



Effective Supervision for Enhancing Quality of Doctoral Research in Computer Science and Engineering

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Abstract

This article reflects on effective supervision and possible guidance for enhancing quality of doctoral research in the computer science and engineering field. The aims of this study are (1) to understand supervision and the role of supervisors in the quality of doctoral research, (2) to elaborate on effective supervision in the computer science and engineering field and challenges in effective supervision, and (3) to identify key indicators for evaluating effective supervision with a view to improving the quality of doctoral research. After studying various pieces of literature and conducting interviews with experienced supervisors and doctoral students, the article concludes by describing important characteristics in effective supervision. Some of the features for effective supervision are common to other areas of research; however, in computer science and engineering and similar fields, it is important that a supervisor takes the role of a team member by giving proper advice on the reports, algorithm and mathematical modeling developed in the research, and demonstrating the ability to provide advice on complex problems with practical approaches.

Keywords Effective supervision · Supervisor · Doctoral research · Doctoral students · Quality · Computer science and engineering

Introduction

The third cycle of study (i.e., doctoral education) is fundamentally different from the first and second cycles, which mainly follow a teaching-based approach. Doctoral education in the computer science and engineering field requires independence, responsibility, and the ability to formulate complex problems following a hypothesis that can build the concept of the research and methodology, and therefore, a model of carrying out research under supervision can be very effective. The quality of doctoral research can be ensured by adopting a good teamwork model and engaging efficiently in research roles where supervisors may lead, advise and support the doctoral students, and the doctoral

students can consult with experienced supervisors on possible approach, methodology, risks, and the direction of the research.

In this article, I review literature on effective supervision to find out more on theory and results from other research works. I also report on interviews I performed with four of my colleagues who are experienced supervisors and four doctoral students in the department of computer science and media technology at Malmö University and the department of electrical, electronic and computer engineering at University of Pretoria, in order to discuss, analyze, and conclude on effective supervision in doctoral research.

My intention in researching this topic is to enhance my supervisory practice in doctoral research and to make myself more familiar with challenges in effective supervision. By completing this study, I try to provide important characteristics that constitute effective supervision, particularly in computer science and engineering and similar engineering fields, which can also be used by new supervisors to apply a good supervision method with their doctoral students. Moreover, I recommend indicators in the evaluation of effective supervision with respect to improving the quality of

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doctoral research that can be used by the board of doctoral supervision.

Supervision and Quality of Doctoral Research

According to Ref. [1], to ensure a high quality of doctoral research, several resources need to be considered, including qualified experts in the subject field, research infrastructure, availability of funding, and national and international networks. The focus of this article is on qualified experts in the subject field or supervisors’ role in enhancing the quality of doctoral research in computer science and engineering.

Doctoral education is important for both doctoral supervisors and doctoral students. It is also a vital activity for universities in developing research and talent [1], which are elements in economic development and society at large. Doctoral students may follow a hypothesis or an idea that builds the concept of research and methodology that they need to follow under supervision. They may expect a supervisor who will advise them on research and lead them to increasing degrees of independence. Doctoral supervisors play an important role in the supervision of doctoral students’ research progress, and in the interaction between the doctoral students and the department, as well as the university as a whole. Any institutional initiative to enhance the quality of doctoral research will have to involve consultation with doctoral supervisors from that institution, as they serve as the main transmission interface between the institutional strategies and their implementation.

