MOTIVATION FOR AND BARRIERS AGAINST THE INCLUSION OF STANDARDISATION IN EUROPEAN ACADEMIC RESEARCH AND EDUCATION

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Executive Summary

The EC has repeatedly been pointing to the need to improve the education regarding standardisation (COM (2011) 311). Recently this need was confirmed by the "Joint Initiative on Standardisation (JIS)" of the public and the private partners in the European Standardisation System (COM (2016) 358). The JIS called for actions *"to explore and promote standardisation as an element of formal education and academic … training"*.

This study aims at providing explanations for the paradox that the economic importance of standardisation is undisputed at both the macro and the micro level, yet research and especially education on standardisation is rare or absent.

The assessment provides the picture of the present situation regarding

- the ***barriers*** impeding "standardisation" to become an element of research and teaching in European public research organizations (PROs) and higher education institutions (HEIs) and
- the ***motivation*** for those PROs and HEIs which engage in standardisation-related lecturing and research.

This insight is direct support to the work of the JIS. It also gives orientation to the EC for proposing appropriate policy measures within its limited responsibilities and respecting the principle of subsidiarity.

Based on a review of the very limited literature about drivers and barriers on conducting research and teaching about standardisation and feedback from several experts in standardisation research and teaching, an online survey was distributed among the standardisation community. These include authors publishing scientific papers about standards and a control group of highly cited researchers and their co-authors. In summary, we have received 296 responses, whereof 155 respondents completely filled out the questionnaire, which provides a sound basis for the empirical analyses. The missing feedback from the highly cited researchers is a clear indication that standardisation is not an attractive research topic for them.

In addition to the quantitative analysis of the survey results, we analyse in a qualitative way via telephone interviews, the answers to the open questions especially those about the barriers related to research and education in standardisation.

Regarding conducting ***research*** on standardisation, knowledge exchange and transfer have been identified as major drivers as well as its contribution to public welfare in general and standardisation in particular. This intrinsic motivation has already been identified by Blind and Gauch (2009) with a focus on nanotechnology and recently by Blind et al. (2018) based on the assessments of researchers working in an institute of materials research. Obviously, research on standardisation has a very multidisciplinary, but also applied character, which makes standardisation activities such as transfer channel and network opportunities very interesting in general, and in engineering and IT in particular.

The major barriers for not performing research is the lack of internal and external appreciation again supporting the findings by Blind and Gauch (2009) and Blind et al. (2018), but also Blind and Mangelsdorf (2009), where the participants in standardisation worked in the German machinery and electro-technology sectors.

It is suggested by the survey respondents that the most appropriate solution to promote research about standardisation is to provide more public and private funding. However, a change in the internal governance of HEIs and PROs to support research on standardisation and more support by standard development organisations (SDOs) is also asked for.

The major drivers for ***education*** on standardisation are the synergies with research, contributing to, the topic of standardisation itself, its multidisciplinarity as well as the links to and demand from the private sector. The latter two are highly correlated, i.e. the closer the links are, the higher the demand from industry is, which calls for a more intensive integration of industry into the teaching of standardisation. This also confirms the recent findings by Hewitt-Dundas and Roper (2018), who identify cooperation with business in addition to both the availability of financial resources and the financial pressure as driver of programme innovation, i.e. the introduction of new programmes and the withdrawal of existing programmes in UK universities. They provide “Biomedical Science”, “Discrete Mathematics”, but also

"International Management" or "Law" as examples of recent programme innovations. In addition, Brennen et al. (2014) show based on case studies that changing demand for higher education is reflected in the provision of new programmes.

However, the lack of interest by students and support by their respective faculties makes the integration of standardisation into the curricula difficult. This supports the findings of Brennan et al. (2014), who show that the lack of institutional support including a missing autonomy or a restrictive regulatory framework is hindering the introduction of new programmes into the curricula, i.e. all the lessons and academic content taught in a university or in a specific course or programme.

Since the barriers are more severe internally, more external support and demand from industry as well as support from SDOs are perceived as useful solutions. Nevertheless, the researchers also have to do their "homework" by better embedding the topic of standardisation into the theories of the various academic disciplines.

Combining the assessments related to research and education about standardisation with the characteristics of the respondents some additional insights could be derived. Firstly, the strong intrinsic motivation of experts involved in standardisation, doing research and providing teaching about standardisation has to be noted. This might be an important component to take into account for the derivation of solutions. Secondly, the high synergies between research and education on standardisation, but also the active involvement of researchers in standardisation is an important aspect to be considered. Thirdly, researchers being employed at HEIs face more problems in general than those working at PROs. Fourthly, there are obviously synergies between standardisation, conformity assessment and metrology within the whole Quality Infrastructure (Guasch et al. 2007), which are an interesting opportunity to integrate other institutions and their resources in implementing possible solutions.

Based on the survey results, qualitative insights from the comments on the open questions and a validation workshop with the members of the ETSI Strategic Task Force 515 "Design and Development of Teaching Materials for Education on ICT Standardisation" and the representatives of three national SDOs at Leipzig, the general recommendations below have been derived, which include specific measures for PROs, HEIs, SDOs, industry and other stakeholders. They are presented before eventually the possible implications for the Joint Initiative of Standardisation (JIS) are elaborated.

Firstly, despite the very comprehensive survey approach to address researchers possibly interested in performing research and offering teaching the response to the survey remained on a rather low level in particularly by respondents being involved in both research, education and standardisation itself. Therefore, there is a generic need to promote the visibility of standardisation as subject for research and teaching.

Secondly, there is obviously a high level of fragmentation within the standardisation research community due to its inherent high level of multidisciplinarity, i.e. requiring the contributions from different disciplines in addition to its relevance for different disciplines, The individual disciplines however, are unable to build a critical mass. Therefore, all interested and relevant academic disciplines should be invited to contribute to a common comprehensive theoretical framework as a basis for further future research activities.

Thirdly, the awareness of students about the relevance of gaining knowledge about standardisation is clearly limited. In addition to the promotion of attending voluntarily courses, the introduction of basic modules about standardisation focusing on the main elements (see Blind and Drechsler 2017) in obligatory courses, such as those initiated by Danish Standards in collaboration with various faculties at Danish universities, could provide a basic awareness of standardization and lead to a greater interest among students. Eventually, the demand from students might also become a more important driver for offering educational courses on the topic of standardisation.

Fourthly, even before addressing the issue of standardisation within HEIs it is obviously necessary to teach teachers in secondary and tertiary schools to include basic elements about standardisation within the curricula e.g. of social studies promoting eventually the awareness of the relevance of standardisation and standards for society as a whole.

Fifthly, support measures should address both standardisation research and education and also consider their activities in standardisation due to the large overlap of the activities and the strong positive synergies. From an economic perspective, both the standardisation research and teaching and the active involvement (in standardisation) contribute to a public or at least a club good, i.e. the development of a standard. Therefore, publicly funded support can be justified in general and particularly with the case of health, environmental and safety standards, because they generate positive externalities.

