Integrating standardization into engineering education – The case of forerunner Korea[1,2]

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Abstract

The Republic of Korea is a forerunner in integrating the topic of standardization into engineering education at the academic level. This study investigates developments and evolutions in the planning and operating of the University Education Promotion on Standardization (UEPS) in Korea. This paper examines why the Korean government initiated the UEPS, how the UEPS has operated, and what the educational content of the UEPS program is. This study of the UEPS may serve as a benchmark of how to incorporate technical standards into science and technology education at both the national and individual university levels. Some implications and considerations for the future introduction of similar courses in other countries are discussed.

Keywords

Technical Standards, Standardization, University Education Promotion on Standardization, UEPS, Korea

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Introduction

> "Pupils must learn that norms, standards, rules of thumb, and whatever other normatively determined types of technological knowledge form an important part of what technologists need to know."
> - Marc J. De Vries (2005)

Even though education about technology-based standards has surfaced in the agenda of public policy and technology education (Choi and de Vries 2011), few countries have yet to implement a nationwide program on technical standards. As reported by De Vries and Egyedi (2007), incorporating standards in regular education courses has been much more actively accomplished in countries such as Korea and China and less in the Europe and the United States. "At the national level, South Korea is far ahead in implementing standardization education in academic curricula. It does more than Europe as a whole" (Hesser and de Vries, 2011, p. 10).

Korea's leading role is a reason to give this country special attention. This paper, therefore, aims to present an analysis of Korea's University Education Promotion on Standardization (UEPS). The following sections provide a description and analysis of the UEPS, including its background, objectives, features, curriculum and textbook development, achievements, and student feedback. We end with a discussion and some conclusions.

Literature review

Verman (1973) had already expressed the need for education about standardization in the 1970s, but the topic has generally received little attention in the literature. Early professional papers about the need for education and training about standardization include Bloomfield (1999), Hesser (1999), Hesser and Czaya (1999), and Sikora (1999). Kurokawa (2005) stated that globalization, changes in human resource development, and the increased societal importance of standards due to increased relationships between standards and legislation, required Japan to pay more attention to standards in education. A trigger for Japan was that a Japanese company could not export its double-tub, semi-automatic washing machines, because these did not comply with the applicable international standards. Education should create more awareness of standards, provide standardization experts with capabilities, help experts in their careers, help in cross-organizational and international standardization, and assist companies in profiting more from standards and standardization (Kurokawa 2005). A United States perspective was presented by Cooklev (2010), who referred to the macro-economic impact of standards and to their importance for individual companies and noted that a growing number of countries had developed a national standards strategy. Many of these strategies refer to the need for education about standards. Cooklev then addressed the general criteria for curricula as formulated by the (US) Accreditation Board for Engineering and Technology (ABET, 2006), from which he concluded that, indeed, engineers should be educated about standards.

Hesser and de Vries (2011), in their white paper on academic standardization education in Europe, emphasized the impact of standards and standardization on modern societies and social interactions. Standards reduce transaction costs and information asymmetries, constitute interfaces between elements of technical and service systems, shape and/or constitute markets, and serve public interests, such as safety and sustainability. The industrial revolution was built on standards and, also, on the transition from an industrial to a knowledge society based on information, knowledge and services that requires standards. The importance of standardization will probably increase (Hesser and de Vries 2011): socio-economic and technological integration depend on the availability of adequate standards and, thus, on the capability to develop such standards. Standards are a prerequisite for advanced technologies, such as nanotechnology, to enter markets on a large scale (Blind and Gauch 2009). Developing the appropriate standards is increasingly challenging and requires sophisticated standardization knowledge, because of the increasing interdependency of different technologies, the increase in product development speed, and the growth in the number of companies and other stakeholders involved. Moreover, political actors like national governments and the European Union increasingly refer to standardization in relation to legislation as a regulatory instrument, as a means of facilitating international trade (WTO 2005), and as an instrument to enhance innovation (European Commission 2008). Governmental officials, thus, also need standardization knowledge at the strategic level.

The next important question would be who needs to know what. Here we refer to a recent paper in this journal by Choi and de Vries (2011), which also refers to other relevant sources. Next is the issue of curriculum development. Studies addressing this issue include de Vries (2005), de Vries and Egyedi (2007), and Choi (Ed.) (2011). Krechmer (2007) focused on curriculum development especially for engineers.

