Reforming Doctoral Education for the Knowledge Society: A competency development perspective

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Abstract. This article proposes conceptual frameworks for reforming doctoral education to better train research and development (R&D) professionals ("knowledge professionals"), while also training for the academic profession. Knowledge professionals represent personnel who are involved in R&D activities, including researchers, support staff, and others. Doctoral education is experiencing rapid changes, both structurally as well as within academic programs, and recent reform initiatives emphasize competency-based doctoral education as a response to the societal demands of the knowledge society. This paper briefly overviews the competencies for doctoral students, and proposes how to implement the concept of competency in doctoral education practice.

Keywords: Doctoral education, knowledge society, competency, knowledge professionals

1. Introduction

Doctoral education is considered a key engine for economic development in the knowledge society because strong doctoral programs attract talented human resources, including doctoral students and professors (Meek et al., 2009; Salmi, 2009). Global rankings and world-class university initiatives emerged in the knowledge society as a form of measurement and as a policy approach for developing top-ranked universities, respectively (Shin & Kehm, 2012). Within knowledge society discourses higher education has been rapidly massified across countries, and advanced degree programs, especially doctoral programs and in developing higher education systems, have also grown significantly (e.g., Nerad, 2010; Shin, Postiglione, & Ho, 2018). For example, between 2000 and 2015, doctoral degree recipients in Malaysia increased from 148 to 3,569, in Mexico from 1,036 to 5,782, and in Slovakia from 446 to 1,914, according to 2017 UNESCO data. This increase in doctoral programs in the developing higher education systems is quite remarkable.

However, doctoral education is experiencing rapid changes with the growing societal demands for diversified qualifications for doctoral degree holders. Policy and academic discourses on doctoral

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education have focused on competency development and professional training (Austin, 2010). Competency became the focus in order to emphasize a broad range of transferable skills, technology, knowledge, and experiences to comply with diverse and rapidly changing societal demands of doctoral degree holders (e.g., Austin & McDaniel, 2006; Nerad, 2015; Teichler, 2006). Professional training was an institutional response to meet the demands from the knowledge society through developing various education programs (e.g., coursework, workshops, internships, etc.). However, the term "professional training" does not satisfy the societal demands raised by the knowledge industry, which emphasizes research and development (R&D) for innovation and entrepreneurial activities.

These diversified social demands have been interpreted and institutionalized differently depending on the social context (Shin, Kehm, & Jones, 2018). The European countries that have developed doctoral education based on individual relationships between supervisor and doctoral students are undergoing rapid changes (Shin, Kehm, & Jones, 2018), beginning to adopt systematic reforms focused on standardization, including coursework components (Kehm et al., 2018). Compared to European initiatives, US doctoral education reforms have focused more on competency development to satisfy diversified and changing societal demands (Austin, 2010). "Graduate Education 2030: Imagining the Future," proposed by the Council for Graduate Schools emphasizes "transferable" and "cross-disciplinary" skill sets for doctoral education (2017). These changing societal demands and the growing knowledge industry have boosted new types of doctoral training in both North America and Europe.

In addition, traditional goals for doctoral education (training the next generation of scholars and traditional professionals) do not fit well into the conceptual frame of the knowledge society. The knowledge industry requires a knowledge base that is less discipline-based, and well-trained human resources that are more than traditional "professionals" such as lawyers, doctors, priests, and teachers, etc. Although the literature explains these societal demands using a concept of "professional training" (or professional development), this concept does not highlight the characteristics of the knowledge society and professional work. The professionals who are working in the knowledge society are mainly working on research and development because research and development (hereafter, R&D) is a foundation for knowledge production and technological development. In the knowledge society, the funding for R&D has rapidly increased, as has the number of knowledge professionals. For example, the number of personnel who are involved in R&D activities including proposal writing, project management, project consulting, and assessment has increased three-fold during the last two decades, according to 2017 UNESCO data.