Furthermore, according to the International Postgraduate Students Mirror published by the Swedish National Agency for Higher Education (Högskoleverket) in Ref. [2], 10% of the Swedish doctoral students, as shown in Fig. 1, have experienced shortcomings in supervision that have hampered their research. This becomes serious in the computer

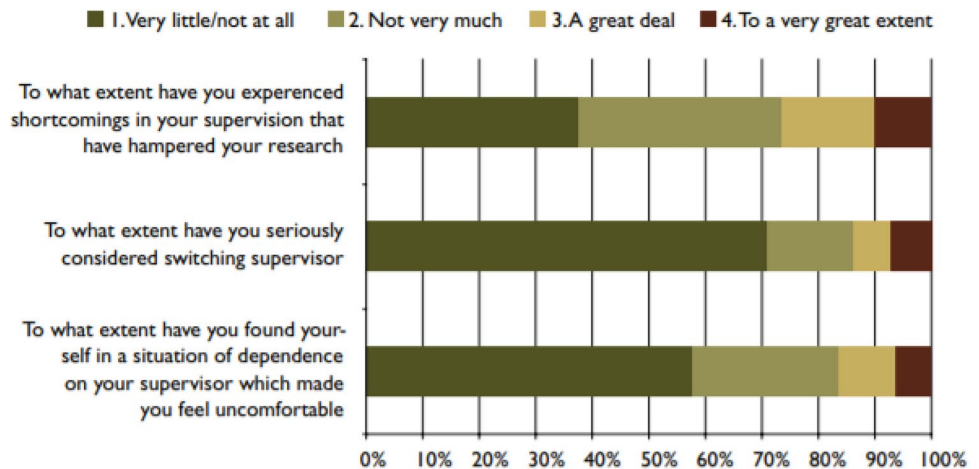
science and engineering field, where shortcomings in supervision might be due to lack of proper skill and knowledge in a specific research field such as communication networks, artificial intelligence, or computer systems and architecture. Therefore, departments in which doctoral students are enrolled must ensure supervisors have a high level of competency, with proper skills and knowledge in the field, to avoid preventing doctoral students from graduating in a timely manner or even from the graduation ever. Supervisors have a moral obligation to provide good and efficient supervision, while spending quality time ensuring proper research progress of the doctoral students.

Formal training of supervisors (for example, doctoral supervision course) can give them knowledge on different approaches to supervision or research ethics, while informal peer-learning exercises [1] may contribute to continuous development of a common supervision culture based on good practices.

Effective Supervision in Doctoral Research—Literature Review

A research study performed in Ref. [3] explained that in effective supervision, not only transferring of knowledge is required, but students also expect certain skills from their supervisors, namely that they are able to inspire confidence, stimulate critical thinking, and help a student be focused in his/her research. In other words, doctoral students expect their supervisors to be more than just knowledgeable. In addition to the knowledge and skills indicated above, students expect an effective supervisor to demonstrate characteristics such as sincerity, openness, compassion, sympathy, respect, courtesy, fairness, loyalty, positive thinking, initiative, and availability. However, the question arises of whether one supervisor can have all these characteristics to meet the criteria for effective

Fig. 1 Supervision in action [2]



supervision. In answering this question, it is worth mentioning that the research in Ref. [3] was performed among several doctoral students and supervisors and from their answers, a collective list of characteristics was reported that can constitute an effective supervisor. In reality, it might be difficult to find all these characteristics in one supervisor. However, having all these characteristics may substantially improve the relationship between the supervisors and doctoral students. The interviews that I performed suggest a remedy to this complex relational situation, particularly in the computer science and engineering field where there might be collaborations with industry that may challenge some of the above characteristics, such as availability of the supervisor.

In addition to the above, Joanne Byrne et al. in Ref. [1], indicate that providing timely and detailed feedback from supervisors is also associated with effective supervision. From Refs. [1, 3–5], timely and effective feedback is considered as prompt feedback without long delays. It should be provided within a few days or a week after the submission; annotated with constructive comments in the documents submitted by the student; contain corrections in terms of language, format and organization of the document, as well as advice on improving sections that are not prepared appropriately; and avoid discouraging the student with comments that are negative or too general, but rather use positive comments about a section that is prepared well or results that are presented well. Timely responses to the document are expected by both supervisors and students. A meeting between the student and supervisor after the feedback is encouraged in cases where there are many comments, or some comments need more details from the supervisors.

