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Roles and Functions of Supervisors: Impact on the Learning Outcomes of Professional Engineering Doctoral Students

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ABSTRACT

CONTEXT

Professional engineering doctorate degree programs (awarding a Doctor of Engineering degree, Eng.D.) was established in response to an increased demand for application-oriented, strong industrial-based high-level technical personnel, which is different from the aims of the research-oriented degree programs (offering a Doctor of Philosophy, Ph.D.). For the development of professional engineering doctoral students, the professional ability, mentoring skills and attitudes of supervisors are key factors that will directly affect their learning outcomes.

PURPOSE OR GOAL

Using mentoring theories on the roles of mentors, this research focuses on exploring the role and functions of supervisors in process of doctorate studies for these professional engineering doctoral students.

APPROACH OR METHODOLOGY/METHODS

This study used a mixed research method to collect the data from a leading Chinese research intensive university. A questionnaire was used to examine the views of professional engineering doctoral students on their supervisors' mentoring. Follow-up one-on-one interviews were adopted to get a deeper understanding of supervisor's role and functions in the mentoring process.

ACTUAL OR ANTICIPATED OUTCOMES

Preliminary data analysis showed that the students had a high overall satisfaction with their supervisors. They perceived that the supervisors had played a positive role in promoting their learning outcomes. In particular, while serving as a guide in engineering knowledge and research methods, supervisors also offered technical advices and provided additional resources for students' projects and tasks as related to their professional roles in respective corporates. Such a diversity of supervisors' roles and functions seemed to promote the students' role in facilitating the cooperation between universities and enterprises.

CONCLUSIONS/RECOMMENDATIONS/SUMMARY

By elaborating on the roles and functions of supervisors in promoting the learning outcomes of professional engineering doctoral students, this study will provide practical and innovative suggestions for the design and evaluation system of mentoring for professional engineering doctorates.

KEYWORDS

professional engineering doctoral students, supervisor, mentoring

Introduction

To respond to the changes in the industrial structure and meet the needs of economic development, there is an urgent need to cultivate a large number of high-level talents in engineering to meet the needs of social development. Different from traditional engineering doctoral education (offering a Doctor of Philosophy, Ph.D.), which aims at developing research-focused talents, professional engineering doctorate degree programs (awarding a Doctor of Engineering degree, Eng.D.) aims to cultivate high-level talents geared towards industrial needs and technological applications (Kot, Hendel, 2012; Hawkes, Yerrabati, 2018), which can greatly promote the transformation from frontier technology to its application, and effectively alleviate the social pressure of the shortage of engineering talents. The British Association of Engineering doctorates (AEngD) points out that professional engineering doctoral students are more professional-oriented than traditional Ph.D. students, which better adapt to the needs of business development and thus help engineering and technical personnel with research experience to take up leadership positions in future businesses. Therefore, various countries and universities have been committed to building a distinctive training model to promote the continuous and effective progress of professional engineering doctorate degree programs. Due to the cultivation of knowledge and engineering quality of professional engineering doctoral students, the in-school supervisors are under more arduous mentoring pressure in the current cultivation system.

For example, the Engineering Doctorate (Eng.D.) in Composites Manufacture of the University of Bristol in the UK is a four-year doctorate program for researchers who aspire to key leadership positions in the industry. The Eng.D. is undertaken as a partnership between industry and academia, they spend 75% of their time at their sponsoring company carrying out the industrially focused research project, while the remaining 25% of their time is allocated to completing bespoke taught units. The program has very high requirements for in-school supervisors to make full use of students' school time. Besides, Delft University of Technology the Netherlands started its engineering doctorate program in 1990, and there are currently four engineering doctorate programs. In the school's two-years professional engineering doctorate degree program, each professional engineering doctoral student will have a supervisor. The supervisor for the first year is the instructor, and the supervisor for the second year is a professor who is responsible for the student's work. The relevant comprehensive quality and mentoring of the supervisors are key factors for students' learning outcomes.