The traditional functions of the academic profession have been changing from traditional scholarly work—teaching and research—to a wider range of academic work including R&D and entrepreneurial activities (e.g., Clark, 1998). The Changing Academic Profession survey data demonstrate that most academics spend significant time on R&D related activities (Teichler et al., 2013). In addition, the more recent follow-up project, the Academic Profession in the Knowledge

Society (APIKS), highlights how academic work has changed as universities engage in the knowledge society. This article proposes conceptual frameworks for reforming doctoral education to train knowledge professionals as well as traditional goals for training the academic profession. These "knowledge professionals" represent personnel who are involved in R&D activities, including researchers, support staff, and others as defined in UNESCO and OECD data (for details, see OECD, 2012, p.21).

2. Growing knowledge industries and changing academic work

This section discusses how the rapid growth of the knowledge industry brought changes in industries and how these changes created new jobs, especially research and development jobs. In addition, changing societal demands of the knowledge society have expanded professorial roles from teaching and research to include more R&D functions. These changing job markets in academia and industry require transformative changes for doctoral education.

2.1 Growing knowledge industry and doctoral education

The knowledge industry has grown enormously over the past two decades. According to the US National Science Board (2016), the knowledge industry accounted for about 27% of the world economy measured by GDP during the last 15 years. In addition, the hi-tech industry has also increased in size and importance, especially in the fast-growing economies such as China, Russia, and India where the growth rates were 10 times, 11.5 times, and five times, respectively. Such growth has stabilized in advanced economies such as the USA, EU, and Japan where the growth rates during the same period were 1.9 times, 2.1 times, and 1.1 times, respectively. The growth of the knowledge industry requires different types of knowledge and skills. The changing demands from markets require universities to train their doctoral students to be more than scholars or trained professionals (e.g., OCED, 2012).

The growth of the knowledge industry is similar across various sectors (e.g., commercial, education, health, hi-tech manufacturing, etc.). The highest rate of growth was in the health industry (2.5 times growth during last 15 years) as shown in Table 1. A similar growth rate across different sectors suggests that the knowledge industry is widely applicable across industrial sectors. In policy discussions, policymakers tend to emphasize a specific industry such as the bio-medical sciences or hi-tech related industries, but the knowledge society is closely related to a wide range of industries. In addition, the knowledge society is related to economic production "process" in general from production to economic consumption across all sectors (e.g., Gibbons et al., 1994; Stehr, 1994). This fact implies that doctoral education should perhaps align a wider range of disciplines rather than just specific fields such as science, technology, engineering and mathematics (STEM).

Table 1. Growth of knowledge industry worldwide (2000-2014)

	2000	2005	2010	2014	Growth (2000-2014) (%)
Total	9,493,268	13,507,710	18,148,160	21,348,911	225
Commercial KI	5,662,626	8,102,330	10,755,920	12,773,142	226
Education KI	1,331,804	1,895,481	2,596,846	3,009,278	226
Health KI	1,554,787	2,367,604	3,283,518	3,785,148	243
HT Manufacturing	944,051	1,142,295	1,511,876	1,781,343	189
Business Service	2,962,504	4,227,694	5,637,241	6,638,006	224
Financial Service	1,856,405	2,701,739	3,622,181	4,501,416	242
IT Service	843,717	1,172,898	1,496,498	1,633,720	194

Data source: US National Science Board (2016), Key Science and Engineering Indicators.
Notes: Unit is millions of current dollars

Table 2. Growth of knowledge professional job market (2000-2015)

	Total R&D personnel per thousand total employment			Share of Researchers (%) (2015)
	2000	2015	Growth rate (%)	
Malaysia	1.1	5.8	549.2	84.8
China	1.3	4.9	372.3	43.1
S. Korea	6.5	17.4	269.0	80.6
Austria	8.6	16.7	194.1	61.0
Italy	7.2	11.3	157.1	48.6
Norway	11.1	16.1	144.4	72.2
Singapore	10	14	140.3	86.2
Netherlands	11.5	15.3	132.8	61.3
UK	10.4	13.2	127.3	68.7
Switzerland	13.5	16.9	125.5	53.7
Australia	10.6	12.7	119.4	
Germany	13	15.2	116.9	60.6
France	13.7	16.1	116.8	64.8
Canada	11.1	12.5	112.2	68.3
Sweden	16.1	17.5	108.5	79.9
Japan	14	13.9	98.6	75.7

Source: UNESCO data in 2017
Notes: The thousand employment is full-time equivalent.