Having ideas for standardization education is one thing but implementing them is another. This topic has been addressed by de Vries and Egyedi (2007), Choi, de Vries and Kim (2009), Choi and de Vries (2011), and Hesser and de Vries (2011). The findings in these studies suggest that successful implementation depends on (1) national policy, (2) the availability of resources at the national level, and (3) close cooperation between industry, standards bodies, academia, other organizations in the field of education, and government.

In a recent workshop held in May 2012, attended by 45 participants from 17 countries, it was re-affirmed that close cooperation between national standards bodies and universities is crucial. Participants confirmed the need for governmental involvement and the engagement of other stakeholders and emphasized the importance of identifying national priority areas and using the network of participants in standardization committees. Some countries benefit from special arrangements; for instance, in Indonesia, Memoranda of Understanding exist between the national standards body BSN and universities (Gerundino, 2012). Additionally, there is a need for a broad set of education tools to promote standardization education and for more publication outlets to create and support academic involvement in standardization education (Choi and Puskar, 2011).

Choi and de Vries (2011) compared and analyzed 27 programs about technology standards in the higher education level and characterized Korea's University Education Promotion on Standardization (UEPS) with its semi-nationwide outreach[3]. Among the early adopters of academic education programs about standardization, notably China, Indonesia, Japan and Korea, Korea has presumably the largest number of university-level technical standards and standardization courses in the world: 81 courses in 41 universities in 2011. China follows Korea, with 28 universities in 2009 (Wenhui and Chaoyi, 2010). However, Korea's UEPS has never been described in detail but only briefly introduced in some articles (Kang, 2005; Lee, 2007; Choi (Ed.) 2008; Choi, 2010). This paper fills this gap in the literature by describing and analyzing 10 years of the historical development and operation of Korea's UEPS.

Methodology

The description of Korea's University Education Promotion on Standardization (UEPS) is based on a review of public papers and internal documents, interviews with professors, and feedback from discussions with foreign experts in international workshops. Most factual and statistical data stem from internal reports of the UEPS program available in the Korean Standards Association (KSA), the UEPS coordination and operation institute, in particular annual reports. These reports document the considerations in the early planning stage, discussions about implementation, qualitative and quantitative outcomes, feedback from students, and major issues and challenges of the UEPS. Some available minutes of the UEPS steering committees meetings and advisory meetings and reports of the annual workshops were also analyzed.

Personal interviews were conducted with relevant Korean Agency for Technology and Standards (KATS) officers, KSA staff, and related professors. The first author of this paper was also closely involved in the UEPS as co-author of the main general textbook, lecturer in courses, and speaker or participant in some related meetings and workshops. There have also been several useful opportunities to discuss the implications and observations of the UEPS at international workshops[4], and some observations of foreign experts at these workshops were incorporated in this study.

UEPS: background and objectives

Korea's competitiveness initially came from relatively inexpensive labor; subsequently, more highly skilled human resources have increasingly supported Korean industrial development. This

[3] For details, see Choi and de Vries (2011), page 118-120 as well as Figure 2

[4] Some of the recent workshops include "ISO/KATS workshop on Cooperation between National Standards Bodies and Universities," held 7-9 May 2012 (Gerundino, 2012); and "International Workshop on Development of Education about Standardisation for Developing Countries," held 6-8 Dec 2011 in Kuala Lumpur, Malaysia (Kasim (Ed.), 2011).

has been possible because Korea has continuously implemented educational reforms to improve its educational systems at all levels to support national productivity. Human resources development is be more important to a country like Korea, which has scarce natural resources. Today, the proportion of Korea's population with tertiary education is one of the highest in the world (OECD, 2011). The economic transformation of Korea can be summarized as being due to industrialization and globalization (SaKong and Koh, 2010), and its export-oriented economic development policy is a cornerstone of its development. Recognizing the increasing importance of technical standards and standardization in globalization and technical trade, the Korean government initiated the University Education Promotion on Standardization (UEPS) program.

Although the Ministry of Education, Science & Technology (MEST) is responsible for Korea's educational systems in general, other governmental agencies sometimes initiate programs when important fields or urgent issues are emerging. For instance, education in the field of intellectual property rights was initiated by the Korean Intellectual Property Office (KIPO). The UEPS is in this category as well. This specific program for technical standards was initiated by the Korean Agency for Technology and Standards (KATS).

In 1999, the KATS established an overarching law, the *Framework Act on National Standards,* which was intended to overarch related acts on standards and conformity assessment. This Act requires the Korean government to set up a Korean National Standards Plan (KNSP) every five years.