Since standardisation plays animportant role for both standardisation research and teaching for engineering in general and IT in particular, the highest benefits of support measures can be expected here in the short term, because there are also the closest links to industry in general and standardisation activities in particular. Country-specific characteristics, like the focus on engineering or IT, should be taken into account as well as the general level of development of research and teaching about standardisation. Countries with an established infrastructure in standardisation research and education could share this with those countries missing these institutions, e.g. in the context of the principle of twinning projects.

Sixthly, standardisation is a central instrument of the national or European Quality Infrastructure, which has also the character of a public good. Therefore, support measure should consider the synergies between conformity assessments and metrology. For example, the European Metrology Programme for Innovation and Research (EMPIR) as part of Horizon 2020, the EU Framework Programme for Research and Innovation has already included pre- and co-normative programmes to support timely metrology research and to accelerate the development of a draft specification (to be used for European or International standards). This kind of collaboration should be continued and expanded to push PROs and HEIs to intensify their activities in standardisation research and education, in particular, in light of Fenton et al. (2018) observations that international standards only partly refer to scientific references.

Seventhly, standardisation is an important instrument for SMEs (Blind and Mangelsdorf 2013) or Start-Ups (Abedelkafi et al. 2016). Since governments have recognized market or system failures related to SMEs and Start-Ups, they are supporting education related to entrepreneurship. Therefore, public support programmes for developing and establishing university curricula about entrepreneurship, like EXIST in Germany, should explicitly incorporate standardisation in addition to the information provided about patent applications or trademark registrations.

Eighthly, supporting instruments and initiatives should integrate the resources already available at SDOs. Access to standards and Technical Committees should be provided not only to researchers focusing on and academics teaching about standardisation, but for researchers in general. By opening the SDOs for researchers, the latter also become more attractive for companies due to the important motive of knowledge sourcing (Blind and Mangelsdorf 2016). Nevertheless, companies already active in research with a potential interest in standardisation should be integrated within such support schemes, e.g. the Germany Federal Ministry of Economic Affairs and Energy has launched a program WIPANO to support knowledge transfer via patents and standards, which is funding not only research organizations, but also companies developing their research further towards standards.

Ninethly, industry companies and other stakeholders, e.g. governmental and non-governmental organizations, active in standardisation, but also the SDOs themselves have to signal much more explicitly their demand for graduates educated in standardisation and researchers active in standardisation.

Tenthly, PROs and HEIs have to adapt their incentives schemes and governance to acknowledge that research and teaching about standardisation to internally attractive for researchers. Very few PROs have already included the contribution of standardisation in their mission statement and consequently, in their reporting system not only covering scientific publications and patents, but also the contribution to standards (Zi and Blind 2015; Blind et al. 2018). However, this approach has to be extended to a much larger number of PROs and HEIs.

Finally, successful examples show that a long-term support for the development of an eco-system of researchers, teachers, SDOs, experts, companies and other stakeholder involved in standardisation has to assured to allow a self-sustaining combination of research, teaching and the active involvement in standardisation.

Guided by the shared vision for European standardisation of the Joint Initiative on Standardisation (JIS) aimed at improving the current European standardisation system, we are able to derive some recommendations according to the three domains of the JIS. In particular, we make some proposals related to fostering awareness, education and understanding about the European Standardisation System and their actions, identified for improving the European Standardisation System.

1 Introduction

1.1 Background

The EC has repeatedly been pointing to the need to improve the education regarding standardisation (COM (2011) 311). Recently this need was confirmed by the "Joint Initiative on Standardisation (JIS)" of the public and the private partners in the European Standardisation System (COM (2016) 358). The JIS called for actions *"to explore and promote standardisation as an element of formal education and academic … training"* (domain 1/action 3).

This assessment aims at providing explanations for the paradox that the economic importance of standardisation is meanwhile undisputed both at the macro and the micro level, whereas research and especially education on standardisation is rare or absent.

The assessment provides the picture of the present situation regarding

- the barriers impeding "standardisation" to become an element of teaching and research in European universities and
- the motivation for those universities which engage in standardisation-related lecturing and research. This insight is direct support to the work of the JIS. It also gives orientation to the EC for proposing appropriate policy measures within its limits of competence and respecting the principle of subsidiarity.

1.2 Methodology

The overall goal of university education is the professional qualification for certain job descriptions (Schaper 2012). Job descriptions are not static. They evolve and change over time. Relating thereto the education needs to be adapted constantly (Expertenkomission IngBW 2015). To ensure a professional qualifying, competency-oriented education, a tight cooperation between industry and university is essential (Baumann et al. 2014) in order to identify and evaluate required knowledge, skills and competencies (Weinstein and Houston 1974).

Higher education is generally classified into three different models: The Humboldtian, the Napoleonic, and the Anglo-Saxon model, all of European origin (Sam and van der Sijde 2014):

- Higher education under the Humboldtian model (German model) attaches great importance to academic freedom of teaching and research together with the freedom to learn without the interference from governments. That means teaching is directly related to the research of the professors, who are required to conduct their research for teaching purposes. That means new contents are added at the initiative of a particular professor who has a special interest in a certain topic or if a new professorship for a certain topic is founded.
- Within higher education under the Napoleonic model (French model) institutions such as universities are seen as public entities, authorizing the students to apply their professions. At the same time, degrees from different colleges are requested to equally qualify students. That means the whole system is highly centralised, which means it is impossible for higher education institutions to design curricula autonomous, whereby research takes place outside of universities.
- The Anglo-Saxon model (British model) has the basic feature of personality development, which means the whole model tends to put more emphasis on professionalism, rather than technical (and vocational) knowledge and skills as the students' focus is to deal flexibly and intelligently with the changes and challenging situations. Universities are institutionally independent with regard to offering programmes and just operate within a general framework defined by the government but with quality control and supervision conducted by independent institutions.

In general, the higher education system worldwide in Europe is dominated by the Anglo-American model, which places an emphasis on the liberal arts as well as on multi-disciplinary education at the undergraduate level (Anglo-Saxon model) and research in the graduate level, patterned after the Humboldtian model (Sam & van der Sijde 2014).

Taking these institutional framework conditions into account we also consider the university-, and faculty-specific drivers, but also individual motivations, e.g. derived from the self-determination-theory, and barriers for the development of new university programmes or the integration of new content into existing curricula. Based on the already existing insights an approach for the empirical implementation of the study was developed and presented in chapter 3. Within this study, we focus on “non-ICT engineering", "ICT engineering", "economics", "law" and "business", which are mostly traditional academic disciplines, but complemented by metrology and material sciences.

In a first step, the limited existing literature about the motivations and barriers academics envisage related to standardisation education and research in particular, but also to the introduction of new topics in curricula in general. These insights plus feedback from experts in the fields were used to develop an online survey about the motives and barriers related to research and education on standardisation.

In a second step, the target group for the survey was identified. In addition to the mailing lists of the European Academy for Standardisation EURAS and the Conference on Standardisation and Information Technology (SIIT) which includes academics and experts being active in standardisation education and research, we identified researchers with publications in standardisation. In addition to focusing on scholars active in “non-ICT engineering”, “ICT engineering”, “economics”, “law” and “business”, those working in “metrology” and “material sciences” have been added. Finally, a group of highly cited researchers and their co-authors have been used to expand the target group to all areas in science.