In the knowledge economy, societal demands for trained manpower is growing and advanced degrees such as master's and doctoral degrees are becoming entry-level qualifications. One might argue that a doctoral degree is an over-qualification for most R&D jobs, but an advanced degree is

becoming the minimum entry-level qualification for many positions (e.g., OCED, 2012). The growth of doctoral degrees has been increasing and doctoral degree production has doubled even in higher education systems such as Italy, Norway, Canada, and Australia over the last 15 years, according to UNESCO data (2017). In addition, the growth of the R&D industry is well represented by the growth of R&D personnel (researchers, technicians and other support staff) as shown in Table 2. The growth rate is highest in Malaysia at 549% , followed by 372% in China, and 269% in South Korea.

The rapid growth of the knowledge industry and growing job markets in R&D require well trained knowledge professionals. Some of them are directly involved in research and development activities, others work on research funding and management, and the others work on research support functions. All require an in-depth understanding of R&D activities regardless of whether they are directly involved or support the R&D activities. At the inception of the R&D industries, research staff were filled with non-doctoral degree holders, while today growing numbers of these positions are filled by doctoral degree holders. In addition, R&D management and support staff positions used to be filled with bachelor's degree holders and master's degree holders, but new positions are increasingly replaced by doctoral degree holders. This changing job market requires universities to provide different types of doctoral training courses for those who have a career plan for working outside of academia.

2.2 Changing faculty roles in the knowledge society

Professorial roles have also changed with the emergence of the knowledge society. Traditional academic roles have focused on teaching and research, and knowledge society discourses added R&D and entrepreneur activities (e.g., Austin, 2010) as the third function. The new functions have been encouraged by national R&D policy and the emphasis on R&D has changed academics' roles in many countries (e.g., Shin, Kehm, & Jones, 2018). In this context, R&D investment has increased significantly on a global scale. According to UNESCO data in 2017, China and South Korea doubled R&D investment over the last 20 years. The share of R&D (4.3%) in total GDP is the highest in Israel and South Korea followed by Japan, Sweden, Australia, and Denmark. These countries spend over 3.0% of their total GDP on research and development.

Although industrial sectors have consumed a large share of R&D expenditure, higher education institutions have also benefitted from increased R&D investments. According to the US Key Science and Engineering Indicators (US National Science Board, 2016), in advanced economies higher education institutions consume over 10% of R&D expenditure, although most of this investment is used by industrial sectors, typically more than 60% as shown in Table 3. This increased R&D expenditure in higher education institutions has changed the major functions of the academic profession from the "traditional" functions of teaching and research to activities based on knowledge and technology development, and entrepreneurialism.

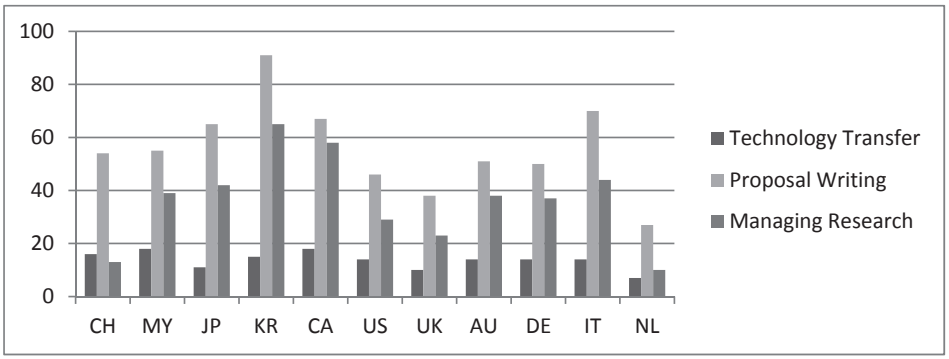
Table 3. Share of R&D expenditure by sector (2015)

