Changing our ways of supervising part-time postgraduates using an online supervision framework

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Abstract
This paper investigates a technique that responds to the question of how to improve the efficiency of remote supervision meetings for part-time postgraduate engineering students working in industry. A variety of difficulties are often experienced with supervision of these students, such as logistical problems with attending face-to-face supervision meetings, maintaining a good focus during meetings, and general inefficiencies in responding to supervision advice. This paper focuses on an experimental online supervision framework designed for remote supervision of distance, part-time graduate students working in industry. The supervision framework builds upon two fundamental network technologies: voice over IP (VoIP) and a shared virtual workspace provided by a Virtual Network Computing (VNC) service. The supervision framework, which is influenced by knowledge management theories, includes guidelines in a short reference manual to facilitate its use. Evaluation of the framework is structured around using Activity Theory (Engeström, 1999) *to gain insights into the usefulness of the meeting activities and the tools applied.*

Introduction

Supervision approaches for part-time and off-campus students typically use a combination of methods such as face-to-face (f2f) meetings, telephonic consultation, and e-mail correspondence (Erwee & Albion, 2011). While these approaches can be effective, the supervision of part-time postgraduate students is often complicated by a combination factors. Foremost of these, as experienced by my research colleagues and me include:

- a general lack of reporting done by the student after the meeting;
- poor 'visibility' in that the supervisor is unable to view design artifacts or documentation (e.g., students not showing evidence of their work in meeting);
- students frequently cancelling or rescheduling meetings, sometimes at the last minute due to pressures at work; and
- supervision advice being misunderstood or forgotten.

While the initial scheduling, and sometimes rescheduling, of f2f meetings may be inefficient and cause frustration, this is of minor concern compared to other difficulties. The lack of 'visibility' and the misunderstandings that happen during or after meetings are significant factors that cause inefficiencies and sometimes dissatisfaction. Nevertheless, the supervision of part-time, industry-based postgraduates can be well worth it. The supervision of these students holds much potential: their projects, often embedded within a complex industry context, can potentially offer the most interesting of topics that lead to useful, real-world discoveries. Many other benefits of supervising these 'invisible' students are discussed at length by Neumann and Rodwell (2009).

This paper reports on an intervention to enhance supervision of part-time, industry-based electrical engineering postgraduate students specializing in the field of computer engineering. This intervention was started in response to a decline in our students' progress and their concerns about high levels of stress. An additional reason was to cater for the increasing mobility of supervisors and students (e.g., extended periods spent overseas).

The intervention involved the development of a distance supervision framework, which we have called the Online Guided Research Track (OGRT) framework. This framework, which builds on knowledge management theories, focuses on establishing an effective collection of online tools to support students, together with guidelines that explain preparatory and follow-up tasks students do to improve the effectiveness of the meetings. The OGRT is a refinement of its predecessor, the 'guided research track' which did not include online tools and was used mainly for supervising campus-based honors students.

This paper proceeds with an explanation of the research methodology and research participants studied. After this the OGRT framework is introduced, giving an overview of its design and accompanying guidebook. The evaluation method, explaining how the framework was tested using Activity Theory, is then presented. Next, findings obtained by applying the framework for supervision meetings with the participants are reported on. The last section discusses benefits and drawbacks encountered in the investigation and reflections on the students' impressions of its usefulness. We conclude with practical considerations related to using these methods and our plans for further develop and improve of the framework.

Method

The main objective of the OGRT framework is to increased opportunities for student/supervisor interaction in an online context, allowing the student and supervisor to work collaboratively on documents (e.g., chapters of a dissertation), and software tools (e.g., CAD and code compilers). Such a virtual environment is planned around allowing the supervisor to demonstrate tasks to the student, and vice versa. This is opposed to the traditional case where such tasks are only spoken about. Although it is necessary for students to master the understanding of abstract instructions in their discipline (Felder & Silverman, 1988), the learning of techniques can be enhanced by enabling tacit knowledge transfer through opportunities for observation (Eraut, 2000). These opportunities for tacit knowledge transfer, albeit not in a shared physical space in our case, are planned as a means to enhance our supervision meetings with part-time, off-campus postgraduate students.