The first KNSP 2001-2005 highlighted the importance of the *systematic development of human resources* for national and international standards activities. The Korean Government aimed to develop a stronger national standards capacity and to improve its effectiveness in national and international standard settings. The second KNSP 2006-2010 was more specific in section 4.3, *"Training standards experts and building expert network"* and section 4.4, *"Increasing awareness about standardization and strengthening promotion and education activities."* These two sections guided the Korean Government to expand the standardization program in its universities nation-wide. As a part of the KNSP, it was envisioned that educating university students about the role and importance of standards may be crucial to enable them to better play roles in their future jobs in companies, government, and academia. The third KNSP 2011-2015 reaffirms the importance of human resources and presents specific objectives for education and training in one of the subsections of 4.2, *"developing standards professionals and improving the capacity of the private sector."* It specifies the objective of educating 10,000 students in formal education from primary school to graduate school levels during the years 2011-2015.

The UEPS originated not only from the national plan but also from the lasting discussion in the standards experts community in Korea. In principle, the UEPS was initiated by the three-phase KNSPs that have continuously highlighted the importance of human resources development and management for technical standards and standardization issues to strengthen Korea's competitive edge. It is also interesting to note that there was no specific mention about university in the first KNSP 2001-2005. The planners in the KATS and the KSA developed the conceptual details of the

UEPS program in a project proposal in 2002 and started the implementation in 2003. Although it is not crystal-clear when the university program was first mentioned, a few interviewees informed us that a university program and an academic society for standardization were repeatedly suggested ideas by standards experts in Korea since the 1990s, but many experts thought them very challenging to implement. The discussion in the community in Korea included a few workshops for participants in government-funded projects for standards, advisory meetings for human resources development for standardization organized by standards-related organizations, and a meeting of the trade union of workers of the KSA. The planning group favorably considered a university program, because it could open a new opportunity and provide new energy, particularly for the long-term perspective, for human resource development for standardization. Drawing on the project plan and implementation, formal education programs about standards, including for the university level, were specifically incorporated more in the second and third KNSPs than in the first KNSP.

UEPS: operation and evolution

Planning and operation

Two organizations, the Korean Agency for Technology and Standards (KATS) and the Korean Standards Association (KSA), have played central roles in planning and operating the University Education Promotion on Standardization (UEPS). The KATS, a government agency and Korea's national standards organization, set up the national plan, the Korean National Standards Plan (KNSP), and also secured funding for the UEPS. The KSA was chosen as the UEPS coordinator because of its focus on standards and quality and its 40 years of expertise in the education and training sectors. The KSA, as a non-profit public institute under the KATS, has implemented and operated the UEPS since its inception.

The KSA also set up a Steering Committee of the UEPS to discuss its strategic direction. This committee comprises around ten key representatives from universities, industries, and standards-related organizations. The Steering Committee meets a few times a year and provides strategic advice and recommendations to the KSA about planning and operating the UEPS, such as for textbook development and university outreach. The Steering Committee also serves as the approval body for the draft textbooks, reviews the applications, and selects the new universities for the UEPS.

After two years of planning and preparation of the UEPS in 2002-2003 and after long discussions, the program was characterized as having an easy-to-implement format. The planning process for general cross-discipline courses was complicated, because there were very few examples available to benchmark inside or outside the country. At that time a few universities in Korea had already

opened courses, but they were all for major-specific courses[5]. One of the challenges for general course design was that only a small number of professors can teach all the fundamental areas of standardization. For that reason, the team teaching method, or inviting guest lecturers, was suggested and adopted in the design. The team teaching approach worked to provide students with the chance to meet with real field experts, but it is reported that their introductory lecture is often duplicative. It was more difficult to estimate how many universities might join in the program. Some skeptics believed that few universities would be interested in opening the UEPS program. A pilot program was initiated in 2004 with the expectation of five to ten universities participating. The initial program was successfully joined by 11 universities and 982 students. An explanation for this success is that KSA made it easy for universities to join the program by providing a common textbook for free, teaching materials, a guest lecture pool, and a field trip opportunity. Table 1 provides an overview of characteristics of this course.