	GERD (PPP $billions)	Business	Government	Higher education	Private (nonprofit)
USA (2013)	457.0	70.6	11.2	14.2	4.1
China (2013)	336.5	76.6	16.2	7.2	
Japan (2013)	160.3	76.1	9.2	13.5	1.3
Germany (2013)	101.0	67.8	14.7	17.5	
S. Korea (2013)	68.9	78.5	11.2	9.2	1.2
France (2013)	55.2	64.8	13.2	20.8	1.4
Russia (2013)	40.7	60.6	30.3	9.0	0.1
UK (2013)	39.9	64.5	7.3	26.3	1.9
India (2011)	36.2	35.5	4.1	60.5	

Data source: US National Science Board (2016), Key Science and Engineering Indicators

Changing academic roles are represented in the Changing Academic Profession (CAP) data (Teichler et al., 2013), which is an international comparative project involving 19 higher education systems. According to the CAP data, academics in most countries are actively involved in research proposal writing. Over 40% of academics have participated in proposal writing in nine of 11 countries according to Figure 1. In addition, over 40% of the academics have engaged in research project management in four countries (Japan, Korea, Canada, and Italy). This suggests that almost half of the academics are involved in R&D activities in the changing societal environment of the knowledge society.

However, a relatively small proportion of academics (less than 20 percent) are involved in technology transfer activities. This is because technology transfers are mainly conducted by the academics in the sciences, technology, engineering, and mathematics (STEM). However, growing numbers of academics in the non-STEM disciplines are also influenced by knowledge society discourses. For example, academics in non-STEM disciplines are beginning to realign their research to contribute to social development. This is because academics try to improve the social relevance of their research in the knowledge society.



Data source: Teichler, U., Arimoto, A., & Cummings, W. K. (2013). *The Changing Academic Profession: Major Findings of a Comparative Survey*. Dordrecht: Springer.
Notes: (1) Vertical line is the percentage of the responses who participated in each of the three types of activities
(2) CH (China), MY (Malaysia), JP (Japan), KR (Korea), CA (Canada), US (United States), UK (United Kingdom), AU (Australia), DE (Germany), IT (Italy), and NL (Netherlands).

Figure 1. Academics' involvement in knowledge society activities

In addition, the traditional functions of teaching and research (plus service) have changed with knowledge society discourses. Professors were expected to do both teaching and research (plus service and administration) in the past, but growing numbers of universities began to hire research only and/or teaching only academics (Finkelstein et al., 2016; Shin & Teichler, 2014). In addition, universities began to actively hire staff to efficiently support teaching and research activities. These positions were filled by educated specialists called "para-academics" (Macfarlane, 2011). The para-academic sector has been rapidly increasing in most higher education institutions. The boundary of the "academic profession" is "unbundling" with the emergence of these para-academics, as discussed in Macfarlane (2011), and Whitchurch (2008).

3. Doctoral education reforms in the knowledge society

In this changing environment, doctoral education has experienced rapid transformations. These changes include structural changes as well as changes in academic programs. In particular, higher education researchers began to write about the competencies with which doctoral students should graduate. This section briefly overviews the competencies proposed by higher education researchers, especially the work of Austin and McDaniel (2006) and the skills for researchers that the OECD (2012) proposed. Finally, this section suggests how to implement the competency perspective in doctoral education. Most doctoral education literature uses "skills" and "competencies" interchangeably, as does this paper, although Nerad (2015) argues differently.

3.1 Reforming doctoral education for the knowledge society

Doctoral education has been criticized by industry, policymakers, and higher education scholars (e.g., Austin, 2010; Shin, Postiglione, & Ho, 2018) because most programs tend to focus on training next generation academics. However, job markets for doctoral degree holders are diversified and the skills and technologies they require differ accordingly. According to the US doctoral student survey, 86% of doctoral students in engineering and 76% in the physical sciences find employment outside of higher education (US National Science Foundation, 2015). In addition, traditional teaching and research positions in the tenure track have been declining in most higher education systems. The Changing Academic Profession data show that about 40-50 % of academics hold non-tenure positions across countries (Teichler et al., 2013). Traditional professorial positions are continuously declining in the US and other higher education systems (e.g., Finkelstein et al., 2016).

