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Motivations and Learning Outcomes: The Profile of Professional Engineering Doctorates

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Work-in-Progress:

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Abstract

The development of the economy calls for large numbers of high-quality engineering talents, who can stand in the forefront of science and technology, and lead the transformation of technological advances into applications. Despite the call to diversify the training of Philosophy Doctors (Ph.D.s) to prepare them for multiple career paths, Ph.D. training still remains as the main venue for the training of high-level academic talents. To produce more application-oriented engineers, an increasing number of professional engineering doctorate degree programs (awarding Engineering Doctor degrees, Eng.D.) emerged, targeting to training high-level innovative and application-oriented talents. Based on different training purposes, the motivations and expectations of an Engineering Doctor degree are different. These will affect students' engagements and learning outcomes, especially part-time students.

Focusing on a leading Chinese research intensive university H, this work-in-progress examines part-time professional engineering doctorates' motivations and expectations of their program and learning outcomes during the program. A questionnaire and follow-up one-on-one interviews were used to collect data. Preliminary findings suggested that the main motivation of part-time doctoral students was to improve theoretical knowledge and professional competence. Meanwhile, part-time doctoral students' understanding of basic knowledge and cutting-edge knowledge in the engineering field had increased significantly. This study provides an understanding of the motivations and learning outcomes of these part-time engineering doctorate students. Practical suggestions will be proposed for improving the training system for engineering doctorates.

Introduction

More and more application-oriented leading engineers are urgently needed to respond to scientific and technological revolution and industrial transformation. The traditional doctoral education focuses on the cultivation of academic talents, and there are certain differences between scientific research and the actual work of enterprises. In response, universities in many European countries and the UK, and some universities in the United States, have begun to explore doctoral training related to engineering applications. The Engineering Doctorate is designed for future leaders and innovators

for industry and research, which needs to simultaneously satisfy industries needs and delivering a doctoral level contribution to knowledge [1]. Compared with traditional doctorate degrees, engineering doctorate degrees are more concerned with solving practical industrial problems, which is conducive to the development of some emerging industries.

In order to meet the needs of building an innovative country and improving engineering and technical personnel training system, Academic Degrees Committee of the Chinese State Council began to set up Engineering Doctor degrees in 2011 [2]. Since 2016, a number of pilot universities have gradually begun to officially recruit students for Engineering Doctor degrees. Doctor of Engineering is oriented towards engineering practice and innovation. The training program is often jointly run by universities and enterprises, which mainly trains high-level engineering and technical personnel.

At present, the development of engineering doctorates programs and the doctoral students training in such programs is still in its burgeoning stage in China compared to its counterparts in some other countries. Therefore, it is helpful to understand the current situation, so as to optimize this process. This study focuses on two aspects: (1) students' motivations to pursue Engineering Doctor degrees and what they expect to get through the program; (2) what students have already acquired through the program.

Literature review

With the diversification of demands for doctoral students from multiple stakeholders, in particular the industrial representatives, academic research no longer stands as the main reason for doctoral students to pursue a doctorate degree (including both the Ph.D. and the Eng.D.). According to a study of collaborative doctoral education in Europe [3], the main motivation to enroll in a collaborative doctoral program was the chance to conduct research that was more applicable to "real-life" problems. In addition, increasing employment prospects, especially in non-academic sectors and gaining a better insight into non-academic fields were equally important reasons [3]. Bastalich [4] emphasized that for those doctoral students with work experiences, they wanted to increase their experiences as professionals through their doctoral study and apply new research knowledge to their later work practice.

The motivations for pursuing engineering doctorate degrees are similar, and the most important one is to solve practical problems. Hawkes [5] pointed out that, engineering doctoral students usually have observed the problem of practices for some time and wanted to find solutions to make things work better in their work places. Professional engineering doctorate degree programs provide them with the opportunity to develop a doctorate with an industrial applicability [6]. In addition, enhancing employability and career prospects is what engineering doctoral students expect.