Table 1 Characteristics of the general UEPS course

Course	Description
Coordinator	Korean Standards Association
Primary target group	Undergraduate Engineering Students
Title & Textbook	Future Society and Standards
Credit	2~3 credits (32~48 hours for 16 weeks)
Type	Common/Majors, Elective/Mandatory
Syllabus	Main Common Textbook with Flexibility by Professors
Teaching Assistance	Power-point Slides of Textbook, Online Teaching Materials
Others	Guest Lecture Pool, Field Trip contacts

The KATS has secured funding of approximately $5-8 million US dollars each year since 2005 for the UEPS implementation. That funding has enabled the KSA to allocate a few, full-time staff to develop and operate the UEPS program along with government and private sector experts. Around 30-40 % of the UEPS funding from the KATS has been used for the KSA's administration, textbook development, publications, organizing events, and surveys. The other 60-70% of the funding has been used for direct grants to each participating university, around $5-10 thousand US dollars per each semester course. The grant does not provide any labor costs or profit to the universities or professors, but it is intended to reimburse direct expenditures of the UEPS for guest lecturer invitations, student field trips, and a minimal level scholarship for a teaching assistant. This was an additional set of teasers for universities to start the course. The KSA provides participating universities with a basic teaching syllabus, free common textbooks, a teaching

[5] For instance Chung-Ang University has a graduate school course for information and communication technology (ICT) disciplines since 1998 (Kwon, 2009).

manual, a lecturer pool and field trip contacts so that new participating universities and professors can easily and effectively implement a course about standards.

Feedback for improvements

The UEPS survey shows that around 90% of the students responding to the UEPS courses rate them as medium or above in satisfaction level with the courses and recommend them to other students; see **Figure 1**. Some UEPS courses were selected as among the highest rated courses by students in a few universities. Also, a majority of the students expressed a willingness to recommend the course to other students.

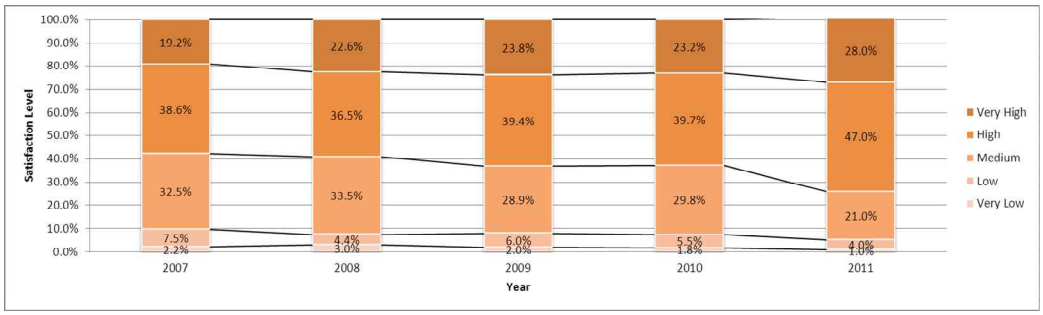

Figure 1 Student feedback on the UEPS (Source: KSA)

In order to stimulate networking and benchmarking among participating universities and professors, the KSA has organized annual UEPS workshops targeted at the responsible professors and teaching assistants. The workshop usually comprises presentations and panel discussions by invited professors, lecturers, and, sometimes, excellent students. In 2011, the workshop invited a presentation about 'ten competencies for standards professionals in companies' by a standards executive of LG Electronics.

The KSA operates a UEPS website for efficient communications among professors and lectureres. The website provides professors and lecturers with teaching materials, references, a quiz, and a questionnaire for exams. The website, which is unaccessible by students, also supports administrative activities, including the UEPS application, contact point registrations, and student services for verifying and printing certificates of the UEPS courses.

Evolution

In total, 604[6] courses have been delivered and 38,054 students participated during the years 2002-2011, as shown in **Figure 2**. These courses were delivered in one three-year college and in 59 four-year universities. These 59 universities constitute around 27% of the 222 four-year

[6] Because some universities operated multiple UEPS courses in different divisions or campuses, the total number of courses is calculated as the sum of the UEPS courses open each semester.

universities in South Korea. Over the years, the UEPS has continued to evolve by drawing on the feedback from students and lecturers. In 2005-2009, the UEPS expanded nation-wide, and around 5000 students were educated each year, with some fluctuations. The courses are cross-disciplinary, and the majority of the courses were targeted at engineering school students. They address the importance and implications of standards and standardization. The UEPS syllabus and textbook were developed by a team of experts organized by the KSA in 2003 and fully revised in 2007.