In addition, some studies explored factors associated with doctoral students' career choices. For example, Kim and colleagues (2018) found that doctoral students' inspiration for an academic job is closely associated with their academic disciplines and their initial career interest. However, Shen and colleagues (2018) found that only small numbers of research productive doctoral students in China find academic jobs in higher education. Horta (2018) further investigated the determinants that affect doctoral students' career plan for non-academic jobs. He found that the doctoral students with high "managerial skills" prefer to have careers outside of academia (e.g., business, government, or entrepreneurs). These studies imply that the knowledge professional track is one of the critical career paths and their career plans also depend on things other than research skill.

In these changing academic and societal environments, institutional leaders and policymakers are discussing new initiatives for reforming doctoral education in most higher education systems (Shin, Kehm, & Jones, 2018). These demands are well reflected in the policies that emphasize the science, technology, engineering, and mathematics (STEM) fields. For example, funding policy emphasizes STEM research. With these social pressures, doctoral education in STEM fields has developed distinctive programs compared to non-STEM fields (e.g., Ge & Ho, 2018). Doctoral students in STEM fields have more internship opportunities and their learning environments are much better than in other disciplines. Although policymakers and institutional leaders interpret the challenges from different perspectives, a common view is that doctoral education should be more competitive and more prepared to meet the societal demands of the knowledge society (e.g., Nerad, 2010, 2015; Shin, Kehm, & Jones, 2018). These initiatives highlight the belief that transferable competencies/skills are critical for doctoral education in the knowledge society.

3.2 Competencies for academics and knowledge professionals

Competency-based reforms for doctoral education might be an answer to the need for competitive and socially responsive doctoral education (Shin, Postiglione, & Ho, 2018). To that end, doctoral education programs could be redesigned according to the core competency areas. In practice,

however, knowing how to reform doctoral training is a challenging issue, as discussed in Nerad (2015). Institutional leaders could reform doctoral education by developing all areas of competencies in their programs. This approach would expand the scope of doctoral education from preparing for the academic profession to preparing for positions outside of academia (e.g., Kehm et al., 2018). However, it is difficult task to add new coursework to existing doctoral programs because the scope may become too wide, the costs too expensive, and time to graduation too long. A strategy is to find a compromise between the traditional discipline-based doctoral program with a competency-based doctoral program.

The competencies and skills required for the knowledge society are well articulated in Austin and McDaniel (2006) and the OECD (2012). Austin and McDaniel (2006) focused on the competencies for the academic profession while the OECD focused on "researchers." Austin and McDaniel proposed 15 skills in four areas (conceptual understanding, knowledge and skills in areas of faculty work, interpersonal skills, and professional attitudes and habits) and the OECD (2012) proposed 19 skills in six broad areas (interpersonal skills, organizational skills, research competencies, cognitive abilities, communication skills, and enterprise skills). Research on skills and competencies have been further developed in follow-up studies. For example, Guo and associates (2018) categorized 12 core skills in one of three categories of knowledge, academic skills, and academic dispositions (e.g., values, norms, etc.) according to their doctoral education model. Similarly, Jung (2018) found three major competencies (task oriented, idea oriented, and attitude oriented) based on her factor analysis of doctoral students in Hong Kong. Although academic researchers highlight different dimensions and perspectives, both Austin and McDaniel (2006) and the OECD (2012) provide insights on the competencies for doctoral education.

Table 4. Competencies for the academic profession and knowledge professionals

Competency Areas	Academic Profession Track	Knowledge Professional Track
Core Skills	. Knowledge of the discipline (theory, research method) . Communication skills . Teamwork and collaboration skills . Cultivating professional networks . Career planning skills	
Job Performing Skills	. Teaching/learning . Engagement/service	. Grant acquisition . Project management . Patenting/ knowledge transfer . Leadership
Understanding Working Environments	. Purpose/history of HE . Institutional mission . Institutional citizenship	. Problem solving . Participating in policy making . Negotiation skills
Identity Development	. Identity as a scholar/professor . Ethics and integrity . Balancing in life . Motivation for lifelong learning	. Innovation . Entrepreneurship

Institutional leaders could incorporate a combination of these competencies in their doctoral education reforms. The 34 skills proposed by both Austin and McDaniel and the OECD could be reorganized into four categories each (core skills, job performing skills, understanding work environments skills, and identity development skills), for both the academic profession track and knowledge professional track. These four categories of skills are based on a synthesis of similarities. Although these four categories are not based on empirical data, these four categories propose critical implications for doctoral education reforms and might be used as the basis for empirical studies of doctoral competencies. As shown in Table 4, there are five "core skills" for both academics and knowledge professionals. In detail, these core skills are related to their knowledge in their own discipline (theory and research method), interpersonal skills (collaboration, communication, and networking skills), and career development skills. These core skills are not different between academic track and knowledge profession track because these skills are basic qualifications in the fields either as academic profession or knowledge professional.