In a third step, the answers to the survey complemented by responses to open questions and some additional interviews with some of the respondents have been analyzed. They were also differentiated by country, discipline and professional attitude.

In a final step, the insights have been the basis for the derivation of general recommendations as well as specific proposals directed at actions of the JIS.

2 Review of the Literature

The objective of the literature review is the identification of barriers, which block European universities offering standardisation education to their students (lecturing) and to undertake standardisation research. However, we are also interested in the identification of the motives for universities to integrate "standardisation" in their teaching/research programmes. The motives to conduct research in the area of standardisation is not covered in the literature review as – in contrast to the limited literature about education in standardisation – no literature is available. The available studies about the motivations concentrate on companies' (Blind and Mangelsdorf 2016) or individual researchers' motive to get involved in standardisation (Blind et al. 2017, 2018), but not about performing research about standards. However, both the motivations and barriers perceived by researchers will be addressed in the survey.

The literature review has used two types of sources:

1. We searched for all academic literature on education in standardisation by consulting the databases Web of Science provided by Thomson Reuters, Scopus provided by Elsevier and GoogleScholar.
2. We reviewed relevant policy documents and non-academic reports, white-papers and press releases (grey literature), e.g. via internet searches.

Standardisation-related education literature has been published by universities, NSOs/ ESOs/ISOs- and industry representatives. To identify barriers and motives regarding providing standardisation education (lecturing) and to undertake standardisation research we analyzed the following documents and publication in the state of research:

- Important previous studies concerning actual implementation, teaching approaches and contents in *standardisation education* (e.g. Hesser & de Vries (2011), the IFAN Guide (2014), ISO (2014), Japanese studies (Nakanishi 2013), the Indonesian Study by Rosiawan (2013), the Korean studies by Choi & de Vries (2011, 2013).
- Conference publications and keynotes held by university and standardisation representatives concerning *teaching standardisation in higher education, e.g. in the ICES conference series.*

Within our literature review, we tried to also consider the literature about drivers and barriers for the development of new university programmes or the integration of new content into existing curricula considering the different country-specific education models as described in the introduction.

To achieve the above-mentioned goals we analyse the available literature guided by the following standardisation research questions. Since the literature does not provide answers to all questions, the survey is shaped in a way to provide the insights missing from the literature review.

Implementation of standardisation in curricula and boundary conditions

- Which areas of standardisation are already considered in current teaching approaches?
- Which teaching concepts (e.g. lectures, workshops, practical works) are used and for which reasons?
- How are teaching concepts and/ or contents implemented in the curricula of the particular field of study (e.g. elective course, compulsory subject, teaching of standardisation within the context of superordinate subjects)?

Stakeholders/ Key players in standardisation education

- Who are the initiators of specific programmes or courses and who are the drivers for a stronger implementation of standardisation in higher education (e.g. professors, students, NSO's, ESO's)?
- What is their motivation? (e.g. further activities, career, education)
- Are lecturers teaching standards also carrying out research within the field of standardisation following the unification of research and education?
-

Actual implemented contents in standardisation education

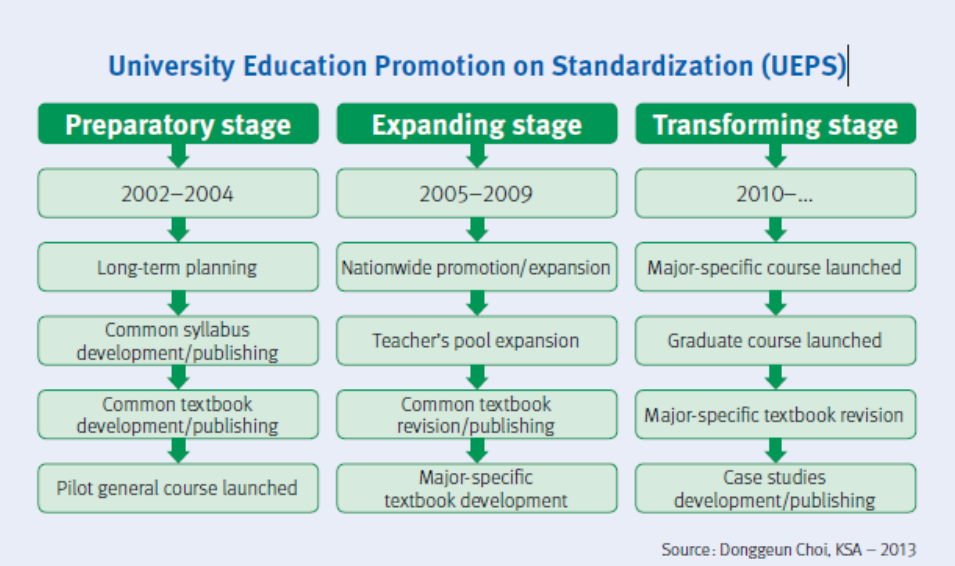
- Which contents are actually taught depending on the respective field of study?

Proposed contents for standardisation education

- Which contents and teaching concepts are proposed by the private sector or further stakeholders including standardisation bodies involved in standardisation, but which are not implemented yet?
- How do proposed contents differ from actual implemented contents?

2.1 The teaching of standards by institutions of higher education

Standards play a vital role in our global economy, permeating nearly every area of our lives. From common technical specifications that allows for interoperability, standards enshrine certain features of a given product that makes our modern interconnected global economy possible. Despite abundant benefits and the pivotal role they play in the global economy, the education regarding standards and standardisation is limited especially, in Europe. University courses dedicated to standardisation or even mentioning standardisation within a course are rare and often limited to certain fields or disciplines or more technical institutions. In Europe there are only a few institutions dealing with standardisation with some examples including the Rotterdam School of Management (Erasmus University, the Netherlands), Tilburg Law and Economics Center (TILEC), the University of Luxembourg, the Institute of Technology of Management (Technical University Berlin, Germany) or the University of Geneva (Switzerland) and in North America for example, the 'École de technologie supérieure' (Canada) or the Catholic University of America, where the course no longer exists (see ISO 2014, Choi and De Vries 2011). Inclusion of the topic of standardisation ranges from references to standards with regard to a technical task, over workshops or complementary courses to programmes where standardisation plays a central role.



Source: Choi, KSA (2013) in ISO (2014)

Figure 1: UEPS in Korea within the KNSP framework

The exception lies in Asia, most notably initiatives undertaken by the Republic of Korea and their respective standardisation agency. Indeed, Korea developed a structured plan regarding standardisation education termed 'University Education Promotion on Standardization (UEPS)'. With the realization of the importance of standards in a globalised and increasingly more technical economy, the government of Korea in 1999 passed the 'Framework Act on National Standards'. This required that every five years, the government set a National Standards Plan (KNSP). Included within the KNSP

2001-2005, KNSP 2006-2010 and the KNSP 2011-2015 was the emphasis on the importance of education in standardisation and consequently, initiatives being launched. The first timeframe being the acknowledgment of a need of more Human Resources in the area, the second, tasks targeted at the training of more standardisation experts and the promotion of the field in education and the last, a more detailed approach with targets beings set (ISO 2014).