Students hope to develop and update their skills through the professional engineering doctoral training [7]. Additional motivations include expanding current connections in both industry and academia, hoped-for changes in career and a push by employers to have a doctorate [5], [6].

The requirements for doctorates are more diversified and the society needs versatile talents who can work in different departments. Thus, the process of doctoral education should enable doctoral student to develop a range of generic or transferable knowledge and skills. These knowledge and skills are not only valuable for the successful completion of the doctorate, but also for career development after the doctorate in a wide range of professional sectors [8]. Industry-related doctoral education helps students develop such abilities. Wardenaar [9] mentioned that in multi-actor research programs, students could be confronted with different people, which would increase their abilities to adapt to boundary-crossing research. Similarly, because of dual participation of enterprises and universities, professional engineering doctoral education can greatly develop students' transferable abilities, including networking, communication, negotiation, teamwork, flexibility, writing skills and autonomy [6]. Besides, students learn the theoretical knowledge needed for research and broaden their horizons [10]. Through the doctoral program, they can deepen understanding of the industry culture [6]. Due to the deep understanding and connections in the industry, students can also develop entrepreneurship within engineering doctorate [6].

Methodology

Participants were professional engineering doctoral students from a leading Chinese research intensive university H. They came from six different disciplines, including Naval Architecture Engineering, Ocean and Civil Engineering, Mechanical Engineering, Electronic Information and Electrical Engineering, Materials Science and Engineering, Chemistry and Chemical Engineering, and Aeronautics and Astronautics. All of they were part-time students and held formal job positions in industry or some research institutes.

This study used a mixed research method. A questionnaire was used to examine the main reasons for choosing an industrial doctorate and the skills and abilities they had improved. The questionnaire survey was conducted to all the students after they completed their first semester. In total, 47 valid questionnaires were collected, and the participation rate was 73.44%.

Qualitatively, one-on-one interviews were adopted to get a deeper understanding of their motivations, expectations, and learning outcomes. The study employed purposeful sampling to recruit part-time doctoral students. Twenty participants have been interviewed. Sample interview questions include, what is the main motivation for pursuing an Engineering Doctor degree after working as a full-time professional? What

skills and abilities do you want to improve through the program? What have you learned from your studies so far? So far, we have analyzed ten manuscripts.

Preliminary Findings

Quantitatively, improving the level of theoretical expertise and enhancing professional skills were the two main motivations for part-time engineering doctoral students to purse engineering doctorate degrees. Obtaining a highest degree (i.e. a doctorate degree) was also considered an important reason for their enrollment, with nearly 50% of respondents. Only 6.38% of students considered for post promotion. Percentages of respondents are shown below in Figures 1.