The other three categories of competencies are job performance skills, understanding work environments, and identity development skills as shown in Table 4.

- Job Performance Skills: These are related to the conduct of jobs in academia or industry. Doctoral students are expected to develop teaching skills and engagement/service activities for an academic career. Those on the knowledge professional track are expected to learn skills for grant acquisition, project management, leadership, and knowledge transfer.
- Understanding Work Environments: These competencies are related to the "effective" and "relevant" conduct of jobs in given work environments. For the academic track, doctoral students are expected to understand higher education, institutional mission, and active participation in their institutional decision-making processes. Those on the professional track are expected to actively solve problems in their field, participate in policymaking, and negotiate with multiple participants.
- Identity Development Skills: These are related to foundational and core attitudes about their jobs. The identity as an academic is different from that of a knowledge professional. Doctoral students begin to develop their identity during their doctoral training and further develop it in their work place.

3.3 Proposed model for competency-based doctoral education

A critical issue for competency-based doctoral education reform is how to incorporate these competencies into doctoral programs. Socialization theory has been used to explain the doctoral training processes (e.g., Weidman et al., 2001), and emphasizes the processes of being an academic. As the term "socialization" infers, doctoral education is more than knowledge and skill acquisition and

includes values, attitudes, and norms expected for professional jobs. In this regard, interactions with their professors, senior colleagues, and professionals are critical for their socialization processes. Recent studies (e.g., Guo et al., 2018; Jung, 2018; Shin, Kim, Kim & Lim, 2018) also found that interactions with classmates and professors are critical for program satisfaction and competency development. This makes it clear that the socialization process is one of the major components in doctoral education. The competency perspective that this article is based on emphasizes both informal socialization as well as formal training. A critical issue for reforming doctoral education is how to combine formal coursework with informal socialization.

Figure 2 demonstrates two possible scenarios for reforming doctoral education from a competency perspective. A core challenge is how to develop the skills proposed in Table 4. This article assumes three to four years of doctoral education because the Bologna Process recommends three years for doctoral education. As Model 1 proposes, we might teach core skills during their first two years when they are studying coursework (mostly, in the US and East Asia), and train in other skills (job performance skills, understanding work environment skills, and identity development skills) during their third and or fourth years.