The manufacturing industry in China is transforming, from the original labor-intensive type to the current technological innovation type, in which leading talents in engineering technology are the key strategic resource. China began to set up the professional doctorate degree in engineering in 2011, and since 2016, a considerable number of pilot universities have officially recruited engineering doctoral students. However, the current training of engineering doctoral students, especially the level of supervisors' mentoring, does not fully reflect the unique needs of professional engineering doctorate degree programs. The current mentoring system of engineering doctoral students in China is the "dual supervisor system" combining an in-school supervisor and an enterprise supervisor. However, in the specific implementation process, the mentoring on the professional doctoral students by the in-school supervisors received criticism that such mentoring practices can be quite homogenous with that offered to the academic Ph.D. students (Liu, Li, Zhao and Xu, 2016; Wang, 2018). The innovative and practical characteristics of the engineering doctoral students put forward higher requirements for the mentoring content and effectiveness of the supervisors.

Based on the above analysis, it is of great significance and value to explore how the mentoring of in-school supervisors play its due effect and role in the cultivation of engineering doctoral students. Therefore, this study tries to clarify the roles and functions of the supervisors in the cultivation of engineering doctoral students. So, this study mainly focuses on understanding: (1) the impact of the mentoring of supervisors on the learning outcomes of engineering doctoral

students. (2) the role and functions of supervisors in the mentoring process of engineering doctoral students.

Literature Review

To ensure the quality of the cultivation of engineering doctoral students, the supervisor is often the key factor (Lee,2008; Murphy, Bain and Conrad, 2007). Excellent supervisors often have rich academic experience, unique academic thinking skills and perspective, and a noble academic personality. Under their mentoring, students are more likely to develop scientific spirit, form their academic values, enrich their knowledge structure, and thus produce better learning outcomes and promote the rapid growth of academic ability (Lee, 2008). Roberts (2000) interpreted the connotation of mentoring from the perspective of management. He believed that mentoring is the role of a knowledgeable and experienced person who acts as a supporter, supervising and encouraging the academic and personal development of a less knowledgeable and experienced person (Roberts, 2000). From a psychological perspective, Levinson et al. (1978) defined mentoring as the process by which one person guides another person's psychosocial development by providing moral and emotional support. Jacobi (1991) elaborated on the content of the mentoring of supervisors from the perspective of pedagogy. He believed that the relationship between guidance and mentorship focuses on the growth and achievement of the mentee. This mentoring relationship is personal and reciprocal, and the mentoring process is not limited to professional progress, it also includes career development, role demonstrations, and psychological support (Jacobi, 1991). With the continuous advancement of doctoral education, researchers have increasingly studied the relationship between supervisors' mentoring and the quality of doctoral cultivation, and they tried to understand the relationship from different dimensions of supervisors' mentoring, such as the effectiveness of mentoring, the content, frequency, and the various ways of mentoring.

Supervision is considered one of the most influential factors in doctoral experiences (Sverdlik, Hall, McAlpine and Hubbard, 2018). Gardner (2009), Lin (2012), and Gube, Getenet, Satariyan and Muhammad (2017) also concluded that supervisors' mentoring has a significant effect on students' satisfaction, persistence, and academic achievement. In addition, the quality of students' learning and the final learning outcomes are closely related to the mentoring of the supervisors (Gube, Getenet, Satariyan and Muhammad, 2017). Therefore, a good mentoring relationship, along with appropriately designed mentoring content and mentoring process can effectively promote students' sense of accomplishment and satisfaction, thereby producing high-quality learning outcomes (Sverdlik, Hall, McAlpine and Hubbard, 2018). On the contrary, poor quality supervision may negatively affect the students' learning outcomes. Specifically, previous research by scholars has shown that poor supervision will significantly extend the time for students to complete their studies and reduce the quality of research results (Cullen, Pearson, Saha and Spear, 1994; McCulloch, 2010), and reduce the number and quality of publications (Cullen, Pearson, Saha and Spear, 1994). In addition, poor supervision may cause students to encounter various obstacles in the process of completing their research, and even lead to physical and mental health problems, which will negatively affect students' learning outcomes (Haag et al., 2018).