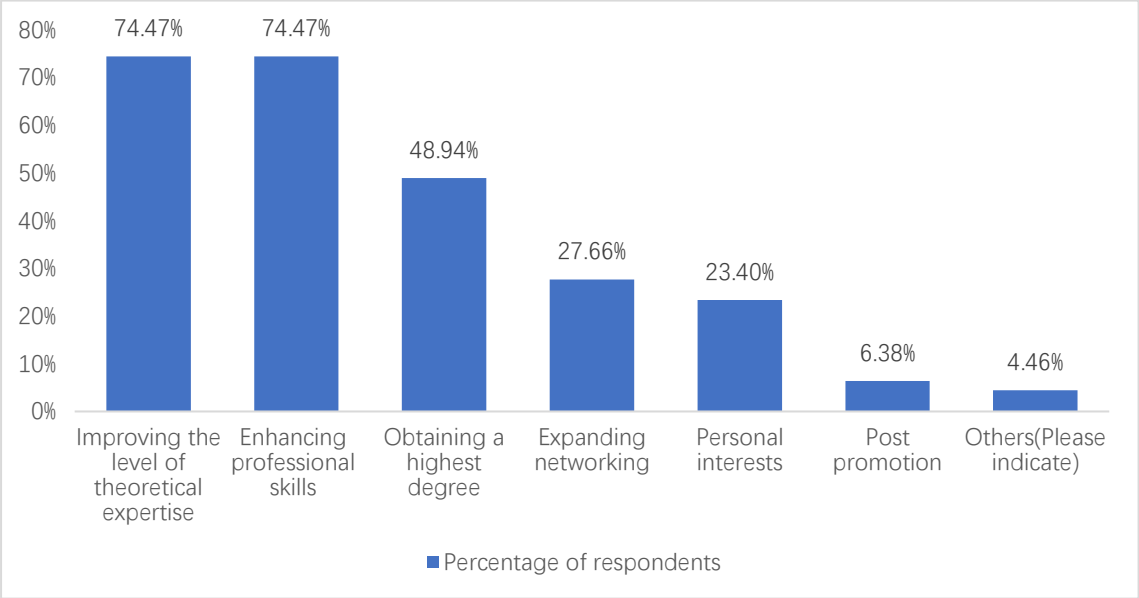

Figure 1: The reasons for you to purse an industrial doctorate

Here, the learning outcomes were mainly assessed from the dimensions of knowledge and skills. Students improved significantly overall, with an average score of 4.53 out of 5. Among them, the improvement of knowledge was the most obvious and both were above 4.87. The following top five were academic research ability, interdisciplinary thinking, analytical thinking, innovative thinking and engineering application ability. Relatively, the bottom three were teamwork skills, organization and coordination ability, and leadership. Among them, the least improved knowledge or skill was leadership, which was below 4. Scores of the degree of improvement are shown below in Figures 2.

