supervision style on a continuum of structure, referring to a supervision style as being more structured or less structured. Supervisors who fell on the more structured end of the spectrum typically required that their students follow or agree to certain practices (e.g., sharing meeting minutes) and expected regular communication (e.g. frequent meeting or e-mail updates) to ensure effective collaboration. The less structured supervisors, however, eschewed strict rules and rigid expectations of students in favour of having a more flexible collaboration. In this regard, the personal perceptions of 'what it meant to be a supervisor' played a role; for example, Sp-G3 recommended and Sp-G1 required all students to develop and share agendas in advance of meetings because both saw the practice as a way of training students in structuring their thoughts, which not only resulted in an effective meeting but also prepared them for professional research career.

Sp-G1: I tend to be a little more on the structured end of the scale of possible supervisory styles and like agendas...[I'm] helping you to learn this kind of discipline, because you will make progress better with this kind of structure.

Sp-G3: I think it's a very important skill for the students to figure out how they want to use the time with me, I mean it's something that I request my students do, I think it's a very good practice.

Sp-G2 and Sp-G4, on the other hand, were less structured than Sp-G1 and Sp-G3 and only articulated the worth of an agenda relative to their own needs. Specifically, because they were not always able to read them before a meeting, they did not see any point in having their students go through the effort of creating one.

Sp-G2: It kind of makes me feel guilty, asking people to send me an email [if] I'm not going to read it...I feel as a supervisor, that unless I can give quality feedback on it...it's just like "oh, I have this rule and you have to do it."

Sp-G4 reiterated this same thought, saying that it was not fair to request something of a student that would not be made use of. These expressions of consideration for the student, and mindfulness of the power dynamic inherent to the relationship is a different perspective on the role of a supervisor. In these cases, the role is understood with less emphasis on professional development which in turn enables more flexibility for the individual student and greater variation in practice within a research group. Students of Sp-G2 and Sp-G4 reported dropping by their supervisors' office if they needed while meetings with Sp-G1 and Sp-G3 were almost always pre-scheduled. For St1G2, this less structured style improved communication of both research and non-research items, such as personal life stresses. Additionally, this understanding of the supervision role may be related to the supervisor's personal interests and time constraints; Sp-G2 expressed a desire for providing more mentoring to her students and saw this as additional support the CS department should deliver.

While our analysis of the data identified a variation in supervision styles, none appeared to be categorically better or worse than any other. The relative level of structured supervision seemingly did not have much of an effect on either student research progress or relationship satisfaction. However, a mismatch between work styles and practices of a supervisor and student within a given relationship could stress the collaboration dynamic and slow research progress. Our data suggests that senior students (post-docs and senior PhD) could cope with this mismatch and adapt to their supervision style more readily than junior students.

Despite a rich variety of tool use among the students, they shared in common the behaviour of reshaping their own practices to accommodate and adapt to their supervisors. This was evidenced by shifts in behaviour for the purpose of collaboration, such as sanitizing personal notes to prepare them for the supervisor, or an adoption of scheduling or calendar tools. A change in student practice was

also frequently the result of one's knowledge of supervisor practice; for example, an understanding of occasional supervisor forgetfulness might result in a habit of student-generated post-meeting reminder emails. One student (not identified for the purpose of anonymity) described adoption of a new style of directing meetings with the supervisor, in reaction to the supervisor's tendency for going on tangents, saying *"I've learned to have one thing only to discuss."* The success of this arrangement is in turn determined by the student's ability and willingness to adapt, as well as the context of the adaptation, including their stage of research, length of the relationship, and physical colocation of students and supervisors.

All supervisors reported that they rarely shifted their practices for a student and only then in exceptional circumstances. For Sp-G2 this occurred when the student was perceived to be struggling, and thus more structure was introduced by the supervisor, such as requiring an agenda or a set timetable of meetings. For Sp-G4, this happened in the absence of the regular matchmaking between supervisor and student; typically, supervisors and students choose to work together, but in situations when Sp-G4 was assigned as a supervisor and had to work with a particular student, there was more willingness to adapt research practices and communication preferences to meet the student's needs and make things work. Sp-G1 also admitted to being incapable or unwilling to change behaviour to avoid conflict with a student, citing time constraints and considerations for cognitive capacity (such as the taxing effect of being party to multiple research collaborations) as factors.