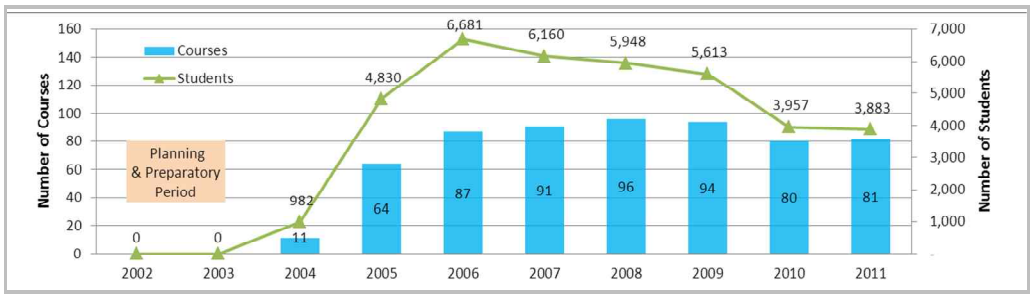

Figure 2 Number of UEPS courses and participating students (Source: KSA)

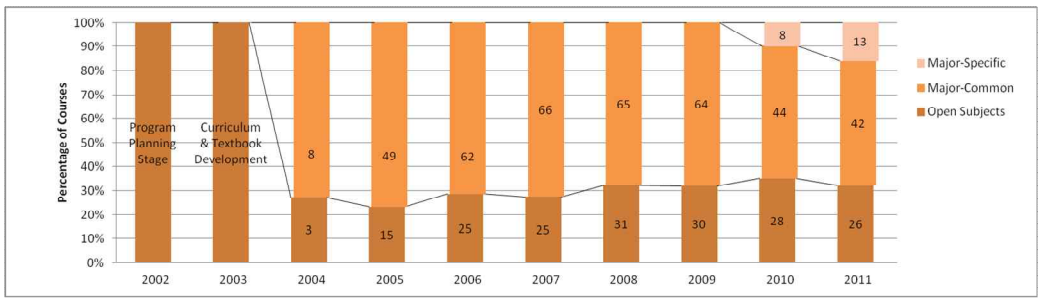

Figure 3 Share of different categories of different UEPS courses (Source: KSA)

Figure 4 UEPS evolution – preparatory, expanding, and transforming stages (Source: authors)

Since 2010, the UEPS has started to diversify its approach. Before 2009, all the UEPS courses were using the common and cross-disciplined textbook, *Future Society and Standards* (KSA, 2007). As of 2007, four more specific textbooks have been developed for information technology, mechanical engineering, electrical/electronic engineering, and environmental engineering, respectively for majors in these areas, see Figure 3. **Figure 4** shows that more major-specific courses were started after 2010. Details follow in the next section.

UEPS: contents development and diversification

General course development

Because the major objective of the University Education Promotion on Standardization (UEPS) is to make engineering students more aware of standards, the contents of the UEPS were planned and prepared to teach about the basics, development, and use of national and international standards. Because this topic is not technology-specific, the contents could also be used for some courses in non-engineering majors, such as business administration and economics.

Professors are encouraged to use the contents of the textbook *Future Society and Standards*. As a result, it is used in more than 60% of the UEPS classes, so the contents of this textbook (**Table 2)** shows the major contents of the courses. The contents also frame the syllabus for the general UEPS courses.

Table 2. UEPS common textbook and syllabus (KSA, 2007)

Parts	Chapters
I. Introduction of standardization	1. Standardization overview - Definitions, Classifications, Objectives, Impacts and Importance
II. Standardization Activities	2. International Standardization - International Standards, Standardization, Organizations 3. National Standardization - Development, Structure, Implementation and Future 4. Company Standardization - Business Strategy, Management, and Standardization
III. Contents of Standards	5. Metrology and Reference Materials - Scientific/Industrial and Legal Metrology, Reference Materials, SI, International Cooperation 6. Conformity Assessment - Conformity Assessment overview, Conformity Assessment in Korea, Major Countries, Mutual Recognition Agreement
IV. Use of Standards	7. Standards and IPR - IPR and Economic Activities, Standards and IPR, Standardization and Anti-Competition 8. Future of Standards - Current and Future Trends and Issues of Standards

When general UPES courses are open for all engineering students, there is a greater tendency to focus on the given syllabus and textbook. When the general courses are open only for specific majors, they tend to have more major-specific contents, around 30% to 40%. This situation stimulated opening major-specific courses of the UPES, which means that around 2/3 of the classes are using the textbook, and the rest are using other materials.

The theory from the book is being complemented with practical experiences by means of company visits and guest lectures. Students visited companies such as Samsung Electronics, Hyundai

Motors, and GM Daewoo. Guest lecturers were provided by these companies, as well as the standardization organizations KATS, the KSA, government and universities. Some of the lecturers are leaders in national and international standardization activities. The KSA created and provided a lecture pool to make it easier for the universities to invite a guest lecturer. Around half of the classes are lectured by those guest lecturers. During the period shown in **Figure 5**, the number of lecturers in the UEPS pool steadily increased from 50 lecturers in 2005 to 294 in 2011. The 294 lecturers include 63 industry experts, 96 university faculty, and 135 experts from research institutes.