Many departments recommend a supervisory team, which can provide doctoral students with a wider network and access to expertise, rather than the traditional one-on-one relationship model of supervision. This is also associated with effective supervision of doctoral students. Supervisory teams or having more than one supervisor in doctoral supervision may complement the research skills needed for a project and improve the doctoral student's chances of achieving the learning objective, and he or she can benefit from an enhanced student learning experience. There are always advantages to co-supervision, e.g., less risk of insufficient and inappropriate supervision and a greater chance that the doctoral student will complete the study [6], owing to his or her receiving sufficient and appropriate advice from the supervisor(s) [7].

In light of the above, does the size of the supervisory team matter, and how does one address challenges in co-supervision? I tried to find answers to these questions in the interviews, as described in the following section.

Effective Supervision in Doctoral Research in Computer Science and Engineering—Interviews

The interviews I carried out for this assignment involved four experienced doctoral supervisors from Malmö University and University of Pretoria, three doctoral students and an industrial doctoral student. In this way, both supervisors' and students' perspectives on the topic could be collected. The interviews consisted of the same types of question, but worded to suit each interviewee's specific role, in line with the objective of this study. Moreover, a final open question was included in case the interviewees would like to add anything to the information provided, in case I had missed any question, and to provide an opportunity for the interviewees to bring up additional discussions. This approach helped me to find more information on the relationships between answers provided by both supervisors and students to the same types of question, considering their specific roles, as stated in Ref. [8]. I noticed that finding doctoral students willing to participate in the interview was challenging, perhaps due to their busy schedule or perhaps because we work in the same departments and they thought their answers might be discussed with their relevant supervisors, although I informed all of them that the integrity of the participants would be protected.

From my interviews with four experienced doctoral supervisors from department of computer science and media technology at Malmö University and the department of electrical, electronic and computer engineering at University of Pretoria, effective supervision is defined as hands-on, frequent and engaged supervision with a team that work together in planning, conducting and evaluating a research study. In this model, the supervisors are responsible for setting a clear goal, while the student is responsible for planning how to get there, with help along the way. Moreover, there must be effective communication and regular meetings between the students and supervisors [9]. The students should learn to share their work continuously and provide materials before the meeting, and the supervisors should be invited to a dialogue during the research or writing of papers, etc. Supervisors need to be prepared for the meetings, help in establishing communication between their doctoral students and other researchers within the university and outside the university, and encourage the students to participate in international conferences, workshops and maybe summer/winter school for possible training. This can help the students to become independent researchers and extend their research networks. In addition, supervisors can provide a doctorate student with self-study courses, also known

as reading courses, to help them gain knowledge, skills, experiences, and a deeper understanding of the specialized area of research.

In a model defined in Ref. [1], the benefits of having a supervisory team are expected to go beyond pure supervision of the doctoral research. In this model, co-supervisor(s) can focus more on pastoral care and mentoring, and the main supervisor mainly gives advice on research-related matters. The characteristics indicated in “Effective Supervision in Doctoral Research—Literature Review” point to the relational nature of supervision where the relational aspect goes beyond the knowledge and skills of the supervisor [8].

The doctoral students in the interview indicated that supervisors are expected to be experts, parent and friends, and to lead the research and monitor the progress, all at the same time. The professional relationship between the supervisors and students needs to work well in order for the research to be successful. If there is no such relationship, the situation might be difficult. This means that supervisors also need to be flexible, show courage, and take the role of leader. A remedy to such complex relational situations would be an open mindset and lots of courage; however, that may not be feasible in practice. In practice, open discussions, and possible anonymous evaluation by an independent third party to detect signs of malfunction would be helpful to see if the supervision is efficient or not and to receive possible comments on improving the supervision practice.