4.2 Theme 2: Distributed Cognition Demands

There is a high attention and memory demand on both students and supervisors conducting research — a process further complicated by its being distributed across multiple individuals.

The theoretical framework of distributed cognition [9] (or DCog) lends itself well to an understanding of the supervisor-student relationship. Distributed cognition theory, developed by Hutchins in mid-1980, emphasizes the social aspect of cognition. In his seminal study, Hutchins described the DCog theory within the context of navigating a US navy vessel whereby the transfer of information between crew members and various tools and external representations make the ship's navigation possible [10, 11]. In a distributed cognitive framework, the unit of analysis for cognition is not an individual but could be a small sociotechnical system comprised of individuals, their environment and its artifacts. In our case, students and supervisors, as well as their shared and personal tools and practices, can be considered as components of a cognitive system dedicated to the complex task of research. In our interviews, we found evidence of supervisors and students relying on different components of the cognitive system to perform and support tasks and distribute responsibility for execution of practices. For example, Sp-G2 mentioned a '24 hours rule', an established practice of having students be responsible for sending a reminder if they had yet to receive requested items more than 24 hours after a meeting. Sp-G1 sometimes passed on items to students to keep as their 'agenda seeds' for future meetings and, in doing so, was able to relinquish responsibility over them.

Sp-G1: I might say...let's just put it on the agenda [for] next time we meet...and then I've tossed that basketball to [the student], and I'm not gonna try and remember any more...

More intragroup awareness between members of a research collaboration, achieved through either increased use of shared workspaces or microupdate tools like Twitter and Facebook, was also identified as desirable by participants, in part because it would decrease the burden on the supervisor to be the only source of research group information. G3 also reported relying on Facebook for microupdates, but only during the summer when some group members were away or did not maintain regular hours.

According to DCog theory, the cognitive mechanisms involved are not limited to those happening within an individual actor but involve rich interactions between internal processes and external representations and artifacts [9, 19]. Our participants' use of documents and diagrams, especially those co-created between supervisor and student, suggests that artifacts as representations of research are particularly useful for helping to remember a conversation and recover context of a past meeting (See [19] for a discussion of cognitive artifacts and the importance of external representations on cognitive functions and problem solving efficacy).

St1G1: I keep a written notebook mostly to organize my thoughts...

Sp-G1: A lot of time what's happened is that someone comes in and has already written something on a page and then we further discuss it and maybe add a layer of annotation on that page as we discuss it...I then gain some mind space on the page...

The importance of various components within a cognitive system and the information flow between components (whether it be the student, the supervisor, a shared, or a personal artifact), can vary for each supervisory relationship. Our data suggest this difference is related to the supervision style; in the case of less structured supervisors (Sp-G2 and Sp-G4), the student is the main component of the cognitive system, and thus personal (non-shared) tools and practices have a more prominent role in the success of research. In the case of those in G4, for example, sometimes the supervisor entered meetings with students without "having any idea of" what was going to be discussed; it was the role and responsibility of the students to know, not the supervisor:

Sp-G4: I tend not to [take notes], (laughs) but I ask the students, 'whoa, ok, so what happened last time?'

In the case of more structured supervisors (Sp-G1 and Sp-G3), the information exchange between the student and the supervisor is more detailed and shared tools and practices are more prominent. Consequently, these supervisors are more likely to require shared artifacts and practices such as agendas or meeting minutes. However, as previously reported, when the less structured supervisors exhibit a shift in behaviour to adapt to changing relationship dynamics, an increased or introduced dependence on tools and practices - such as regular contributions to a research wiki or requiring an agenda for every meeting - was often the outcome; with a decrease in perceived accountability of the student in the system, tools and practices became elevated components.