The research method for this study involved four parts: 1) selection of the students; 2) design of the OGRT framework including motivation for the tools chosen and the structure of the manual for guiding use of the framework; 3) the process used to obtain data from meetings; and 4) the evaluation method that involved applying Activity Theory to the data. Each of these aspects is refined in the subsections that follow.

Selection of students

Our selection of students included both students making adequate progress and some behind schedule. We included a selection of students showing good progress with the expectation of revealing techniques that work well, instead of investigating only aspects of inefficiency. Four MSc students were selected from a pool of 19 part-time, industry-based postgraduates. We selected MSc students because most of our students are at this level and our supervision challenges occur more frequently with MSc rather than PhD students. The selection of students was largely randomly, but done so that two of the students were exhibiting adequate progress and the other two inadequate progress. The students were also chosen to provide some variation in the distance of their workplace from the university campus.

Design of the OGRT framework

The OGRT framework, in a structural sense, comprises the following three aspects: 1) the student/supervisor talking aspect (the ‘T-aspect’), 2) the shared visual computer desktop aspect (‘V-aspect’), and 3) the planning and guidance aspect (‘G-aspect’). The aspects of the framework are illustrated in Figure 1. As shown in the figure, the T-aspect is implemented using a Voice-over-IP (VoiP) software tool, Skype in this case. The V-aspect aspect provides a remote accesses computer desktop, provided using the Virtual Network Computing (VNC) software system (Kaplinsky, 2001). In terms of the G-aspect, this is provided as a short reference manual, called the “OGRT Quick Guide Manual” (Winberg, 2014), together with a series of lectures (the GRT lectures series) presented at the start of second semester.

Figure 1: A general impression of the OGRT framework.

The OGRT framework includes procedures, that is to say activities students and supervisors perform. These activities make use of above mentioned tools and documented in the OGRT Quick Guide Manual using a collection of illustrative models and written guidelines intended to guide and facilitate students and supervisors using the framework. The manual is not written in traditional textbook style; it is instead in the style of an engineering manual, constituting concise bullet-list procedures and well-annotated diagrams. Only a small portion of the Quick Guide actually provides guidelines specific to online supervision meetings. The bulk of the manual suggests strategies for carrying out parts of a research project (e.g., how to plan the research methodology), but some of these parts include suggestions to facilitate online supervision meetings discussing specific aspects of the research process.

Figure 2 shows one of the procedural models from the manual showing a representative view of how the guidelines are presented. While the manual is structured around particular milestones (e.g., proposal, draft literature review, etc.) and a duration of time between each one, in practice these milestones and durations are likely to differ between students. At the time of writing this paper, the manual (at version 0.1) is undergoing further development and is intended to be released in July 2014.

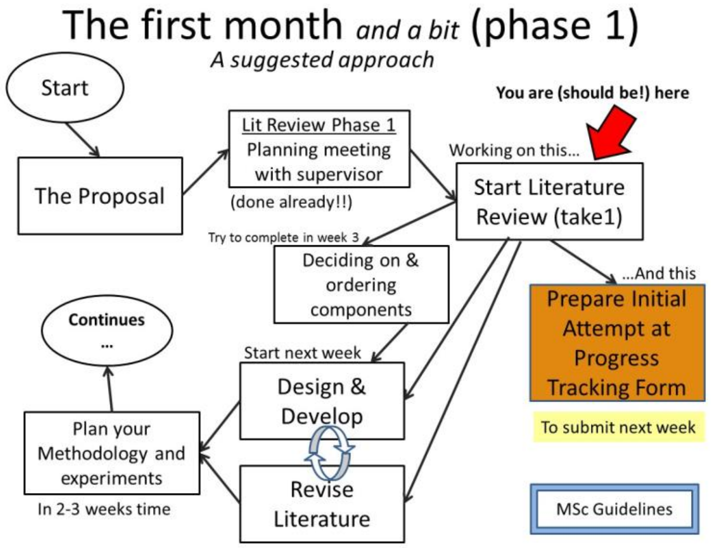

Figure 2: A model illustrating tasks for the first phase of the OGRT framework and their interrelations, extracted from the OGRT Quick Guide Manual version 0.1.