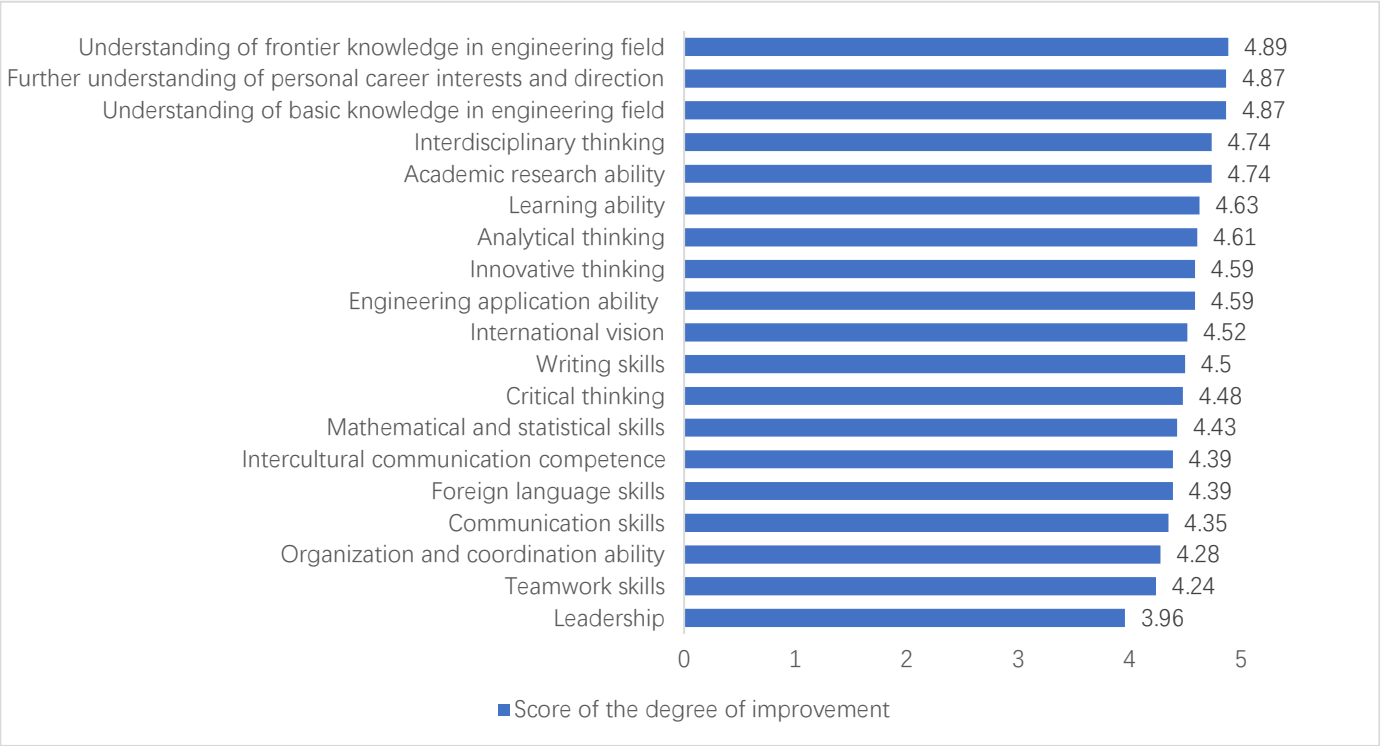

Figure 2: The degree of improvement in the following areas

In addition, our preliminary qualitative analyses indicated that learning theoretical knowledge, enhancing professional competence and obtaining a higher degree were three main motivations of students to study for an engineering doctorate, which was consistent with the quantitative findings. The motivations were driven by two kinds of factors: external issues and internal needs. On the one hand, faced with technical bottlenecks in their work, students hoped to solve practical engineering problems of enterprises. On the other hand, the motivation to improve their own abilities drove students to participate the program. Through this program, students hoped to improve their theoretical understanding, enrich their research ideas, and improve their abilities.

For example, when asked about what the main motivation for pursuing an Engineering Doctor degree after working, Bob, a student from the School of Chemistry and Chemical Engineering who was engaged in product design and development at a research institute, mentioned the needs of the work:

I have encountered some problems in practical work, so I wanted to have an in-depth understanding of how to solve these engineering problems. –Bob

Mark, a student from the School of Electronic Information and Electrical Engineering who worked as an engineer at a stated-owned company, emphasized self-development:

I have always wanted to make some breakthroughs…I hope to improve my professional ability through the resources of the university, so as to become specialized and make some achievements in the field. – Mark

In terms of what they expect to get through the program, what most mentioned by the participants was that they wanted to learn more professional knowledge to improve theoretical knowledge. Meanwhile, they hoped to change the thinking set and enhance their thinking skills through thinking training. Moreover, students looked forward to get in touch with more experts in their specialized fields.

For example, when asked about what skills and abilities you want to improve through the program, Leo, a student from the School of Mechanical Engineering who was engaged in research and development at a stated-owned company, answered:

I studied mechanical manufacturing for my master's degree. I have been engaged in work related to mechanical design and equipment development and materials are very important in my work…But I lack a lot of theoretical knowledge related to materials… So I want to make up for the shortcoming. –Leo

Kevin, a student from the School of Mechanical Engineering who was engaged in technical work at a research institute, answered:

After working for a few years, I may have formed a fixed mind-set. So I want to develop my own ideas and break the inherent thinking mode through the learning of the course. –Kevin

In terms of what they have already acquired through the program, all the participants emphasized that they had broadened their horizons and learned about frontier knowledge and technology through a course specifically designed for such purpose (Selected Topics in Engineering Frontiers). Secondly, they had gained relevant knowledge of other fields and improved abilities of interdisciplinary thinking. In addition, students mentioned that they had learned a lot about academic writing in English and improved writing skills through a writing course.