The KNSP's and their educational features were implemented by the 'Korean Standards Association (KSA)' and a governmental agency, the 'Korean Agency for Technology and Standards (KATS)'. The UEPS was initiated in 2003 and a long-term plan 'Life-long standards education' was set out where standardisation would be taught at all levels of education. Initially, the focus was put on undergraduate engineering schools where standardisation courses were provided and most notably, textbooks created (i.e. 'Future society and Standards'). Further reading, guest lectures from experts and field trips were also provided. By 2010 there were several more textbooks created as well as UEPS graduate school programmes put in motion. The numbers best exemplifies the extensiveness of the UEPS. Overall, "…in the period 2002-2011, 6044 UEPS courses were delivered to 38054 students. These courses were delivered in 59 four-year universities, representing 27% of the 222 four-year universities in Korea, and one three-year college" (ISO (2014), p. 82/83).

Moreover, the KATS and KSA initiatives regarding the education in standardisation has not been limited to Korea itself but also involves international initiatives in collaboration with National Standardisation Bodies (NSBs) aimed at promoting the education of standardisation such as in Indonesia (2012), Brazil (2013), South Africa (2013). Trial programmes (from January to July 2011) regarding education in standardisation was jointly financed by KATS for Korean universities and the Asia Pacific Economic Cooperation (APEC) for other Asian universities.

University (Economy)	Major/Department	Students' Level		
		Bachelor	Master	Doctor
01.CJLU (China)	Business Management	70		
02.Chungang (Korea)	Business		5	13
03.Diponegoro (Indonesia)	Industrial Engineering.	32		
04.EWHA (Korea)	MBA		10	
05.HUFS (Korea)	Industrial Engineering	6	1	
06.Hanyang (Korea)	Business		4	6
07.Kookmin (Korea)	Open for all majors	39		
08. KNU.Educ. (Korea)	Technology Education.		12	4
09.Korea Un. (Korea)	Elect. &ICT Engineering	3	3	2
10.NEU (Vietnam)	Business - Quality	47		
11.P.U.C.P(Peru)	Quality Institute		19	1
12.Trisakti (Indonesia)	Industrial Management		21	
13.Waseda (Japan)	Global Business School	54	98	
14.Yeonsei (Korea)	International Management		18	
Total: 14 Universities - 468 Students		**251**	**191**	**26**

Table 1: Trial Programmes

Source: APEC (2011)

Though Europe has a far less comprehensive approach to the education in standardisation than for example Korea, they too have acknowledged the importance of more education in standardisation. The EC financed project for example 'EU-Asia Link- Standardization in Companies and Markets' (2003-2006), provided a comprehensive textbook, outlined a curriculum, a portfolio of e-learning elements (e.g. PowerPoint slides, tests, animations etc…) as well as created a network group of standardisation experts (Hesser et al. 2010). The online platform is accessible to all that have an agreement with the

Helmut Schmidt University, Hamburg, Germany (see Hesser presentation 2012, Choi and de Vries 2011). The case of Korea provides essential insights into how the education in standardisation could proceed. However, clear differences in contexts need to be taken under consideration. Beyond the nature and characteristic of higher education in the geographic regions is also the notion that the Korean example, with consideration to its export-orientated economy, made standardisation education a top-down national enterprise backed by the government. This points to the underlying notion, that there is not a one-size-fits-all especially in Europe with its diverse educational institutions, economic priorities and NSBs and consequently, motives and barriers to standardisation education.

2.2 Motives

Standards in themselves provide a variety of economic and strategic advantages not only for individual companies but also for countries. Combined with regulation, technical standards affect the majority of global trade. Standards can provide competitive advantages for certain firms, lower trade barriers and costs, influence supplier and buyer relationship, influence R&D and innovation and ensure legal compliance with regulation in a swift and effective manner (Purcell 2008, Blind and Mangelsdorf 2016, CEBR 2015). Standards can shape entire markets and industries. Indeed, “If you control an industry’s standards, you control that industry lock, stock and ledger (Deming 1986 in Purcell 2008)”. Consequently, with standards playing such a large role in the global economy, it is important for many students to be educated regarding standardisation. This does not only pertain to technical areas that require some knowledge of standards such as for engineers. This also includes the social sciences where standards for example, are extremely relevant to fields such as economics and politics and could complement theoretical frameworks in providing a more complete picture of the global political economy. Furthermore, as companies have so much to gain from standards both financially and strategically, knowledge of standards and the standardisation process would provide promising job prospects and a competitive advantage at least for some students.

2.3 Required competences

A survey financed by the British Standards Institution (BSI) found that many employers had to teach new employees about standards and the standardisation process and therefore incurred costs. Indeed, the employers “…indicated the importance of students’ knowledge, understanding and appreciation of relevant standards in the right context, emphasising their desire for standards to be included more widely in the curriculum (BSI 2014, p.4).”

However, Blind and Drechsler (2017) find in their European-wide survey of industry needs only that the basics of standardisation should be taught in specific lectures, but not offered as complete programmes, like international management or law. Consequently, if employers desire students to be taught more about standards, the reason they are not, namely the barriers to the more wide-spread inclusion of standardisation in higher education, will be investigated in the empirical study.

Table 2 shows employees’ competences with regard to standards for different industry job positions, which has a strong technical and engineering focus.

Number	Competence	Engineers in R&D	Sales/Marketing	Marketing	Business Strategists/Managers	Standardisation department	Quality management	Production	Purchasing	Laboratories	Human Resources
1	To know basic terms in the fields of standardisation	x	x	x	x	x	x	x	x	x	
2	To know basic standards and guidelines in one‘s field of expertise	x	x	x	x	x	x	x		x	
3	To know general basic standards	x			x	x	x	x		x	
4	To understand general relevance of standards from the economies and companies point of view	x	x	x	x	x	x	x	x	x	x
5	To know the international committee landscape	x		x	x	x	x				
6	To be able to research standards	x		x	x	x	x	x	x	x	
7	To be able to screen a standard	x				x	x	x		x	
8	To be able to estimate the consequences of an omission of the application of relevant standards in certain application	x				x	x	x		x	
9	To be able to choose relevant standards for a specific application	x				x	x	x		x	
10	To be able to interpret a standard	x				x	x	x		x	
11	To be able to take into account application relevant contents of a given standards for the development of a product or a process	x				x	x	x		x	
12	To be able to evaluate if a product or process meets the required standards in one’s area of expertise	x				x	x	x		x	
13	To know the formation process of standards	x		x	x	x	x				
14	To be able to create a standard					x					
15	To be able to estimate consequences of a new standard or specific content of a standard	x				x					
16	To know and understand the macroeconomic benefit	x	x	x	x	x					
17	To understand strategic aspects of a participation in standardisation	x	x	x	x	x	x			x	
18	To estimate potential possibilities of influence from a company's point of view	x			x	x					
19	To estimate the participation in strategic relevant consortia					x					
20	To initiate new standardisation issues					x					
21	To know rights and obligations in consortia					x					
22	To know and understand the role of standards in management systems and company management system policies			x	x						
23	To know and understand the interaction between innovation, intellectual property and standards (a necessary competence of employees in R&D	x									
24	To be able to identify conflicts with patents and standards or gaps in existing standards	x									