The OGRT procedures are structured according to a sequence of phases, where each phase is provided as a separate chapter in the quick guide as follows:

- Chapter 1: Welcome – What is the guided research track?
- Chapter 2: All about the Literature Review and Referencing – This is no book review.
- Chapter 3: Planning your Research Methodology – Not to be confused with design!
- Chapter 4: Dealing with Design – It's your problem to solve, but I'll be sympathetic.
- Chapter 5: Results – Reporting on experiments and their results.
- Chapter 6: Introduction & Conclusions – Yes really: leaving introductions to the end.

Data collection process

The data collection process is presented first because it impacts the way that Activity Theory (Engeström, 1999) was applied to analyze this data, although the choice of using Activity Theory was chosen prior to deciding what data to collect. Data collection involved two parts; the second part was done about a week after the first. The parts involved the following:

1. Part 1: the remote supervision meeting during which the supervisor filled out a log to record relevant decisions and actions during the meeting.
2. Part 2: a semi-structured follow-up reflective meeting during which the supervisor kept minutes and made notes, in discussion with the student, concerning the effectiveness of the tools used in the previous meeting.

The remote supervision meetings each lasted approximately an hour, and follow-up meetings closer to half an hour each. All the supervision meetings were done remotely using the OGRT framework. During the follow-up meetings, the supervisor took notes to record his impression of how well the student had responded to the earlier supervision meeting and to record comments made by students. Some of these review meetings were f2f. Prior to scheduling the supervision meetings, each student's overall progress on their MSc studies was noted and particular note was made of how far complete their dissertation chapters were.

Evaluation Method

The evaluation of our framework is centered on using Activity Theory (Beauchamp, Jazvac-Martek, & McAlpine, 2009; Engeström, 1999) to frame the study and to gain insights into improving the effectiveness of our online supervision meetings. This subsection briefly recaps aspects of activity theory that are drawn on in this paper.

Generally speaking, Activity Theory focuses on developing insights into human interaction and activity in context. It does not study the individual in isolation, which can hide many of the person's interaction methods and abilities. Activity Theory, as the name suggests, is more a study of actions within a context of performing tasks and communicating with others (Engeström, 1999). Activity Theory can be used in a broad range of contexts, and there is much literature available that recommends ways to apply Activity Theory in specific contexts. This paper applies the theory in a 'socio-technical system' of student-supervisor meetings in an engineering context, in particular ones where technical tools are used while simultaneously explaining what is being done. Our study consequently draws on some of the methods used by Rogers (2004) in application to a computer-based socio-technical system.

In our case there are two subjects: the student and the supervisor. There are effectively two semi-separate activity systems; one centered on the student, the other on the supervisor. A visual summary of these related systems is illustrated in Figure 2.