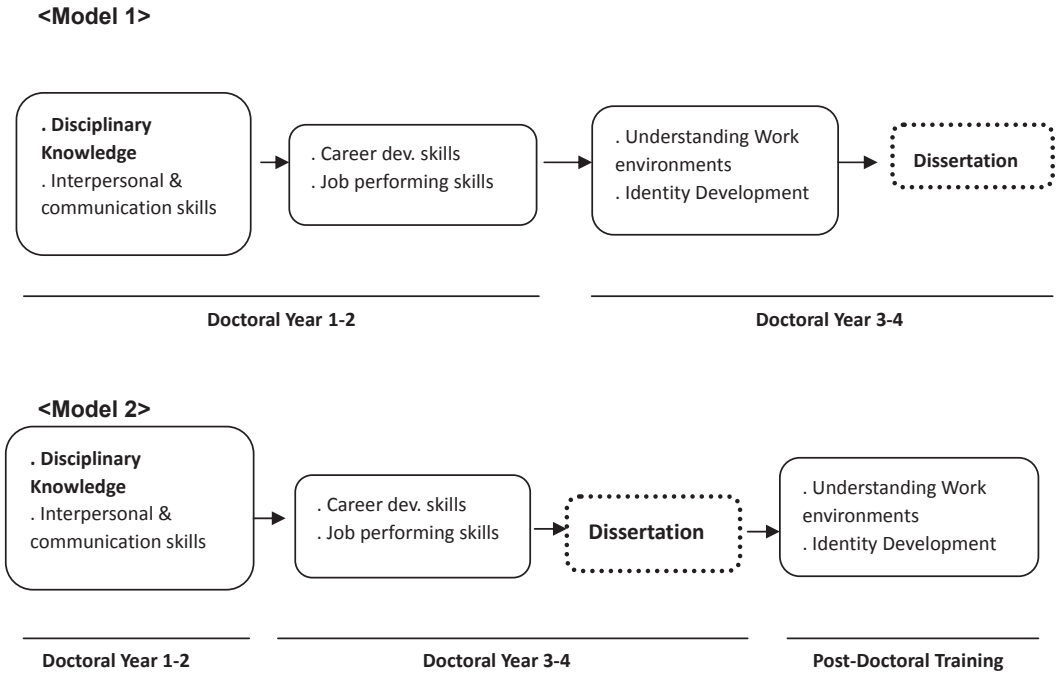


Figure 2. Doctoral education reform models

Model 1 might not be easy to apply because training in these four types of skills (core competencies plus other three skill sets) within three to four years is a major challenge. In doctoral training practice, most programs focus only on discipline knowledge, with little focus on other

competencies. The key issue for doctoral education reforms is knowing how to reshuffle and downsize existing discipline knowledge whether theory, research skills, or disciplinary skills. In addition, training in the other three types of skills (job performing skills, understanding work environments, and identity development skills) requires field practices in academia or in knowledge industries. For example, gaining experience in teaching students or writing grant proposals is not easily gained during doctoral study.

Another issue is how to develop distinctive programs for the academic profession and for knowledge professionals. Although professors can easily develop their training programs for the academic profession, it is a challenge to develop programs for knowledge professionals because it requires more time to develop. It is complicated for universities and professors to develop skills in two separate tracks. One solution is for universities to work together with industry, government, and non-governmental organizations to develop training programs. Doctoral training for knowledge professionals does not necessarily require dissertation writing. In practice, a doctoral dissertation is becoming less significant in many countries, according to the findings of an international comparative study (Shin, Kehm, & Jones, 2018). For example, there are initiatives towards granting doctoral degrees without writing a doctoral dissertation in the UK and Australia. In addition, the transformation of dissertation requirements was seriously discussed at US Council of Graduate Schools in 2016.

Model 2 is more realistic and has implications for policymakers and institutional leaders when designing doctoral education reforms. Model 2 assigns some competency development to the post-doctoral stage (or habilitation stage in some European systems). The post-doctoral period is a transitional one for most doctoral degree holders, as they move from a student status to an independent researcher as an academic or as a knowledge professional. Post-doctoral researchers have a chance to be involved in research projects as a co-PI (or as PI in some cases) and lead graduate students as a mentor or instructor. In addition, they have the opportunity to deepen their understanding of their field (in academia or industry) and further develop their identity as an academic or knowledge professional.

However, these proposed models do not mean that all competency development is solely done by the university. Instead, universities might collaborate with industry or research institutes depending on their focus of training. For example, universities might teach two years of coursework and arrange internship opportunities in collaboration with industry or research institutes to further develop their doctoral students' research and professional competencies. An internship in a company might be a more practical option for doctoral students who are planning to work in an industrial market. Research institutes might be an ideal option for the doctoral students who plan to develop as a researcher for their career. Alternatively, doctoral students might experience teaching responsibilities in a teaching focused university if they would like to find teaching job after their doctoral degree.

3.4. Considerations for doctoral education reforms

The success of doctoral education reforms depends on how much policymakers and institutional leaders consider institutional contexts in their reform programs, because education reforms always bring complexity. First, reform models differ according to the context of the various higher education systems. In countries that have well established master's programs it may be relatively easy to downsize the amount of discipline knowledge in their training programs. However, it is not easy in systems where master's programs are relatively weak or not well organized as in the Anglo-American environment. A master's degree is a one-year program in the UK and one year to one and half years without a thesis in the US. Master's education systems have only recently been established in most European countries. Compared to both Anglo-American and European systems, the master's degree in most East Asian higher education systems including Japan, Korea, China and Taiwan is a minimum of two years and requires a thesis (Shin, Kehm, & Jones, 2018).