Table 2: Overview about necessary knowledge and skills (companies perspective)

Source: Blind and Drechsler (2017)

2.4 Barriers

In order to best understand why the education of standardisation is not more comprehensive and widespread, particularly in Europe, the diversity and contextual nature of standards needs to firstly be emphasized. The number of standards taught, how the content is included in the curriculum and which particular standards are relevant all vary and depend on what one is studying. Some courses on standardisation are required for certain fields such as for building construction or risk assessment. For other fields, learning about standards might simply be encouraged where students are specifically taught about a select few such as in quality management or user-computer interface and design (BSI 2014). Most significantly, is the nature of standards and the standardisation process themselves. Often they might be reactive to a certain new development or innovation or at times established in anticipation of new developments. This underlines the crux of the issue regarding barriers to teaching standardisation namely, the difficulty in theorizing and creating models for the field (ISO 2014, Krechmer 2007). There are vast amounts of variables that can influence the process, certain issues or causalities difficult to describe appropriately or to fully understand and subsequently, making it difficult in creating a coherent explanatory framework (Krechmer 2007). This is also problematic when considering that often institutions of higher education are rather strict regarding new programmes, but also courses in terms of the required structure, use, relevance and the expected learning outcomes (BSI 2014).

The BSI survey though focused on the UK did find some barriers relevant to standardisation education throughout Europe. Extremely insightful are findings regarding issues of access and information. Based on the business models of various National Standardisation Bodies (NSBs) one is required to pay for access to standards. This becomes problematic when universities – having in general no free access to standards – deem it not a sufficiently worthwhile investment to pay for access. This could possibly be even the case if a small number of students would enjoy the access or need it but not a sufficient amount of them for it to be worth the cost for the institutions. Moreover, this perpetuates an already problematic issue, namely, the lack of visibility of the field of standardisation. The survey also indicated that there were issues related to access to draft standards, to the committees or experts as well as students not even knowing whether their respective universities provided access to the standards nor which standards were relevant for their studies and courses. Further issues related to information, communication and transparency were outlined. The presentation of standards and the language used for example, was described by students and academics as being very complex and difficult to understand as well as changes made not being communicated sufficiently, leading to colleagues using outdated standards. Moreover, academics also stated that if they were not actively involved with standards (e.g. being on committees), then it would be highly unlikely that they would have taught the students about them (BSI 2014).

Based on workshops, ISO (2014, p. 84) identified the following as most important barriers from the perspective of NSBs, which have also to be considered by universities. First, standardisation education is in general not recognized a priority by NSBs, which is accompanied by a lack of resources and employees, including experts from industry, available and capable in supporting universities in developing and implementing curricula related to standardisation. Furthermore, the relevance of education in standardisation is not supported by stakeholders, including governments, but also industry. However, it is also observed that universities are often not significantly interested in standardisation, which might be explained by an intensified competition of including new subjects into university curricula. Within this competition, standardisation is handicapped due to lack of missing significance in research and professors promoting the topic of standardisation. Finally, it is noted that teaching materials are not available.

In order to learn from general experiences in including new topics in curricula we searched for further literature and found some studies in the area of medical education. Davis and Harden (2003) find that the lack of professionalism, e.g. ignoring market trends, in higher education institutions is a general problem for innovation in curricula development. More specifically, the missing leadership by the dean is a barrier for curriculum revision as well as a centralisation of the responsibilities for curriculum development. Spallek et al. (2010) have surveyed teachers and they report time pressure, the effort needed and the lack of cooperation, but also a general resistance to change also among students besides lack of facilities, instructors and eventually relevance. Muller et al. (2008) highlight further that

some new topics are more easily to integrate than others. This depends very specific on the characteristics of the subject, which is certainly also true for standardisation.

2.5 Moving forward

With consideration as to the importance of providing more standardisation education as well as the barriers in doing so, how would one proceed and what ideas have been proposed for a way forward. This is critical in framing subsequent survey questions in attempting to find concrete solutions. Learning from many Asian cases particularly Korea, provides insights on how to create textbooks and promote the education of standardisation. Indeed, the 'EU-Asia Link' is a clear illustration of such an initiative. However, it has been insufficient in terms of garnering an increase in standardisation education. The CEN/CENELEC/ETSI created a Joint Working Group (JWG-EaS) after a 2008 European Council publication regarding standardisation and innovation in order to increase awareness of standardisation in Europe. Consequently, there was the notion to initiate action via the European level.

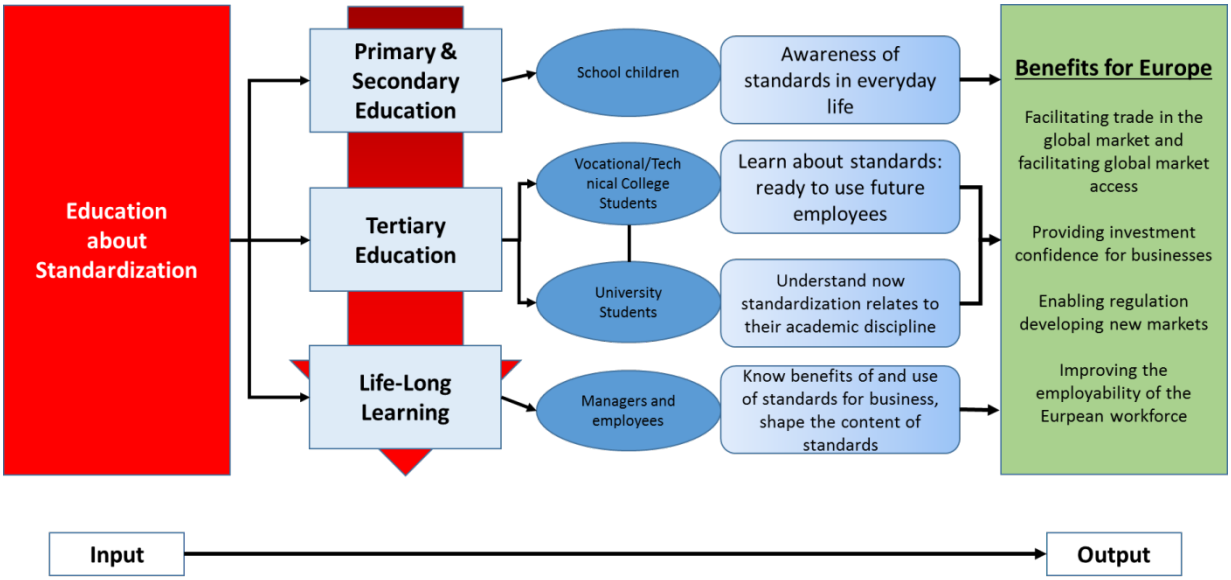


Figure 2: How education about standardisation can benefit Europe

Source: CEN, CENELEC and ETSI Masterplan

However, after it was acknowledged that the "…Education about Standardisation falls mainly under national responsibilities and competences…it was agreed that the JWG completed its task and was hence disbanded (CEN, CENELEC JWG-EaS)." Nonetheless, practical suggestions dealing with issues related to the barriers have been made.