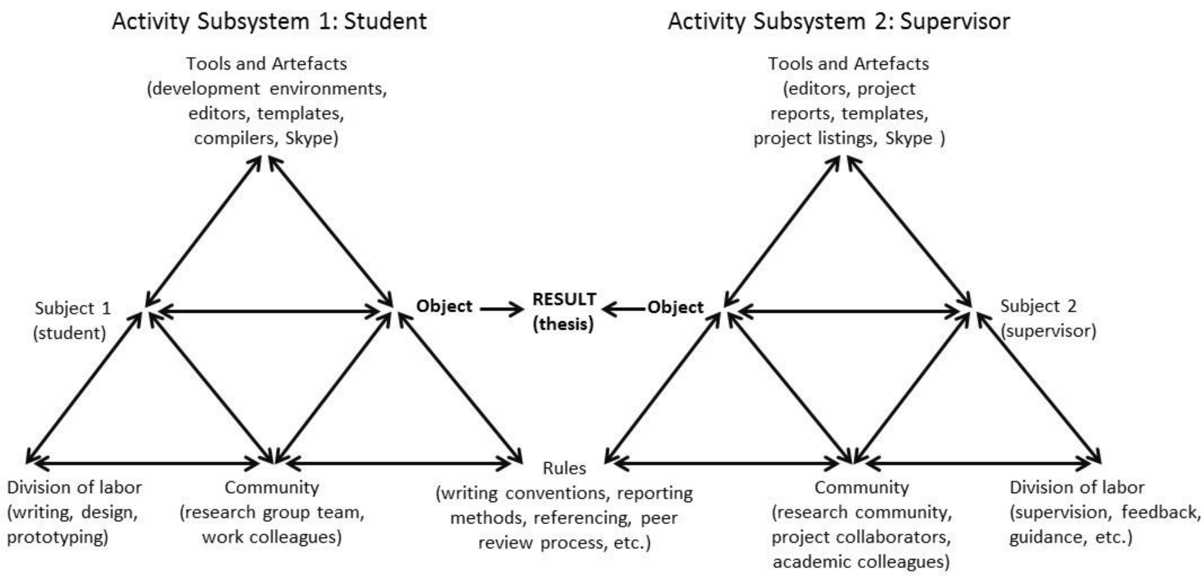

Figure 3: A visual representation of the connected sub-systems of the activity system investigated.

The subject in each activity triangle of Figure 2 represents a person involved in the system, and the arrows represent influences between elements of the system. The object corresponds to the objective of the associated activity, which ultimately leads to an overall result, which in our case is a thesis or dissertation. The tools and artifacts, at the top of each triangle, refer to the tools used and artifacts worked on by the tools. Examples of tools often used by computer engineering students are: code editors and compilers, and artifact examples include code files and document templates. The supervisor would likely use many of the same tools as the student; but there would be more separation between the artifacts used by student and supervisor. In order to focus this study, our investigation considered mainly tools and artifacts used by the student. The rules at the bottom of Figure 2 refer to practices and generally accepted ways to work (e.g., expected conventions for writing reports and using peer review). The rules have been shown as shared to emphasize the commonality of these between supervisor and student, although it is likely that the student's understanding of the rules will be increasing as the project progresses.

The community is the group of people in which the subject is situated, or people whom the subject works closely with. There may be similarities between the supervisor and student community; for example the supervisor and student may attend the same research group meetings. But there are differences also, such as industry-based students being part of a workplace with its own distinct corporate culture. Finally, the division of labor represents ways that the work is divided up. In this study, division of labor is largely concerned with how the individual student or supervisor decides to divide up work that needs to be accomplished and done in preparation and during supervision meetings; for example the student may want to discuss methodology issues as well as ask for help with the design. Since it was only the student and supervisor considered in each system, the focus for this aspect was more on hierarchical structuring of activities rather than division of activities among peers.
The application of Activity Theory in this project involved a process of modeling the activity system for each meeting and looking at commonalities between these. Using this analysis method, we obtained deeper insights into the supervisor/student exchanges, a clearer understanding of common objectives pursued during the meetings, and assemblages of the various mediating tools and artifacts, and the dependence upon these, during the meetings.
The students' progress in writing, based on the level of completeness of their dissertation chapters, was used as a means to identify traits between particular characteristics of the activity systems and performance levels of the students.