In addition to learning and research, the professional engineering doctoral students will have more project connections and cooperation with their supervisors, and even serve as the link between the in-school supervisor and the enterprises (Zhong, 2013). Therefore, the professional engineering doctoral students will have a closer connection with their supervisors both in learning and work. In addition, due to the uniqueness of the cultivation objectives of the professional engineering doctoral students, there will be unique practical difficulties and needs in the mentoring process (Yang, wang and Ding, 2019). Therefore, it is really important to do research on the influence of supervisors on the learning outcomes of professional engineering doctoral students, and explore the role and functions of the supervisors which can effectively enhance the quality of mentoring. However, summarizing the previous research, the articles

and theories on mentoring are relatively mature, but there are not many articles focusing on the professional engineering doctoral students, the students in most research are treated indiscriminately. However, there are obvious differences between professional engineering doctoral students and traditional Ph.D. students. The innovative and practical characteristics of professional engineering doctoral students must be paid attention to in research to better apply the mentoring theory to the cultivation of engineering doctoral students.

Methods

This study used a mixed research method to collect the data from a leading Chinese research-intensive university H. Participants were all professional engineering doctoral students from 7 different schools, including the School of Naval Architecture, Ocean and Architecture Engineering, School of Mechanical and Power Engineering, School of Electronic Information and Electrical Engineering, School of Materials Science and Engineering, School of Biomedical Engineering, School of Chemistry and Chemical Engineering, and School of Aerospace Engineering. All the students are part-time students with full-time jobs (the students of professional engineering doctorate degree program in University H are all part-time students). While participating in the professional engineering doctorate degree program, they also hold certain positions in off-campus companies or research institutions.

First, a quantitative method was used to explore how the mentoring of supervisors affect the learning outcomes of professional engineering doctoral students. A survey was designed based on the different aspects emphasized by prior mentoring theories (Johnson and Huwe, 2003; Johnson and Ridley, 2004). The survey also included questions for exploring other areas of professional engineering doctoral students' learning experiences, such as motivation and course learning experiences. This study focused on their mentoring experiences. Questionnaires are distributed uniformly to all first-grade professional engineering doctoral students enrolled in 2020. A total of 100 participants are included in this research and 66 valid questionnaires were collected finally, the participation rate was 66.0%.

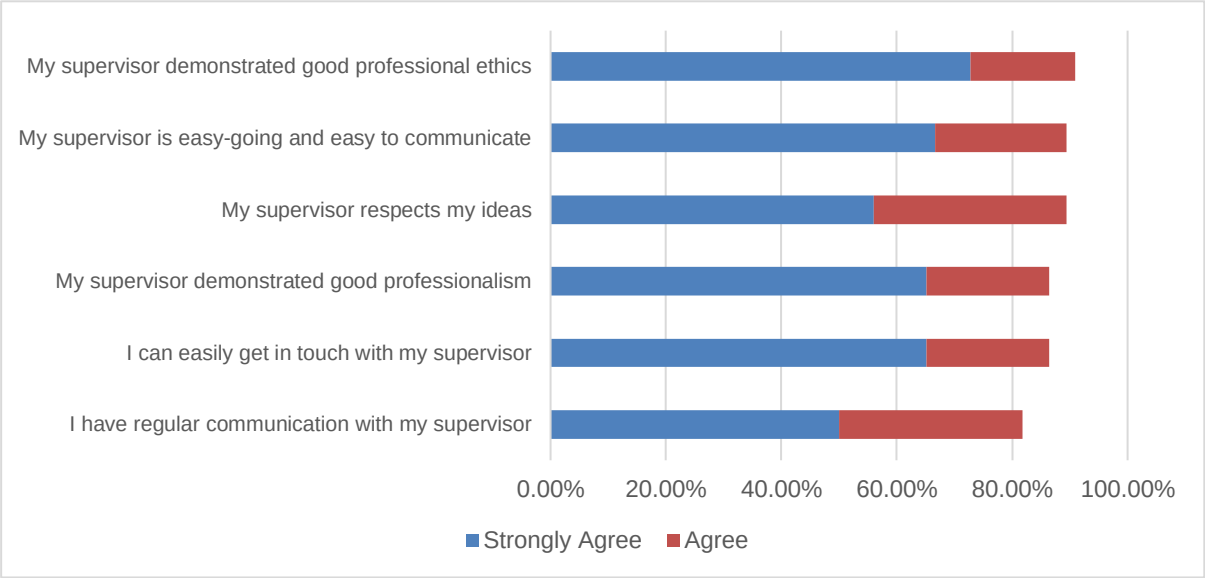
To further explore the perception of professional engineering doctoral students on the role and functions of supervisors in the mentoring process, the research conducted one-to-one interviews and collected relevant data by recruiting professional engineering doctoral students who have already participated in a questionnaire survey. Because the first-grade students need to complete the courses, to better understand the role and functions of supervisors, this study further follow-up interviews of the second-grade professional engineering doctoral students who have already participated in their supervisors' groups and projects. A total of 31 (20 in first-grade and 11 in second-grade) professional engineering doctoral students from different majors participated in the interviews for this study. Sample interview questions include, how often do you communicate with your supervisor, and how long does each exchange last? What kind of mentoring and help did the supervisors provide to you in your work and life, and did it solve the problems? So far, we have interviewed and analyzed 31 interview transcripts.