Choi and de Vries (2011) group six contents modules into core common, higher education oriented and post-formal education oriented domain for better understanding and applications of education practitioners and policy makers (Figure 3).

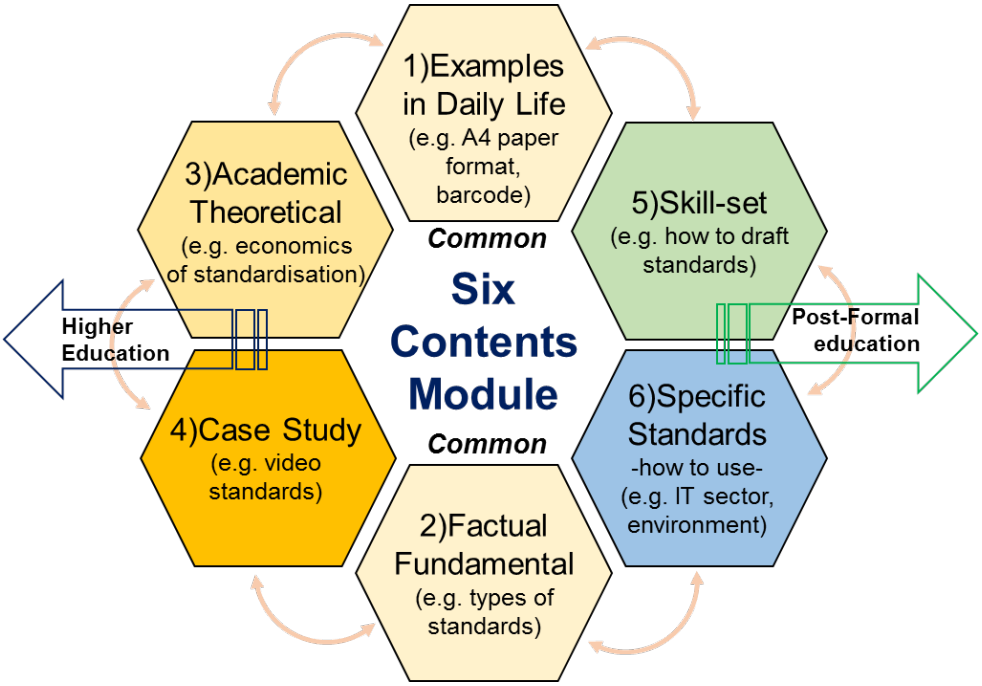


Figure 3: Modules for standardisation education

Source: based on Choi and de Vries (2011)

Choi and de Vries (2011) analysed different levels of education and what sort of modules could be provided regarding teaching about standardisation. Furthermore, they derived a framework for standardization education by combining the major components per target groups or learning objectives for planning and operating standardization education programmes. The proposed framework (see Table 4) is presented along target groups (who), appropriate learning objectives (why), probable programme operators (where), prospective contents modules (what) and preferred teaching methods (how).

Who –Students	Why –Learning objectives	Where –Operator	What –Contents–		How –Methods
			Main contents	Subsidiary contents	
Primary/ secondary education	Awareness	Gov NSBs	Module 1 –Examples (simplified)	Module 2 (simplified)	Contents Camping Quiz Game
Higher education –Under-graduate	Awareness/ specialized knowledge	Gov NSBs SDOs Univ	Module 2 –Fundamental Module 3 –Academic Module 1 –Example	Module 4 Module 5 Module 6	Team Project Presentation Field trip
Higher education –Graduate	Specialized knowledge/ theory	Univ Gov NSBs SDOs	Module 3 –Academic Module 4 –Case study	Module 6 Module 2 Module 5 Module 1	Case study Term paper Workshop
Post-formal education –Gov –Executive	Strategic decision/ policy development	NSBs SDOs Gov	Module 2 –Fundamental Module 4 –Case study (abridged) Module 3 –Academic	Module 1 Module 5 Module 6	Workshop panel discussion
Post-formal education –Committee members –SDO staff	Practical skills or ability	NSBs SDOs Gov	Module 5 –Skill-set	Module 4 Module 3 Module 2 Module 1 Module 6	Simulation Role paying Workshop
Post-formal education –Engineer –Researcher	How to use specifics standards	Biz Univ R&D	Module 6 –Standards	Module 4 Module 3 Module 2 Module 1 Module 5	Experiments Practices

Table 3: Proposed framework for standardisation education

Source: based on Choi and de Vries (2011)

In terms of tackling the issues and barriers related to theory, de Vries (2002) noted that any basic module in the EU should mention the "New Approach"/ "New Legislative Framework" (Decision No 768/2008/EC). This is a concept developed in 1985 with the aim of removing trade barriers with the harmonization of standards in the EU by harmonising legal requirements, which are complemented and specified by harmonised European standards. Indeed, removing trade barriers is related to economic notions and arguments and the connection with the legislative processes. Recently, Delimatsis (2015) edited a comprehensive handbook about the legal, economics and political aspect of international standardisation confirming the relevance of standardisation for several academic disciplines.

Furthermore, similarly to what is, for example, conducted at the Technical University of Berlin, standardisation education can be incorporated within academic debates and fields whether it be their relation to innovation and intellectual property rights as well as their economic and political relevance.

A survey conducted regarding the strategic value of standards education (Purcell 2008) found that a further expansion of standardisation education requires many things to change. This could refer to change in business models of NSBs or a change of engagement such as the Japanese Standard Association stating in the same survey that one should attract the interests of the Chief Technology Officers (CTO) of firms to advertise the use of standards as a tool for market strategy. Indeed, returning to standardisation's position in academia, it should be displayed not only as simply an isolated field but also embedded within other disciplines as an alternative tool.

3 Empirical study

3.1 Approach

The objective of the field research was to identify the aforementioned barriers and motives for an implementation of standardisation contents in research and higher education by conducting a wide field study across Europe in order to allow conclusions of how to eliminate the identified barriers or lower them.

Firstly, we rely in our sampling approach on the members of the mailing lists of EURAS and SIIT. Here, the majority of the European and international standardisation community is represented. The majority of the members are both conducting research and offering teaching in the field of standardisation.

In order to generate a more representative picture of the barriers related to performing research and offering teaching in the area of standardisation, we conducted as a first step, a broad survey among at a target group of researchers. They might be in the position to perform research according to their published research about standardisation. Therefore, they could offer teaching in standardisation in addition to the scholars listed in the EURAS and SIIT mailing lists already active both in standardisation research and teaching. Consequently, we searched for researchers with publications in the area of standardisation. Overall, we targeted around 500 European researchers, who have published at least three articles in scientific journals listed in the Web of Science since 2000 in the following fields:

- Engineering
- Computer Science
- Biochemistry and Biology
- Business Economics
- Government Law
- Material Science
- Physics
- Science Technology in Other Topics

Eventually, we identified almost 500 researchers. In addition, we included their almost 2,000 co-authors in the sample, because very often only the email of the first author is revealed on the first page of the journal articles, which we took as an opportunity to collect further emails. The majority of the papers are about pre-normative standardisation, as ongoing research (and subsequent publications) about the role of the ISO standards in scientific literature – with the exception of the quality and environmental management standards ISO 9001 and ISO 14001 analysed by Pohle et al. (2017) – is rather limited.