Findings

The findings have been divided into two subsections. In the first subsection, the students are introduced, using pseudonyms, and characteristics of their work contexts are given. A condensed form of each student's Activity System is explained and each student's progress is discussed in relation to elements of their Activity Systems. Particular characteristics and differences between the students are highlighted. The second subsection reports on the students' evaluation of the online supervision meetings based on resulted from the semi-structured review meetings.

Activity Systems of the supervision meetings

Four students were selected from our pool of postgraduate part-time students working in industry. Two of these students were making good progress, while the other two were making inadequate progress. For ethical reasons the students have been given pseudonyms in this paper. Although the demographic characteristics of these students are not all the same, the following African pseudonyms have been used: Ayodele, Jamila, Amare, Talib. The first two students, Ayodele and Jamila were among well performing students, who reported to us regularly, and with whom we had regular meetings. The second two, Amare and Talib showed less progress, particularly in terms of their dissertations and other written work (e.g., writing for publication). In terms of design work, all the students were making progress, although the design work done by Amare and Talib was, in comparison to the first two, generally not as clearly focused.
In terms of the Activity Systems related to each of the supervision meetings, the Rules aspect was largely the same in all cases. These rules concerned conventions for writing reports, referencing and presenting results, among other typical academic practices. The other aspects differed between students, and are summarized in Table 1. All the students made use of Skype and VNC during the supervision meetings, so these tools are not listed in the table. Division of labor is separated into two rows: student activities and supervisor activities.

Table 1: Activity Systems for the students investigated.

Subject (Student)	Ayodele	Jamila	Amare	Talib
Tools	Xilinx ISE, Okular, gdrive, OpenOffice, emacs, gmail	Okular, make, OpenOffice, GCC, gedit, xterm, gmail	Xilinx ISE, image viewer, Chrome web browser, gedit	Emacs, xpdf, Latex, xterm, Gimp, GCC, CUDA, Octave
Artifacts	Dissertation chapters, design files, shared minutes, tech. report, PDF papers	Code files, methodology overview fig., draft Intro ch., experiment plan, papers	Code, schematic files, draft design ch., slideshow of design drawings	C, Matlab code, graphs, Latex files, Draft PDF chapters, text files, papers & textbook
Object	Design Chapter	Experiments, Methodology ch. refinement	How to write Methodology chapter	Documenting of results
Division of labor Student:	Demo, explain design features / drawings	Describe experiments, show results	Showing code & designs, report progress	Showing results, demo project parts
Division of labor Supervisor:	Feedback, design advice, documentation improvements	Additional experiments for better coverage, bringing back to the big picture, writing advice	Explaining methodology, advising to construct methodology for project	Refine chapter structure, advice on ways to show results, amount of detail to show.
Community	Laboratory assistants, research scientists, technicians	Programming team (mostly experienced, senior developers)	Computer engineering researchers & FPGA gateware development team	Engineering team (various types of engineers, not just computer engineers)

The activity systems summarized in Table 1 shows differences in object for each activity system, ranging from discussing how to write a methodology chapter (i.e., Amare's meeting) to explaining how to report results (i.e., Talib situation). The students were not all at the same point in their Masters project. Part of the OGRT framework involves students reporting on progress and supervisors keeping track of their progress (this is intended to allow for an early warning system and flagging students 'at risk'). This data was obtained from the students prior to the online supervision meetings, and is shown visually in Figure 4. The figure is a matrix of progress bars, where each progress bar shows the approximate completion level of each aspect of the project. For example, the students had all completed proposals; therefore the proposal progress bar for each student indicates full completion. Only Ayodele had a literature review that the supervisor was fully satisfied with, therefore that is the only progress bar in the "Initial Lit. Review" column that is full; in comparison Jamila's literature review was almost satisfactory but still required a few refinements.