Second, reforming doctoral education depends on doctoral students' status and the institutional mission of their affiliated university. For example, the model might be applicable to full-time students, but not to most part-time students because of the time required to achieve a degree. Given that a doctoral degree takes six to seven years on average in the USA (US National Science Foundation, 2015), the model has limited application for most part-time students. Doctoral program designers might need to develop a more flexible model for part-time students. For example, one option could be to train discipline knowledge in two years, then interpersonal skills, career development skills, and job performing skills in the third year while not requiring a dissertation. Similarly, flexible models could be applied in the universities that are not research-intensive because most doctoral graduates in such universities are not intending to have an academic career.

Another consideration is the weighting between different areas of competencies depending on their target job markets. Some competencies might be emphasized more than others or rely on the students' own efforts. For example, doctoral programs in fields closely connected to practice (e.g., education, business, engineering, medicine, etc.) might emphasize job performing skills more than discipline knowledge. In addition, program designers might emphasize disciplinary knowledge above job specific skills if they already hold these skills from their work experience. These are not easy decisions, but doctoral program reformers are encouraged to study the job markets of their doctoral students before they undertake their reforms. It is critical for providers to ensure the doctoral programs are relevant to the job market, whether it is academia or the knowledge industry.

Finally, reformers might choose to jointly operate competency development programs within a university and or between universities. For example, competency development for the core skill areas (except discipline knowledge) and the three other areas (job performing skills, understanding work environments, and identity development) share similarities across disciplines, so that different

disciplines could jointly develop these skills under the coordination of the university. Doctoral programs in the physical sciences might jointly provide competency development programs. These initiatives would enable universities to save their resources and doctoral students might find collaborative opportunities with colleagues in other disciplines.

In any reform initiatives, institutional leaders often face strong objections from faculty members. These objections are most vocal when they try to discontinue programs. However, once there is agreement that doctoral education is not only to prepare for academic jobs and that most of their doctoral students find jobs outside of the university, then the programs should be more flexible and transformative in line with market demands.

4. Conclusion

Education reforms always come as a result of new societal demands, whether it is an economic crisis, new technological development, or an industrial revolution. The reforms require replacing dated knowledge and skills with new ones. However, educators tend to hold onto "old" knowledge and technology because they are familiar with it, and because they believe that this is the source for creating new areas of knowledge. Societies tend to criticize educators and educational institutions as lagging behind societal changes. However, the major function of education institutions is to preserve cultural heritage as well as to create new knowledge. Because of this characteristic—that education is an accumulation of knowledge and technology—students spend longer on their study.

Societal developments have led to the explosive development of knowledge, leading to increasing the length of education since modern education emerged in the 19th century (Shin & Teichler, 2014). Students' educational attainment has been moving upward from elementary to secondary, and from secondary to higher education. Now, with massification, university and post-graduate education is becoming popular, as seen in the growth of doctoral degrees awarded. However, extending the years needed to gain an education cannot absorb all the societal demands, especially in the knowledge society because knowledge and technology is exploding. For example, ISI journal articles have increased 200 times between 1940 and 2010 according to Shin and Teichler (2014). A critical question is, therefore, whether classic theory and technology should be taught as in the past. If some knowledge and technology is removed from the curriculum, is the quality of education declining?

If we agree that we can selectively teach "core" discipline knowledge and discard other aspects, there is room to add curricula that are relevant to new societal demands either for an academic career or for a career as a knowledge professional. Professors tend to emphasize discipline knowledge and technology because these are at the core of their discipline area, but these are insufficient for their doctoral students to survive in academia or the knowledge industry. Doctoral students will be under-prepared for the job market if their professors teach only disciplinary knowledge, while failing to teach core competencies as discussed in this article.

One may argue that such doctoral education reforms might compromise the quality of the degree. It is true if we stay with the traditional concept of quality. However, the "quality" of education could be understood in terms of how well doctoral graduates are prepared for the job market. Although understanding classic theory is critical for developing new knowledge, most of the classical theories rarely contributes to this process. The knowledge society discourses and societal demands for doctoral education reforms will lead to transformative changes for doctoral education.

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