Preliminary Findings

Regarding the evaluation of the mentoring of supervisors, the questionnaire mainly surveyed the students' evaluation of their supervisors' professionalism, personality, and supervisors' attitudes towards the professional engineering doctoral students. Preliminary data analysis showed that students' overall satisfaction with their supervisors averaged about 87%, which means more than 80% of students believed that their supervisors have good professionalism, moral qualities, and communicate frequently with them. Percentages of respondents are shown below in Figure 1. The data showed that professional engineering doctoral students

have reached a high level of satisfaction with their supervisors, and they have a positive attitude towards their supervisors' mentoring on their learning outcomes.

Figure 1. Evaluation of supervisors by the professional engineering doctoral students



In addition, this research classified the roles and functions of supervisors in the mentoring process through interviewing the professional engineering doctoral students on three aspects, which including the mentoring frequency, mentoring contents, and the ways of mentoring. Because the professional engineering doctoral students in first-grade need to complete their professional courses, not all of them fully participated in their supervisors' groups and projects. The preliminary interview of them found that the mentoring of supervisors on the first-grade students cannot reflect consistent patterns, the individual difference was large. Therefore, to better understand the role and functions of the supervisors in the mentoring process, this study further follow-up interviews on the second-grade professional engineering doctoral students who have already work with their supervisors, the purpose was to gain a comprehensive and in-depth understanding of the role and functions of the supervisors in the mentoring process.

There are totally 20 professional engineering doctoral students in first-grade took part in the interview. The interview data showed that students' views on the mentoring frequency of supervisors were quite different among individuals, students who have participated in their supervisors' groups or projects indicated that the mentoring of their supervisors are frequent enough to meet their needs, while the students who have not yet participated in their supervisors' groups or projects said that supervisors do not mentor them very often. In terms of mentoring contents, first-grade students generally referred that supervisors' mentoring included professional knowledge, work, and life, but few of them specifically explained. When regarding the ways of mentoring, students who participated in their supervisors' groups and projects indicated that supervisors' mentoring often took place in the discussions and meetings of the projects, while others mentioned the main ways of mentoring is separate communication and group meetings.

In view of the special situation of first-grade students, this study specifically followed up the interviews with second-grade professional engineering doctoral students, with a view to obtaining more comprehensive information of supervisors' mentoring. A total of 11 students participated in the interview. In terms of mentoring frequency, preliminary qualitative data showed that 5 of the professional engineering doctoral students thought that the frequency of their supervisors' mentoring was high enough to meet their daily learning needs and solve learning problems in time. Even when time and space are limited, regular communication and discussion were still conducted online. An engineering doctoral student answered the question about the mentoring frequency of the supervisors:

I communicate with my supervisor often. I don't attend the group meeting every time, but I must attend it often, which is required by my supervisor. Whether academic or other activities, I can participate in team activities as much as possible….. The learning requirements are the same as for full-time students.

The remaining students (6) hold different views. They said that there was a disparity between the mentoring frequency and the actual needs of the professional engineering doctoral students. They concluded that the supervisors' mentoring and exchanges with them were not very frequent. Due to the limitations of work, time, and space of professional engineering doctoral students, it was difficult for the supervisors to provide regular mentoring for them. A student said:

There is a big difference in the mentoring frequency of my supervisor. He will not urge me to ask about the progress every day, because he knows that I am busy at work and I also need to balance the time between work and study. I may give him a special report for two weeks or even a month.