As mentioned, Ayodele and Jamila were performing better than Amare and Talib, although Figure 4 shows that Jamila and Talib were closer to completion (they had finished most parts except for finishing the results, conclusion and introduction chapters). Closest to completion was Talib, because his experiments were largely complete and it was just a matter of finishing the write-up. Jamila's implementation was not yet complete. Talib was indicated as having inadequate performance because at the time of these meetings he was in the fourth year of the degree, whereas Jamila was just in the second year. Ayodele and Amare were behind the other two as they were still refining methodology and design aspects and still had most of their implementation work to do. Ayodele and Amare were in their second year of masters; but unlike Ayodele, Amare's literature review and methodology chapters were incomplete, thus Amare's progress was overall lacking.

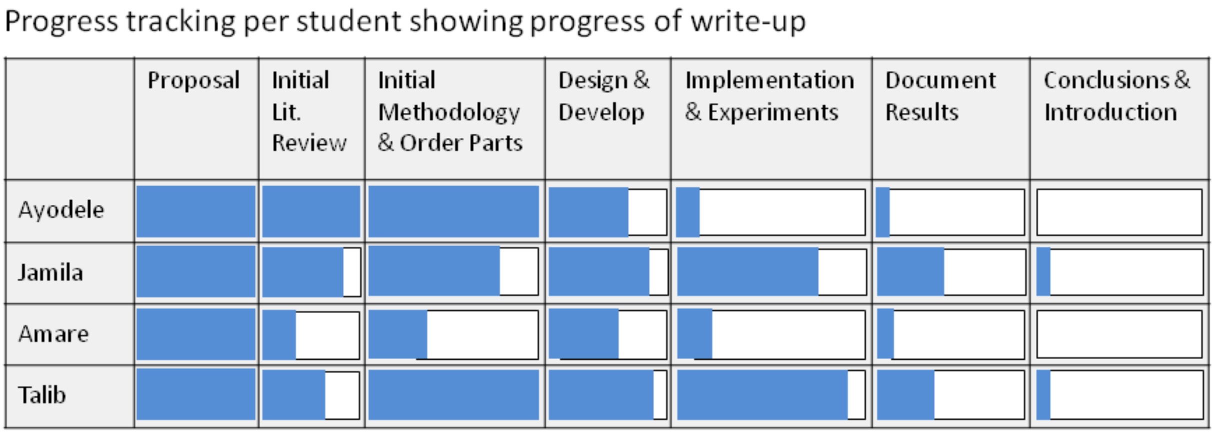

Figure 4: Progress tracking matrix showing each student's level of completion of the dissertation.

Every meeting had a substantial component concerning writing dissertation chapters; but all meetings also included viewing or manipulating design artifacts. Of the students, Ayodele used the least number of design artifacts, using mostly formal written documents, including partly completed dissertation chapters, a self-authored (in-progress) conference paper, various technical documents, data sheets and an assortment of downloaded, mostly peer-reviewed, academic papers. In contrast, Amare used the fewest written documents, and only a few of these were formal documents or peer reviewed. A short draft design chapter was the only technical document written by the student that was used in the meeting.

Jamila and Talib had quite a few similarities in terms of tools and artifacts used, and both loaded and showed sections from academic papers that they had placed on the VNC shared desktop ahead of time. Talib spent a large portion of the meeting showing design artifacts and running Latex scripts to show draft chapters, which was a distraction causing lulls in conversation and delays waiting for the PDF of the draft dissertation to be updated.

As shown in Table 1, labor was divided between students showing and modifying artifacts, and the supervisor providing feedback and occasionally requesting the student to open relevant documents. In all cases the student took the lead in loading and manipulating artifacts. It was only occasionally that the supervisor took control of the shared desktop; usually to add comments to PDFs, flagging parts of design or code files, and to annotate dissertation chapters. The supervisor usually took responsibility for keeping the meeting on track, often drawing students away from implementation details to consider the 'big picture'.

The communities the students were part of differed in each case. Ayodele was part of the most varied community, and was a senior technical laboratory supervisor at the company, working with technicians, as well as scientists conducting experiments (most not on the staff, and only some of them regular visitors). Ayodele had little computer engineering mentorship beyond that provided by the supervisor and occasional visits to the university research group meetings. The technical staff generally had technical degrees rather than higher degrees.