Additionally, the information flow among components of a supervisory Dcog system can change over time due to external factors such as sabbatical and maternity leaves or factors such as the successful transition of the student to a state of independence in their research or the adoption of a new tool or practice.

St1G3: I had some meetings with agendas and some not depending on what stage of the project we were at...

While every collaborative act implies some sort of distributed cognitive system, looking at the supervisor-student relationship as one cognitive system can help suggest which practices and tools will be useful within a given supervisory relationship and help in analyzing the temporal changes in information flow between the components.

4.3 Theme 3: Feedback Channel Dissonance

Among our participants, there appears to be little or no infrastructure in place for students and supervisors to discuss, and advise about their tools and practices. Additional evidence comes from the fact that students knew so little about their supervisors' opinions of their tools and practices that our own joint supervisor-student focus groups served as an intervention for some of the participants; St1G1, for example, came away with the knowledge of being a "master of agendas" and was appreciative of the supervisor's approval, but prior to the joint focus group had been unaware of having any aptitude for crafting them.

Supervisors also indicated uncertainty about students' viewpoints on their practices, and the value of recommending or enforcing them, as well as their effectiveness for research collaboration more generally. For example, Sp-G1 described an unawareness of the relative structure of the research group compared to others, and how it rated on "the scale of possible supervisory styles." Sp-G2 also described a difficulty with knowing if a decision not to hold group meetings was the right choice. Additionally, supervisors directly asked us to share our results as they thought it would be helpful for their future relationships.

A distinction should be noted between feedback on student projects, and feedback on practices:

St1G1: I feel I get enough feedback on what I'm working specifically on...I want to be aware of what I'm not aware of...

But while St1G1 welcomed practice feedback or performance reviews, St3G4 saw little value in this kind of information or advice, reasoning that the supervisor would be less insightful and aware of the struggles and subtleties than the student would have of their own working styles. Furthermore, there was a lack of consensus concerning how such feedback (particularly, critical feedback) ought to be communicated, especially to more sensitive or stressed students. While some students preferred a face-to-face conversation, others foresaw a discussion fraught with social pressures, in particular, a fear of offending the supervisor. On the side of the supervisor, there may also be some tension or discomfort experienced with voicing both positive and negative feedback. In the former case, Sp-G1 worried that it might seem patronizing to a student to complement them on, for example, an agenda; in the latter, both of the two less structured supervisors (Sp-G2 and Sp-G4) also expressed reluctance to critique students' research practices, partially out of fear of suppressing students' future experimentation, intellectual curiosity, and desire to explore new approaches for collaboration.

Sp-G2: I yell at my daughter to do stuff, I don't really feel like I need to yell at my student...

Perhaps not surprisingly, within the specific context of a study of CS, workflows were very much influenced by changes in technology; however, this was not strictly limited to just tool use, but how the discipline of CS itself had changed. Sp-G4 in particular discussed how the evolution and diversification of the field over the years had resulted in there no longer being a shared vocabulary among practitioners or consensus of what constituted a core knowledge that all students and supervisors would have in common. This in turn affected the assumptions one could make about tool use and awareness of technologies, for example, proficiency in LaTex, a document layout and formatting software that was once a standard tool in CS.

Our data suggests that when a feedback channel is broken or incomplete within a supervisor-student relationship, practice and tool use is transferred between peers, both within and outside a research group, but in an ad-hoc manner. For example, three students within G3 mentioned they had started using a wiki, and on a particular platform, after receiving recommendations from another student.

5 Discussion

This section includes our recommendations for design followed by limitations of our work.

5.1 Implications for Design

Our study suggests that no one tool can accommodate the diverse needs of various research groups, however, we think the following implications for design can certainly benefit some, if not all, supervisory and research relationships.

1) Tracking research progress can improve awareness of research and serve as a channel for communicating relationship feedback. As previously stated, some practices required or encouraged by supervisors were done in order to gradually transition the student into an accountable, independent state and ready the student as a professional self-directed researcher. However, there is no mechanism for tracking students' goals and progress, identifying students' professional growth over time, or communicating relationship feedback.