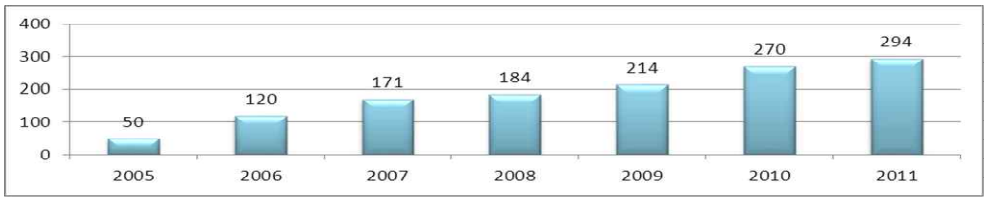

Figure 5 Number of lectures in the UEPS expert pool (source: KSA)

Diversification to specific courses

Major-specific courses were continuously discussed during the planning stage of the UEPS in 2002-2003, but it was decided to focus first on a general course for which the textbook *Future Society and Standards* (KSA, 2007) was developed. The next step was to diversify to different disciplines. For this purpose, development of more specific textbooks started during 2007-2009 for information technology, electrical and electronic engineering, mechanical engineering, and environmental engineering. After revisions from the peer-experts and the Steering Committee, all four books were published in 2010-2011.These four areas were selected because of the quantity and importance of standardization activities in these areas and because most universities in Korea have those four areas in their Engineering College departments. The four textbooks have been also used as a secondary textbook even for some general UEPS courses that are open for some specific majors. **Table 3** presents brief descriptions of the four major-specific textbooks.

In 2010, eight major-specific UEPS courses opened, including two graduate school programs, mostly in information technology or electrical/electronic engineering. In 2011, 13 major-specific UEPS courses opened, including four graduate programs. In addition, new courses for ‘standards and intellectual property rights’ and ‘architecture engineering and standards’ were voluntarily developed and operated in two graduate schools.

The KSA developed three *case studies* to support major-specific courses, particularly in graduate school classes. Two cases are related to information technology or electrical/electronic engineering: “Standardization Cases in Mobile Software” and “Standardization Cases for 4G Telecom & Mobile Broadcasting.” The third case is more related to the societal role of standards – “The Meaning of Technical Standards: A Control Tool for Social Dynamics.” These academic case studies should facilitate graduate school level discussions and stimulate further research in technical standards.

Table 3. Four major-specific textbooks

Major-Specific Textbooks	Brief Descriptions
Information Standardization (Kwon, 2011)	- Scope: Standards and Standardization for Information Technology, including history and organizations - Contents: ISO/IEC JTC 1, Some examples of IT standards - Target: ICT engineering
Electrical & Electronic Standards (Kim, 2010)	- Scope: Recent trends and hot issues in the field of electrical and electronic standards. - Fields: Display, IEC, ISO, LED, Mems, Semiconductor - Target: Electrical and Electronic Engineering
Standards of Mechanical Engineering (Park, 2011)	- Scope: Specific information on the standards in mechanical engineering. - Contents: Standards for the thermodynamic and fluid mechanics. - Target: Mechanical engineering
Environmental Standardization for Sustainability (Lee and Lee, 2011)	- Scope: Product-related environmental standards and sustainability - Contents: Environmental standardization, including related IEC Guides, sustainability and eco-buildings standards, standardization for sustainable development - Target: Environmental engineering

A mentoring system pilot started in 2011. The idea was to invite leading standards experts and ask them to mentor a group of students for case studies or term papers. Students would then have opportunities to communicate with those field experts. In 2011, 22 leading standards experts participated in the UEPS as mentors for major-specific courses.

General UEPS courses are planned to have 50-100 students per class and the specific courses 10-50 students per class. In practice, some general UEPS courses, open for all engineering students and sometimes even for non-engineering students, had more than 100 students; most major-specific courses in graduate school had only 10 to 15 students. As a result, the average number of students per UEPS course decreased from 68 in 2004-2009 to 49 in 2010-2011.This change caused, in part, the decrease of the total number of participating students in the UEPS program from about 6,000 in 2006-2009 to about 4,000 in 2010-2011.

Discussion

The previous sections described the development trajectory of the program for education on standardization by Korea with following questions. Why did the Korean government initiate the University Education Promotion on Standardization (UEPS) program? How has the UEPS operated so far? How has the UEPS evolved? And which contents have been taught, and what is the feedback from students and lecturers?