Jamila was part of a community of colleagues performing similar types of programming work. This student was a junior member of staff and had multiple mentors in the workplace, all of whom had either masters or doctoral degrees, and many of them were willing to give advice and guidance to supplement that given by the supervisor.

Amare was part of a smaller and more focused community, most of whom were involved in the same type of development; but there was little opportunity due to the many and demands and strict deadlines that the coworkers regularly faced for the student to benefit from much mentorship relating to research work beyond that which was provided by the supervisor. Talib was part of a larger and more diverse community that included computer engineers and other types of scientists and engineers. Generally there were opportunities at the workplace for this student to gain advice from coworkers with higher degrees, but this was inconsistent, varying according to coworkers' availability and their moving between divisions.

Reflective meetings

Semi-structured reflective meetings were held between each student and supervisor after the online supervision meetings. These meetings were loosely structured around answering the following questions:

1. Did things go smoothly for setting up the tools (VNC & Skype)? Mention any difficulties or delays you had for this.
2. In terms of the oral discussion, did you find any particular benefits (e.g. over f2f meetings) or challenges encountered?
3. Did you find the VNC shared desktop in the cloud a useful facility? Where there any improvements, such as added tools, you think needed if we use it again?
4. During the meeting, what were some of the most useful tools and types of digital artifacts / files that you made use of? Were any troublesome or distracting?
5. If you had the video link enabled during the meeting, was it useful? In what ways was the video feed made use of?
6. After the meeting did you do some reflection, such as preparing a summary of the discussion points and adding to your todo list?
7. Overall, did you find the supervision meeting useful? Was it an adequate replacement for f2f meetings concerning, considering the objectives of the meeting we tried?
8. Would you suggest this approach to others? Were there any other difficulties you encountered that we might have missed in this discussion?

The answers to these questions were inspected once the review meetings were complete. Notes were arranged into categories of positive responses, negative responses and issues emphasized (not necessarily suggestions of what was good/bad). Examples of the findings are shown in Table 2 and arranged in order of interview question that led to the response. The data were paraphrased notes made by the supervisor during the meetings.

Table 2: Example of student responses arranged according to question that prompted the response.

Question#	Positive Responses	Negative Responses	Issues Highlighted
1: Setting up tools	*VNC worked find, easy to get and easy to install. Was speedy enough once connected to from off-campus. We use Skype often.*	*Needed to use VPN. Took a while to set up VPN. Skype blocked, had to get special permission to use it. Took a while to figure out PDF viewer.*	*Get VPN set up first! Know what tools avail on shared desktop. Suggest settings for new users.*
2: Oral discussions	*Skype worked fine. Can easily get used to gesturing with a mouse instead of with hands.*	*Had to ask to repeat things, was using wrong microphone. Too much background noise.*	*Delay speaking while screen very busy e.g. MATLAB showing graphs.*

3: Shared desktop	*Liked availability of the shared desktop to show things while talking. A time saver! Supervisor could add comments then and there. Saved me time.*	*Shared screen too small, wasting time moving sideways, up/down. Had blocky / pixilation problems at time. Hadn't used the tools before.*	*Some training on using tools would be a big help.*
4: Usefulness of tools / artifacts	*Okular very useful once I'd figured out features. Apps I used (emacs, xterms) all worked fine in the small window size. OpenOffice could be used fine with the Word docs.*	*Most papers on desktop weren't used. Browser didn't work right. Wasted time putting stuff there we never looked at. Prototype inaccessible to supervisor. PC too slow for ISE.*	*Betting planning and suggested types of artifacts to use would probably save the student time.*
5: Skype video link	*It worked fine. I could use the camera to show pages of the textbook.*	*The video link slowed the other things, broken speech.*	*Only use the video link if it is actually needed.*
6: Reflection after the meeting	*After meeting guidelines useful. Made sense: less trying to remember after. Felt more confident. Important items noted.*	*Couldn't do after meeting tasks; had a meeting right after. Too little time to get through all points.*	*Important to actually follow through the post-meeting tasks.*
7: Overall usefulness of supervision meet	*Was useful! A different experience. Was more interactive! Cover things we usually don't do/see in f2f meetings.*	*Counting before & after tasks, esp. setting up, takes more time in all.*	*Ensure agenda planned beforehand. Maybe send agenda for feedback.*
8: Should the method be used again?	*Yes, particularly for the writing stage. Would like this option in future, I felt more motivated. Yes, esp. when busy at work. Helps save me petrol and time.*	*Unsure at this stage. Other kinds of logistic problems. It feels a bit personal. I like an excuse to visit campus and other students.*	*It depends on the purpose for the meeting. Useful alternative to the usual type of meeting.*