A mechanism that increases awareness of and promotes mutual feedback on work practices and the supervisory relationship would help with the selection, adoption, or development of tools and practices that work best for all stakeholders. Devising and committing to a feedback practice or habit could be as simple as a scheduled conversation or a more structured supervisor-supervisee performance review covering research and relationship items.

More sophisticated tools that afford data-driven tracking of the supervisor-student relationship or provide charting of its development over time with respect to selected dimensions of the collaboration (e.g., frequency of meetings, summary of submitted deliverables, and professional activities like conference presentations) can introduce a degree of centralization to distributed cognitive mechanisms of the relationship. It could additionally prove useful as indirect feedback channels that promote increased awareness of individual and relationship practices systematically, thereby avoiding having the onus on the supervisor who might forget or feel awkward to convey such information.

Supervisors in particular commented that a tracking system would be useful for recalling the stage of research for each student and resuming context; additionally, such a tool would help students visualize their progress over time more easily, which may prove helpful to more senior students, such as PhDs, who may be more in need of reminders of their accomplishments as well as indicators that it is time to move on from something they have spent a lot of effort on with little to show for it.

Customer Relationship Management (CRM) systems are examples of designs that provide related functionality, such as automatic aggregation of past activity and communications from various software applications, as well as tracking and alerts for outstanding items, and generation of a dashboard display of relevant relationship history profiles. Instances of CRM have previously been implemented within the academic environment, but typically for administrative and financial management of the student's relationship with the university [20], not with the supervisor. Unlike a typical CRM system which supports a company in tracking and management of its relations with clients, a supervisory CRM should promote a shared understanding of the research between a student and a supervisor. Thus, a supervisory CRM should support students and supervisors equally yet not identically by providing both parties with similar information while prioritizing that which is most relevant to each depending on their role within the relationship. Supervisors and students would also require different access rights and management options to support their roles. For example, supervisors must be able to manage interactions with several students working under their supervision. Another important feature for a supervisory CRM is supporting personalization to accommodate various supervisory styles, stages of research and changes in the supervisor-student relationship. For example, frequency and format of requested artifacts or updates can be increased to apply more structure or centralization to a supervisory relation as needed (e.g., supporting a new graduate student or during sabbatical).

Computational network models could also inform supportive system designs. Spatio-temporal analyses of social networks have already been used to identify emerging relationship trends, including changes in centrality of a network or increasing and decreasing network cohesiveness [22]. Similar algorithms could be applied to research groups or individual supervisor networks to analyze relationship interactions and anticipate disruptive forces. For example, in the case of a sabbatical leave, a supporting system may help to identify the increased priority of frequent student-supervisor contact, and even suggest multiple means of communications, to counteract the detrimental effect of geographical distribution.

A challenge with the implementation of such a system, however, is related to the organizational culture (or lack thereof) of graduate school. Unlike a corporate environment where employees typically have no say over what documentation software or e-mail client they use, there is a lot of individual variation and choice allowed for students and supervisors; some participants were also not in favour of the idea of forced adoption of a system. Additionally not all research communications occur through software systems which means any software modeling tool that attempted to capture the relationship and its dynamic would be incomplete. Furthermore, any new tracking support should aim for little to no additional workload and learning overhead for the students and supervisors and ideally should easily integrate with existing tools and systems. A good example is a Gmail plug-in called Streak; It provides CRM functionality and allows for easy tracking of interactions with several customers and aggregation of the customers' information all from within a person's inbox ([1]).

From our informal talks with students, we also learned about systemless or at least 'offline' practices that are currently used for relationship and project management. For example, another research group used colour-coded sticky notes on a bulletin board to represent the goals for each week; the notes, or goals, were then removed to the side of the board if they were achieved by the end of the week.

2) A dedicated tool and practice awareness mechanism can improve practice transfer among peers. We found some instances of transfer of practice and tool information among peers, including both students and supervisors. While some participants expressed a positive evaluation of this behaviour, and an appreciation for recommendations that came from those they trusted and who were working under similar demands and pressures, this behaviour seemed only to occur in a mostly happenstance ad-hoc manner, with many admitting that tool use was dependent not only on technology but awareness of it and what was available.