This section further analyzes which major lessons can be learned from Korea's UEPS program in comparison with the cases of other countries.

Success factors

The achievements of the University Education Promotion on Standardization (UEPS) can be summarized as being due to a combination of leadership and funding from the government's Korean Agency for Technology and Standards (KATS); of well-organized coordination by the standards related organization, the Korean Standards Association (KSA); of collaboration among the KATS, the KSA and the universities; and of continuous efforts to improve the program by incorporating stakeholder feedback.

The Korean government started investing in standards education because it recognized the strategic importance of standards and standardization. Korea is no longer a country offering low-cost production of products designed somewhere else; it now wants to play -- and does play -- a role in the forefront of technological development. A leading role in the development of standards is also needed in order to do that; therefore, engineers need to be equipped with knowledge about standards and standardization. In line with its national culture and policy, Korea chose a top-down approach. This national plan-based, top-down approach is the major difference from standardization education initiatives in the United States and Europe, which are mainly driven by individual professors, bottom-up. We can observe a centralized approach also in Indonesia, China and Japan. However, it is a challenge in any country to really involve the professors.

Korea's national plan has provided the KATS with the reasoning for the UEPS funding over a decade. The long-term funding enabled the KSA, the UEPS coordinating organization, to dedicate full-time staff and resources to the UEPS program. The KSA has stimulated the inclusion of standardization in engineering education by paying teachers a small amount of money, by providing teaching materials for free, and by arranging opportunities for company visits and guest lectures.

The UEPS has evolved during the whole period. It started with general courses for all engineering students, but it has been steadily diversified to general courses for specific majors and major-specific courses, including for the graduate level. Specific text books and cases have been prepared to facilitate this diversification.

Comparison

The designed characteristics and lessons of the UEPS are useful to compare with other countries, and this comparison may be worthwhile in its future application in other countries. It should be noted that an earlier comparison of different programs is available in a previous study by Choi and de Vries (2011)[7].

[7] For details, please see **Figure 2** in page 118 (Choi and de Vries, 2011)

The first comparison criterion is the source of leadership and resources. The UEPS is a public-sector led program based on a national plan and funding. Similar approaches can be found in China (Wenhui & Chaoyi, 2010), Japan (JISC, 2009), Indonesia (Irianto et al., 2012), and Malaysia (Kasim, 2011). A different approach of self-funded and individual programs is observed in many developed countries, including France, Germany, the Netherlands, and the U.S (Puskar, 2009).

The second comparison criterion is the level of intensiveness to determine whether or not the program's single main objective is to raise awareness about the importance of standardization or to provide more in-depth knowledge. The less-intensive and awareness-raising program of the UEPS can be compared to many of the existing cases in different countries. The programs supported by the Indonesian government at the undergraduate level and the case of Kanazawa Institute of Technology at the graduate level are in this category. Other, more intensive programs with multiple subjects have been observed in different countries – they include programs operated by China Jiliang University (Youhong, 2010) and Tokyo University of Agriculture and Technology (Furukawa, 2007).

The third comparison criterion is the purpose and primary target of the program. The UEPS program is first designed to raise awareness about standardization, and its primary target is engineering university students. Awareness programs tend to have less-intensive courses, but this is not always so. Similarly, most single subject, less-intensive courses for non-engineering students are in this category, such as those of the Catholic University of America (Purcell and Kelly, 2003) or the University of Moratuwa. Some engineering courses have operated a single subject but focus more on major-specific contents. Faulkner University, for instance, operates a course for computer science students that addresses standards in this field. The purpose of most intensive programs is to develop in-depth knowledge about major-specific standards.

It is notable that this comparison should be dynamic, as the situation is changing. As noted earlier, the UEPS program in Korea has gradually become a more self-funded program since 2009 and has more major-specific intensive programs. In the U.S., a few universities operate self-funded individual programs, but the U.S. government just started a grant program for five universities in 2012. In Europe, a regional level plan is set up for education about standardization, and more collective actions seem to be planned for upcoming years, following recommendations of the European Academy for Standardisation EURAS (Hesser & de Vries, 2011). So far, UEPS is the most comprehensive, nation-wide program for standardization education in the world.

Remaining challenges

Of course, there are some issues facing the UEPS that will last throughout the program: a funding-based vs. self-sustainable program; team teaching with guest lecturers vs. training teachers; awareness course vs. intensive or job-relevant course.