Based on one of the interviews with experienced doctoral supervisors, it is indicated that the size of the supervisory team also matters. It is key to keep the supervision team small. A model where the doctoral student has one primary and one secondary advisor who have good track records, who share the area of expertise but still complement each other in terms of skills and perspectives, would be beneficial. A larger team is not a guarantee for success and proper progress of the doctoral research, and it may make the situation too complex for the student as well as for the co-supervisors. A small, well-functioning constellation of supervisors is recommended, as this gives students consistency, coherence and the opportunity to be part of a larger team while keeping focus. In addition to taking gender equality into account, it is crucial to provide early career colleagues an opportunity to collaborate with senior supervisors as a part of the supervisory team.

Based on the interviews and my experience of supervision, a supervisor can help a doctoral student in interacting with other researchers and doctoral students in the same research group, or from other research groups in the department, other departments or even other universities. This can help in terms of knowledge, ideas and solution exchange between the students, as well as access to resources and equipment.

From the doctoral students’ perspectives, since many projects are funded by industry and they see doctoral research in computer science and engineering as similar to engaging in a project, they expect effective supervision, as supervisors also take a role as team members, for example, to find and read papers that could be beneficial to the project and provide advice on a specific method used in that paper. Moreover, supervisors need to review the reports, algorithm and software package produced in the project, and give proper advice (such as pointing out correct terminology used in computer science and engineering, constructive comments on simulation scenario, parameters and results), which requires expertise in the field. By having a kick-off meeting, the research project charter, responsibilities, tasks and goals can be discussed and identified. This would ensure that both supervisors and students have understood and agree on the expected research and deliverables. Moreover, effective supervision is also explained as when supervisors succeed in their role by providing feedback and advice, leading, transferring knowledge and skills, assessing the needs of the students based on their characteristics, and finding the balance between dictating and letting be.

The outcome of my interview with one of the experienced supervisors shows that due to multidisciplinary areas of research in the computer science and engineering field and the possibility of collaboration with companies on industrial applications and research projects, doctoral students might see the value of the research they conduct, not only for the research community but also in terms of its applications outside the academic environment, which can motivate them to continue their research. Based on this collaboration, they can also learn how to cooperate and interact with other people and share ideas and knowledge. Industry collaboration may also have a disadvantage, where doctoral students may limit themselves in the area of the project and research direction. This requires the student’s interest in the topic and good teamwork, together with effective supervision, to make it work better.

Challenges in Effective Supervision: Findings from the Interviews Supported by Literature

A supervisory team is recommended in many institutions as a way of ensuring effective supervision of doctoral students. However, there are sometimes challenges in co-supervision. Conflict around contradictory advice from supervisors can confuse the student and increase the sense of individual work. Some advice from the experienced supervisors interviewed is that this can be reduced by having pre-supervisory meeting before meeting the student in order to avoid such conflict. The interviews also highlighted that another challenge might be the possible lack of alignment between

supervisors and the student. If the supervisory team does not discuss and agree on the goals and aims of the research, this might lead to tensions. In addition, everyone in a team has to be open to ideas and critique and be able to re-think a situation. Furthermore, the student needs to be willing to take advice and guidance from both supervisors. To avoid conflict between supervisors, it is very important to set clear expectations and goals so that the student gets a direction and a tangible goal. According to Ref. [10], understanding the issue and source of conflict can also be helpful in reducing possible conflict. Then, in managing any conflicts that do arise, compromising, emphasizing commonalities and finding effective solution for both sides [10] can help. Both the supervisors and the doctoral students have mutual obligations and responsibilities that need to be considered.

In doctorate education, the head or deputy head of the department plays a crucial role. Department heads or deputy heads can impart experiences and explain the regulations to supervisors and doctoral students, or conflicts can be avoided by early conflict detection through preventive activity.

Another possible challenge in effective supervision that was mentioned in the interviews is availability and time of supervisors. In the field of computer science and engineering and other related fields, there is always possibility of collaboration with industries and companies, and funded projects from them, which may motivate supervisors to spend extra time, even time from their competence development, on ensuring a productive collaboration. This may result in limitation of the time spent on supervision and the availability of supervisors for the doctoral students. A supervisory team model may increase availability of co-supervisions to the students.