Discussion

The findings from our case study show potential benefits in using the online supervision approach. The students indicated that the main advantage of the intervention was improvement in the level of interaction between supervisor and student. For example, the online tools made the collaborative editing of code and documents possible – which was typically not done during f2f meetings. But some hedging was in evidence, shown by qualification phrases such as "it depends on the purpose for the meeting" (Amare).
The added dimension of tacit knowledge exchange, as in performing actions instead of only verbal explanations, shows particular merit. This was characterized by comments such as "… seeing the actions … helped us understand easier how to do it" (Jamila). There was a general consensus that these online facilities encouraged students and helped them feel better motivated after the meeting, as evidenced by "I felt more motivated…" (Jamila). There was a significant difference to the previous meetings; *vis-a-vis* "it was a different experience … I would like this option in the future if possible" (Talib).

The students were enthusiastic about opportunities to save time, and sometimes money, by using this approach, as suggested by "… helps save me petrol and time" (Ayodele).
During f2f meetings students are entirely responsible for remembering or logging the supervisor's recommendations, or deciphering the supervisor's handwritten notes. The online meetings shared this responsibility and eliminated the problem of deciphering handwriting because all the annotations were typed.
The online meeting approach had some drawbacks, most predominantly connectivity problems (e.g., corporate firewalls). Access restrictions were encountered, such as "Skype blocked, had to get special permission to use it" (Talib). Inappropriate equipment was used, for instance a student reported "…was using wrong microphone" (Talib). Another problem was that the supervisor did not have access to physical prototypes under development, for example, in the cases that portable prototype were developed, these could not be brought along to f2f meetings. Other logistical problems were found, for example the student having to find a quiet place to connect if their workspace was in a laboratory or shared office.
The division of labor indicates an unexpected finding: some of the students with colleagues that had higher degrees and could provide them additional research guidance (i.e., the case of Jamila and Talib), did not necessarily outperform students who had little or no support at the workplace. In particular, Ayodele had little additional support but still outperformed both Amare and Talib, both of whom had comparatively more support available at the workplace.

Practical implications
The students' reflective interviews showed that the intervention had overall positive results, such as simplifying logistics in some cases and improving the level of interaction in others, in addition to saving time and transport costs. But it should be noted that the practicality of our approach has limitations, such as the students needing to be well prepared for the meetings, and they need to carry out activities beyond those done for f2f meetings. Consequently, in terms of using this or a similar online meeting, we recommend that the methods be piloted and refined for the context concerned. While the approach may be an effective substitute for many f2f meetings, it should not be considered as a complete replacement for these. Furthermore, our approach has only been tested on computer engineering students, all of whom had experience in programming and installing software.
In order to improve the practicality of our approach, and to further explore its benefits, our future work plans include: extending the online supervision to additional students; refinement of our OGRT framework; using the framework with undergraduate final year students working on design projects to offer a form of a blended supervision comprising group meetings supported by software tools; and supplementing the GRT lectures with short online videos that students can review to remember and better understand the process.

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