First, the sustainability of any government-funded program is an issue: what if the government stops funding it? In the UEPS case, since 2007, the sustainability of the UEPS courses has arisen as the central issue through communications with professors and administrative departments of the universities. Because the Korean Standards Association (KSA) provides small grants to the participating universities on a three-year agreement basis, its continuing operation was first in question when the 2005-2007 agreement expired. Even though the Korean Agency for Technology and Standards (KATS) and the KSA have encouraged the universities and professors to continue the courses after the funding stops, they often did not find this easy.

Universities, of course, are required to control the total number of courses. Many courses funded from outisde are more carefully screened for continuity after the funding stops. Funding expiration of the UEPS limits the opportunity to invite guest lecturers, and this also requires the professors to cover more classes themselves. Often the professors found difficulty in teaching the areas that outside guest lecturers had covered, and this is a partial reason of the demotivation to continue the UEPS. Therefore, both the willingness and the ability of the responsible professors in charge are the most important factors.

Although not all universities continue, self-funded UEPS programs have increased gradually since 2009 in different formats. Some continue in the current format with a smaller number of guest lecturers; some modify the syllabus so that the professor can cover most classes; and others invite a standards expert as a lecturer for the whole course. The KSA has supported free textbooks and provided guest lecturers on an on-demand basis when its budget permits.

Second, the sustainability issue naturally raises the issue of teacher training. This challenge is particularly true for general UEPS courses, because most of the engineering professors are specialized in their technical area but often find difficulty in covering a wide range of other topics such as standards and standardization, conformity assessment, metrology, and standards and IPR. Currently, around half of the UEPS classes are covered by guest lecturers. In order to make the UEPS course long-lasting, the professors should be able to lead the class, even though they can invite a few guest lecturers as a complementary option. This would be less problematic for major-specific UEPS courses, where professors have more expertise in the fields. The issue is still under discussion regarding how to educate professors or lecturers enough to teach most chapters of the general textbook. One of the most practical ideas would be to require the professors to take a few days of training to cover most of the chapters when a new university is selected.

Third, another challenge is whether UEPS courses help students in their future career development and job searching. Some professors do not like the concept that the university is providing workers for the market; they prefer that universities, rather, have the task of familiarizing students with a scientific discipline. However most universities and professors favor having courses relevant for the job market. This question would be a bit easier for the major-specific UEPS courses, but it is more complicated for the general UEPS course, as its purpose is primarily to raise awareness of the importance of standards and standardization. Therefore, the KSA is working now with experts

to specify requirements for standards professionals or standards jobs and also to further develop a more intensive graduate program comprising multiple major-specific courses.

Conclusion

Regardless of such challenges or limitations of the University Education Promotion on Standardization (UEPS), the case of Korea's UEPS program could serve as a benchmark at both the university and national levels. The Korean practice conforms to the recommendations given by Hesser and de Vries (2011) and de Vries (2011), though these recommendations were partly based on (an incomplete picture of) the Korean case.

At the university level, this paper may serve as a trigger for professors and managers of engineering education programs to consider inclusion of standardization in their curricula. If they are interested, then the developed curricula and textbooks in the UEPS might be good references. The developed case studies and the various ways of operating the classes also provide opportunities for cooperation.

More importantly, at the national level, the UEPS approach could be very useful for a country considering a government-initiated or government-university joint program. The UEPS case shows a step-by-step approach by developing a long-term national strategy, securing funding, designating a coordinating organization, and developing a syllabus and textbooks, followed by actual operation. First, it would be a more useful benchmark if the country has a government or non-profit organizations with funding. Korea has already been benchmarked by, and has cooperated with, the governments of multiple countries, including Indonesia, Malaysia, and Peru. With the Korean experiences and challenges in mind during the planning stage, these countries may be able to implement standardization education more effectively. Second, even if a country has insufficient financial resources, it would be feasible to initiate trial programs with a few universities based on the UEPS practices.

Future studies are needed to overcome the remaining challenges and to improve the applicability of education programs in engineering universities. First would be a case study similar to our study in other countries. Noticeable candidates are other countries that have such an approach, such as China, Cuba, Indonesia and Japan. Also, a comparison study for countries in North America and Europe, where currently centralized efforts are limited, would be useful. Second would be more case studies about curriculum development and teaching practices for the various academic engineering disciplines in different universities and countries. Third would be studies on effective ways of training teachers to prepare them for teaching standardization. Finally, career development issues could be addressed by, first, getting information from graduates of the existing courses about the relevance of what they learnt in their professional life and, second, by analyzing the job requirements of companies and organizations.

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