The second approach was to focus on the 3,300 Highly Cited Researchers provided by Clarivate Analytics. They have published a large number of papers, but also rank in the top 1% most-cited in their respective fields over a recent 11-year period, which is an established indicator for the quality of their research. Therefore, we approached these 3,300 researchers with more than 1,200 researchers with affiliations in Europe plus their more than 10,000 co-authors in order to find out whether and why standardization is not an attractive topic for them to research about. The quality of the identified email addresses of the authors of scientific articles in general and standardisation-related papers in particular is quite high with only around 10% of addresses being invalid and 20% out-of-office replies.

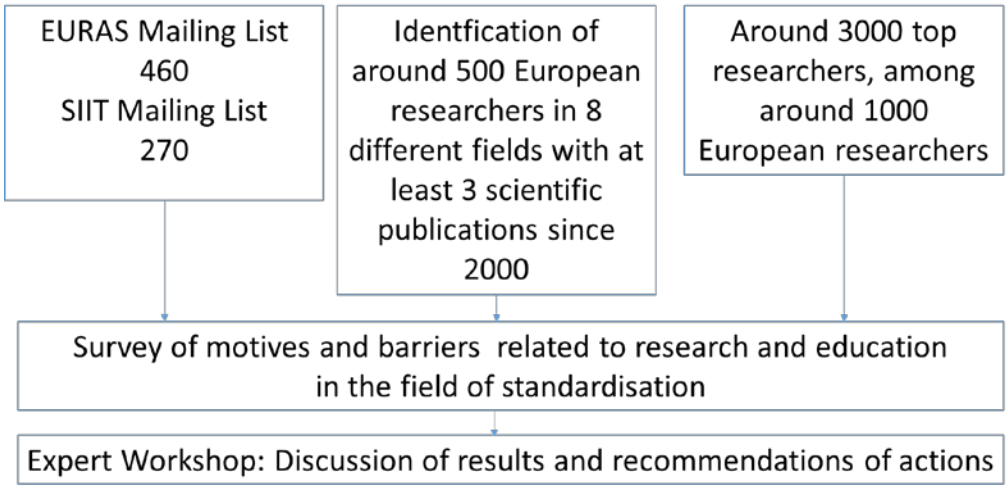


Figure 4: Research approach

Our survey approach combines the questions related to the motivations and barriers researchers face when introducing standardisation in their research portfolio or in their teaching curricula. The survey is based on the insights from the literature survey that were validated with the feedback of seven experts active in standardisation research or teaching. The following main questions are addressed:

1.) Questions about the participant and his/her career
2.) Questions about the current working place and job
3.) Questions about activities in research and education related to standardisation
4.) Questions concerning drivers to perform research related to standardisation,
5.) Questions concerning barriers to perform research related to standardisation
6.) Questions concerning possible solutions to promote research related to standardisation
7.) Questions concerning drivers to offer courses about standardisation
8.) Questions concerning barriers to offer courses about standardisation
9.) Questions concerning possible solutions to promote education about standardisation
10.) Evaluation of the relevance of competencies related to the application of standards and standardisation in the students' future professional careers like in Blind and Drechsler (2017) in order to compare the perspectives of the demand and the supply side

Besides the quantitative analysis of the survey results, we analyse in a qualitative way the answers to the open questions and approach those with detailed answers with particular focus on the barriers related to research and education in via some telephone interviews.

The survey itself was anonymous to protect the participant's privacy. None of the results can be specifically assigned to a certain person or company.

We used the survey tool 'lime survey', which is comfortable to use for end-users and respondents, respects the relevant data privacy issues and allows for the export of the data into an Excel sheet. The survey was accessible via this website https://inno.limequery.com.

After the completing the pre-tests with more than 10 experts who are active in standardisation research and teaching, we distributed the link to the survey between the beginning of February to the end of March 2018. Participants included the target groups mentioned above, the participants of the workshop hosted by the European Commission on May 16, 2017 and the members of the CEN-CENELEC joint working group STAIR to ask their contacts in research organisations and universities.

In summary, we have received 296 responses, whereof 155 respondents completely filled out the questionnaire. Due to the open consultation, the calculation of a response rate is not possible. All received answers provided a sound basis for the envisaged analyses as well as explains the varying number of responses to the different questions. After the completion of the online survey, we approached the respondents (almost 50) to provide their emails for further contacts. After contacting

them in April, thirteen respondents signalled their willingness to conduct an interview, but only nine experts replied to the proposed dates. For the validation of the survey results five interviews took place with respondents from universities and research organization located in Italy, France, the Netherlands, and the USA covering biology, biochemistry, environmental sciences, management and especially with regards to fashion where the interviews lasted on average for half an hour.

3.2 Results

3.2.1 Characteristics of the survey respondents

The differentiation of the respondents by scientific discipline reveals the multidisciplinary character of standardisation research and education. Around one third of the respondents had a background in science, another quarter in engineering and around 10% in economics and management. Applying another sampling approach, Blind and Drechsler (2017) find in their study focusing on the private sector industry a strong background in engineering in general or IT engineering, incl. computer sciences, telecommunications, etc.

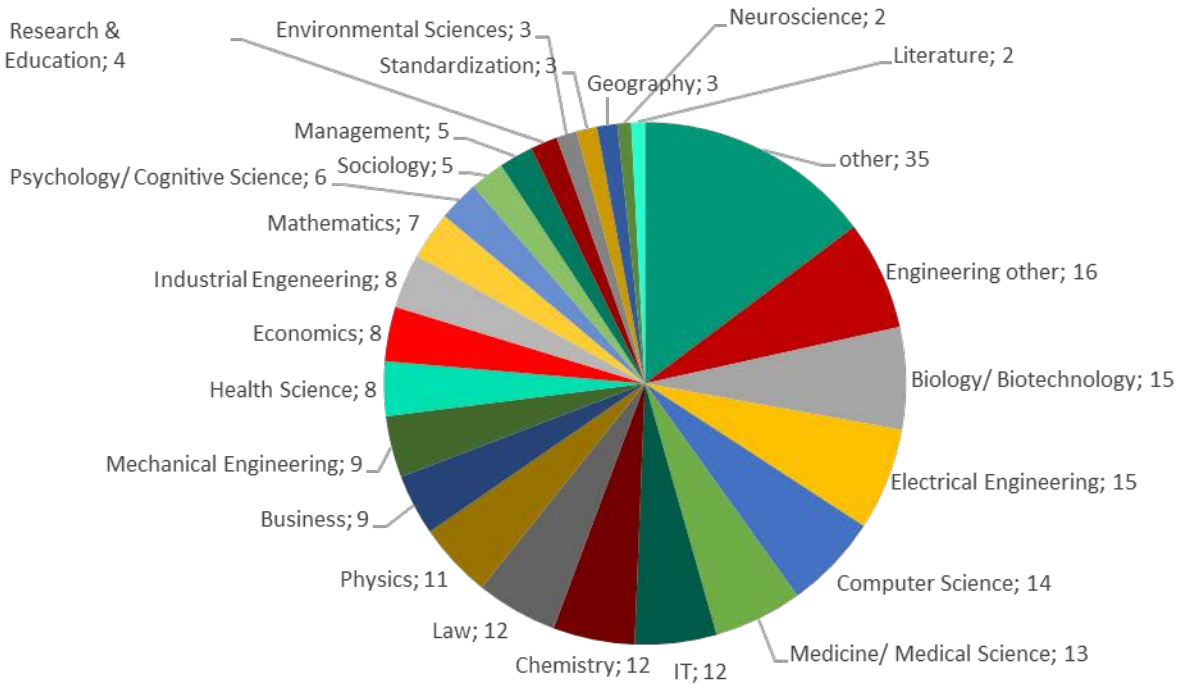


Figure 5: Respondents by scientific discipline (N=237)