Indicators for Evaluation of Effective Supervision with a View to Improving the Quality of Doctoral Research

In two departments of the study, the quality of supervision is monitored by a supervisory board. I asked experienced supervisors in the interview, how effective supervision is evaluated in the board, and it was mentioned that they do not have any specific indicators to evaluate this, but they follow a general approach. Here, I provide some key performance indicators that I observed being used by some computer science and engineering departments in other universities for evaluating the quality of effective supervision.

The measurable key performance indicators (KPIs) which are common in evaluations of effective supervision are research outputs (including scientific publications in journals and conferences); study completion in licentiate and graduation of a supervised doctoral student in a

timely manner (supervision time-to-degree); satisfaction of the doctoral candidates in terms of the quality of supervision (overall opinion on knowledge, skills, availability and characteristics of supervisors, or if serious and repeated problems were reported); and, if possible, following up on the employability of the doctoral graduates in academia or industry after graduation—for example, proposals under the Swedish Foundation for Strategic Research (Stiftelsen för strategisk forskning) require details on attractiveness of PhDs after graduation. Other indicators include national and international networks and collaborations, which may give access to resources and additional research infrastructure, as well as access to research facilities.

Overall, a supervisor needs to ensure appropriate supervision by setting up supervisory meetings, advice on research progress and research methods, proper feedback on the doctoral students' progress reports and scientific papers.

Publication, in terms of quality and impact, is a key indicator. Based on a comment from an experienced supervisor, if publications are frequent and strong, that means there is a high probability that everything else (including supervision, availability of research infrastructure, empirical data collection, analysis, etc.) is in proper phase and working well. An interviewee indicated that a situation is not expected where papers are sliced too thin just to be publishable in several venues (i.e., making too much out of one paper), but research should meet certain criteria such as focusing on novel results and analysis, improved results compared to some recent approaches, complexity of the proposed scheme/method, and applicability.

Some universities use merit portfolios for promotion, rewarding good supervision after evaluation using the above KPIs. Awards for exceptional supervision are a good way to show appreciation, give prestige to supervision activities and develop supervision culture. In the Netherlands and South Africa, supervisors receive a considerable research subsidy for each graduated doctoral student.

Conclusion

Based on the literature review and the interviews, the characteristics that constitute effective supervision and, therefore, enhance the quality of doctoral research are knowledge, skills, characteristics and other practices such as timely and detailed feedback and a good supervisory team. However, due to the multidisciplinary areas of research in computer science and engineering and collaboration with industry, a supervisor in the computer science and engineering field may not meet all the characteristics, but only the key and important ones, and a good supervisory team model may be useful where the goals, responsibilities and aims of the research are discussed and agreed.

Some of the features for effective supervision are common to other areas of research, but in computer science and engineering and similar fields, it is important that a supervisor takes the role of a team member by giving proper advice on the reports, algorithm and mathematical modeling developed in the research and demonstrating the ability to provide advice on complex problems with practical approaches (such as advice on software package, network simulators). In the evaluation of effective supervision of doctoral students, the most common indicators are research outputs (including scientific publications in journals and conferences); study completion in licentiate and graduation of a supervised student in a timely manner (supervision time-to-degree); satisfaction of doctoral candidates in term of the quality of supervision; and employability of the doctoral graduates in academia or industry. These indicators can also directly impact external evaluation of a doctoral program and the department.

As a future work, the interviews and research on doctoral supervision can be extended to various engineering departments for more generalization of the research. Furthermore, the suggested key performance indicators for evaluation of effective supervision can be implemented in the department to verify improving the quality of doctoral research and supervision. In addition, future development of routines for the role of department leaderships can be included in the research.

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Declarations

Conflict of Interest The authors declare no competing interests.

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