In terms of the mentoring contents of supervisors, 4 of the students believed that the supervisors' mentoring contents were the same as that of full-time Ph.D. students, and put forward the same requirements. They were given frequent mentoring in terms of professional knowledge, academic research, and their dissertation work, especially the frontier knowledge of the field and the topic selection of their dissertation. The student mentioned:

My topic has been selected. After I have selected it, in terms of what method should be used to explain the problem clearly, and how to analyze the data to draw some conclusions, my supervisor will give me guidance. My supervisor will mentor me to analyze these topics from the surface to the deeper aspects, and use different statistical tools, which are of great help to the research on this topic.

More than half (7) of the students believed that the mentoring of their supervisors included not only academic research issues, but also engineering practice issues, and even included a certain level of work and life communication, which was richer and more multifaceted than full-time Ph.D. students. In the topic selection of the thesis, more consideration was given to students' actual needs and to solve the actual problems of enterprises. An engineering doctoral student mentioned:

There should be some differences in the contents and focus of the mentoring of the supervisors. Full-time students still prefer academic research. We have both academic and engineering practice issues, even including exchanges in life. After all, we are in different environments. We may have families, jobs, which is different from full-time students.

When regarding the ways of mentoring, students' perception varied. 5 students believed that the supervisors' mentoring modes were the same as that of the full-time Ph.D. students. The supervisors also allow the engineering doctoral students to participate in their research team. In daily learning, they also needed to participate in regular meetings and share their learning and research progress. A student mentioned in the interview:

we have a regular meeting every week, because I am at work, for a short distance from the school and the meeting time is working days, so sometimes it is difficult for me to live in, but they always had a video conference for me, so I could see what the full-time students in the research group were presenting, and I could hear what they were talking about, and in my case, I could have a video conference with them.

But at the same time, other students (6) hold a different view, they believed that the supervisors considered a lot about the cultivation characteristics of the engineering doctoral students in the mentoring process, and the supervisors usually did not force the time and frequency of attendance. The mentoring on engineering doctoral students always be more based on cooperation projects or engineering practice issues. An engineering doctoral student said in the interview:

We are already employed. The mentoring provided by my supervisor is mainly about some practical problems I encountered in my actual work. If I cannot solve it, I need to seek help from my supervisor. The guidance and help in this area are the greatest.

Conclusions

In conclusion, through the questionnaire data, it can be concluded that most of the professional engineering doctoral students (average is 87%) were highly satisfied with the mentoring of their supervisors. Analysis of qualitative data shows that the view of the professional engineering doctoral students in first-grade on mentoring is closely related to whether they participate in projects or not, and does not form a specific pattern. Qualitative data from the second-grade students show that students generally agree that the mentoring frequency, contents, and ways are sufficient for their research and learning to meet their daily needs. However, compared with full-time Ph.D. students, the mentoring frequency is slightly lower, the mentoring contents is more practical, and the way of mentoring is more diversified, as the professional engineering doctoral students are more practically oriented.

Therefore, to fully promote the positive effect of the in-school supervisors' mentoring on the learning outcomes of the engineering doctoral students: (1) It is necessary to eliminate the ambiguity of in-school supervisors' cognition of engineering doctoral students. The supervisors should make a clear distinction between the cultivation objectives and programs of the engineering doctoral students and the Ph.D. students in engineering, rather than simply supplementing the traditional cultivation programs. (2) It is also important to clarify the mentoring responsibilities of in-school supervisors for engineering doctoral students. The supervisors should consider the innovative and practical characteristics of the engineering doctoral students, and reflect in various aspects such as regular communication, academic mentoring, and thesis mentoring.

According to the preliminary work, we find that the cultivation of engineering doctoral students has distinct practical and innovative characteristics, so it is very important to consider the characteristics of the samples in relevant studies. Therefore, future research will further consider the demographic information of engineering doctoral students, including students' grades and majors, to explore the changes in the time dimension of mentoring and supervisors' roles.

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