We think a system specifically developed for the purpose of tool and practice discovery would better ensure effective knowledge transfer and collaboration, thereby saving time and decreasing frustration for supervisors and students who otherwise must address their unsupported behaviour by experimenting with new tools or by applying a strategic combination of old ones to meet a need.

One example of system design that already supports practice transfer is an educational initiative called "This Changed My Practice." It is an online repository for health practitioners to share their most effective or newly discovered practices that support diagnosis or patient care [2]. Additional site features allow users to comment on posts, categorize and 'tag' the content, vote on practices, and refer to related evidence-based literature. A similar platform could be adapted for increasing awareness about various tools and practices among students and supervisors. Recommender systems which feature both collaborative and content-based filtering [18] may also support easy and relevant tool discovery. Further investigation is needed to establish the scope and affordances of such a system, for example whether it would be most useful as a closed system within a single research group or department, or as a completely open one to be shared among academics across disciplines.

5.2 Characteristics of Our Participants and Limitations

We limited the demographic composition of our participant pool to partially control for the wide variety of student-supervisor collaboration. However, one must note the characteristics of our chosen study group when interpreting our results. Firstly, as CS faculty and students, our participants may exhibit a better aptitude for knowledge collaboration and task management, and adoption of new tools than the population at large. While we attempted to account for the effect of the supervision power dynamic during interpretation of our data, as well as minimize its potential influence on all participants' choice to self-censor by having non-mixed (student-only or supervisor-only) member-checking sessions, we acknowledge the difficulty for participants to speak candidly about relationship satisfaction and research progress, especially within a small graduate community of a single department; however, we did specifically question participants about their experiences with communicating positive and negative feedback related to research relationships and believe this difficulty can prove an important consideration for tool and practice choice.

As previously stated, prior to undertaking our research, we were already familiar with the faculty members and some members of the research groups. This guided our sampling decisions for the initial interview requests and the student-only focus group to ensure variability among the participants. Our familiarity with the research practices in the CS department gave us the required context for interpreting participants comments. However, one of the authors is from a different department which provided us an outsider viewpoint in our analysis of the data.

Unfortunately, our demographics are skewed in terms of gender for supervisors (3 females, 1 male). We anticipate that the demographics of supervisors can impact communication styles, and relationship dynamics. Finally, we think there is an even greater variety of student-supervisor collaboration within the CS community and additional studies can further characterize this variety.

6 Conclusion and Future Work

In this project, we conducted an exploratory case study on meetings between graduate students and supervisors, specifically looking at factors that impact choice and success of tools and practices to support effective collaboration. Data from focus group and individual interview sessions with faculty members and students were analyzed using thematic analysis, and resulted in three themes and two implications for design. The first two themes describe factors influencing choice and success of student-supervisor tools and practices while the last theme highlights mutual feedback on work practices as an important yet unsupported area of student-supervisor interaction. A lot is still unknown about students and supervisors' practices and intentions, and thus a lot of work needs to be done before user behavior modelling can begin. Therefore, we recommend the development of systems that will first encourage communication between students and supervisors to increase awareness about the effectiveness of tools and practices in various circumstances.

Despite the small number of participants in our study, we found ample variation in the tools and practices used by students and supervisors to suggest such diversity will be reflected in other populations within academia and geographically distributed, collaborative work environments. We recommend further study to determine how supervisory styles and practices vary between different disciplines (e.g., English Literature, Anthropology) and within alternative arrangements of semi-independent student research. We are interested in undertaking a more in-depth study of supervisors, to better model their individual differences and map them to personas of supervisory styles; for example, we might expect the gender of the supervisor to have a large influence on approaches to or preferences for communication. Also, further research into the individual differences for giving and receiving feedback in a supervisory relationship is necessary to provide guidelines to design the most effective mechanisms for this purpose. Finally, while there are likely commonalities and also differences between manager-employee supervisory relations and supervisor-student relations, a comparative study between the two would help to inform the design of general purpose supportive tools and practices.

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