For example, when asked about the learning outcomes through the program, Alan, a student from the School of Mechanical Engineering who worked as an engineer at a sino-foreign joint venture, emphasized the importance of cutting-edge knowledge in engineering field:

The lectures of Selected Topics in Engineering Frontiers were very close to the current research frontiers, and something was very relevant to my work. This course was of great help for us to understand the current frontier research in our own field, and what are the better research results, achievements and directions. –Alan

David, a student from the School of Aeronautics and Astronautics who worked as an engineer from a stated-owned company, mentioned knowledge from other fields:

I am engaged in avionics and the knowledge that 1 have encountered is mainly related to this aspect. Thus, I was confined to my own domain. However, there are some similarities between different disciplines and fields actually. Sparks can sometimes be created by the exposure to knowledge in other fields. –David

Conclusion and future work

In sum, as a group of part-time doctoral students, these participants indicated motivations for pursuing a professional engineering doctorate as from both the work demands and personal development needs. Through the doctoral program, they want to improve the level of theoretical expertise, enhance professional skills and upgrade qualification and they have achieved some of their goals through the courses they have learned. They have had a better understanding of frontier and basic knowledge in engineering field and exercised a variety of thinking skills.

Based upon the preliminary work, future work includes further analyses of qualitative data concerning the motivations and expectations of the program and learning outcomes during the program. Also, upon the analyses, we will explore the difference between academic and professional engineering doctorates. Additionally, future research will be focusing on the relationship between expectations behind the program and learning outcomes during the program.

Reference

[1] P. Godfrey, "The Engineering Doctorate (EngD): Developing Leaders for Tomorrow with Industry," in *CLAIU – EU (Council of Association of long-cycle Engineers, of a university or higher school of engineering of the European Union)*, Madrid, Spain, 2012.

[2] Academic Degrees Committee of the State Council, "Project of setting up the professional degree of engineering doctor," 8, March 2011. [Online]. Available: http://www.moe.gov.cn/srcsite/A22/moe_833/201103/t20110308_117376.html. [Accessed March 5, 2021].

[3] L. Borrell-Damian, R. Morais, and J. H. Smith, "Collaborative Doctoral Education in Europe: Research Partnerships and Employability for Researchers Report on Doc-Careers II Project," Brussels: European University Association. [Online]. Available: http://www.moe.gov.cn/srcsite/A22/moe_833/201103/t20110308_117376.html. [Accessed March 5, 2021].

[4] W. Bastalich, "Knowledge Economy and Research Innovation," *Studies in Higher Education*, vol. 35, no. 7, pp. 845-857, Sep. 2010.

[5] D. Hawkes, (2016). "Why do a professional doctorate? Evidence from prospective EdD students," *International Journal of Continuing Education & Lifelong Learning*, vol. 8, no. 2, pp. 34-46, 2016.

[6] O. Tavares, C. Sin, and D. Soares, "Building bridges between industry and academia: What is the profile of an industrial doctorate student," in *Structural and Institutional Transformations in Doctoral Education*, S. Cardoso, O. Tavares, and C. Sin Ed. Cham: Palgrave McMillan, 2020, pp.347-373.

[7] A. G. Roberts, "Industry and PhD Engagement Programs: Inspiring Collaboration and Driving Knowledge Exchange," *Perspectives: Policy and Practice in Higher Education*, vol. 22, no. 4, pp. 115-123, Apr. 2018.

[8] D. Bogle, J. Eggermont, M. Dron, and J. W. Henten, “Doctoral Degrees B eyond 2010: Training Talented Researchers for Society”. Leuven: League of European Research Universities. [Online]. Available: https://lirias.kuleuve n.be/1579665?limo=0, [Accessed March 5, 2021].

[9] T. Wardenaar, R. Belder, M. E. E. de Goede, E. Horlings, and P. van den Besselaar, “Skill Development in Collaborative Research Projects: A Comparison Between PhD Students in Multi-Actor Research Programs and in Traditional Trajectories,” in *Organizing Collaborative Research*, T. Wardenaar Ed. Den Haag: Rathenau Instituut, 2014, pp.108-129.

[10] C. Sin, D. Soares, and O. Tavares, “Coursework in industrial doctorates: a worthwhile contribution to students’ training,” *Higher Education Research & Development*, Aug. 2020.