The respondents completed their degrees in more than 20 different countries (Figure 6), with Germany as the most represented dominant country. however not totally reflecting its economic relevance with Europe. Surprisingly, we have many responses from Ireland due to the close network of the Irish standardisation body with the Irish universities and research institutes. The large number of responses from the Netherlands compared to its economic relevance can be explained by the long tradition of standardisation research and education in the universities of Rotterdam, Delft, Eindhoven and Tilburg. In addition, more than 80% of the countries, in which the respondents have completed their degrees, are in Europe. In Figure 8, we display the distribution of the countries, where the Higher Education Institutions (HEIs), such as universities and Public Research Organisations (PROs) of the respondents are located. The distribution is similar, but the share of Germany is slightly lower underlining the mobility of researchers within Europe. Finally, it has to be mentioned that 127 respondents work for PROs and 118 for HEIs.

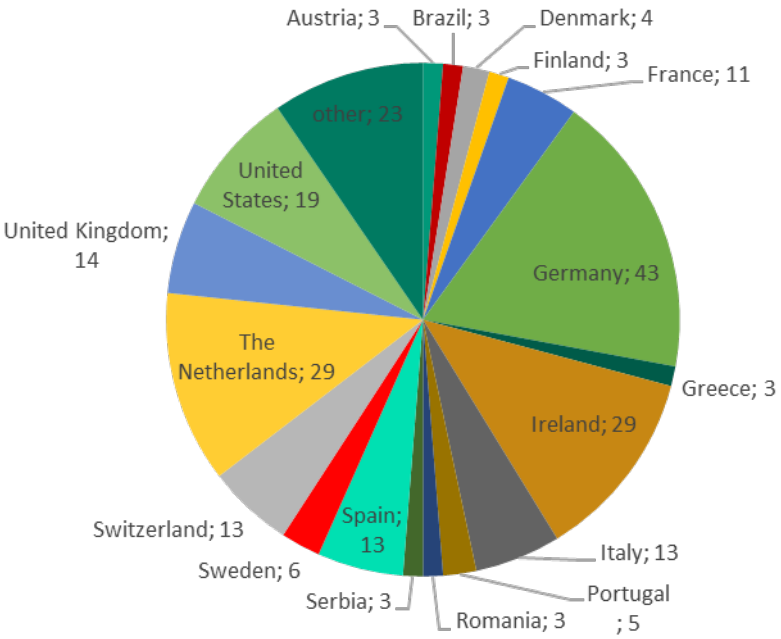


Figure 6: Respondents' country in which highest degree been completed (N=240)

Finally, we have asked for the distribution of responsibilities between research, education and administration, which revealed that the respondents devoted 40% of their time for research, 25% for teaching and just above 15% for administrative issues. It can be assumed that the other almost 20% of the time are also more related to administrative tasks and neither to research nor to teaching.

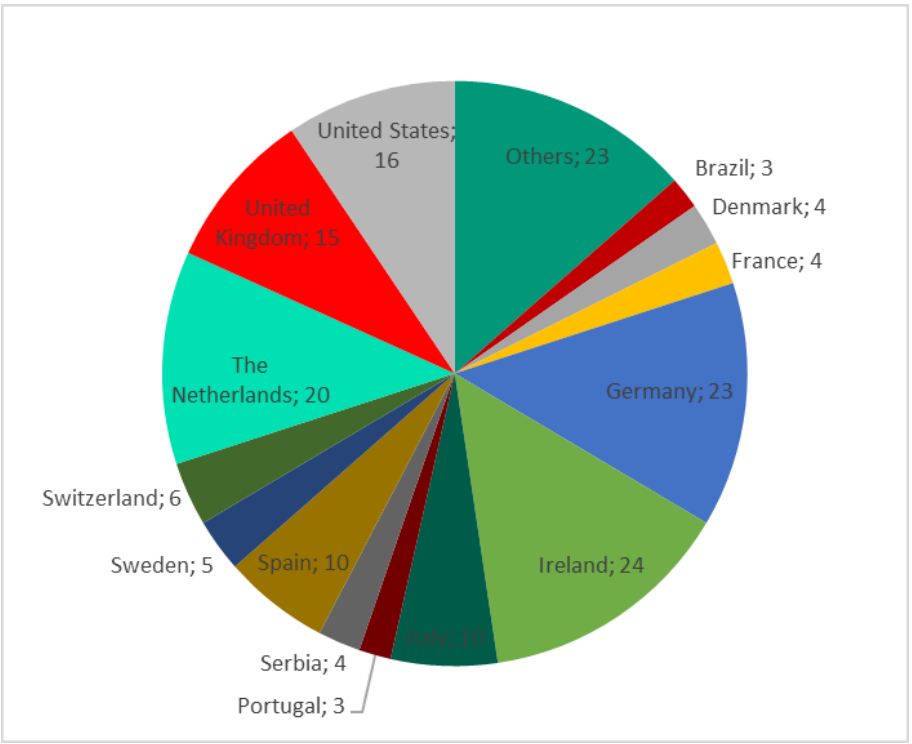


Figure 7: Location of respondents' HEI or PRO (N=192)

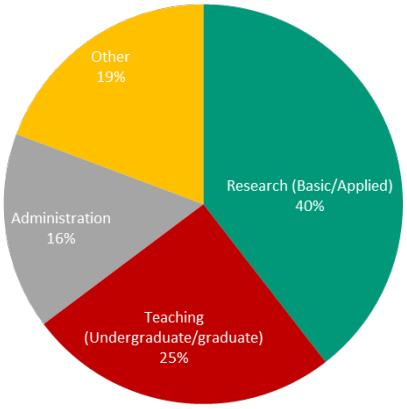


Figure 8: Distribution of responsibilities (N=181)

Since we assume that the institutional framework has an influence on academics' motivation, we asked for the professional orientation of the respondents.

Following Sam and van der Sijde (2014), we attribute research-based education and academic freedom to the Humboldtian model. Professionalism in education we attribute to the Napolean model, which is highly centralised and therefore restricts the autonomy of academics especially, with regards to education. Personality development through liberal education is the focus of the Anglo-Saxon model, which allows universities to operate quite independently within a rather general framework including quality control. Finally, the Anglo-American model integrates the features of the three European models, but focuses also on the competition between HEIs or PROs, which requires an entrepreneurial attitude of HEIs and PROs. Since these five different models no longer exist in their pure form and thus not easily differentiated by country, we asked the respondents for their level of agreement to five statements characterizing them.

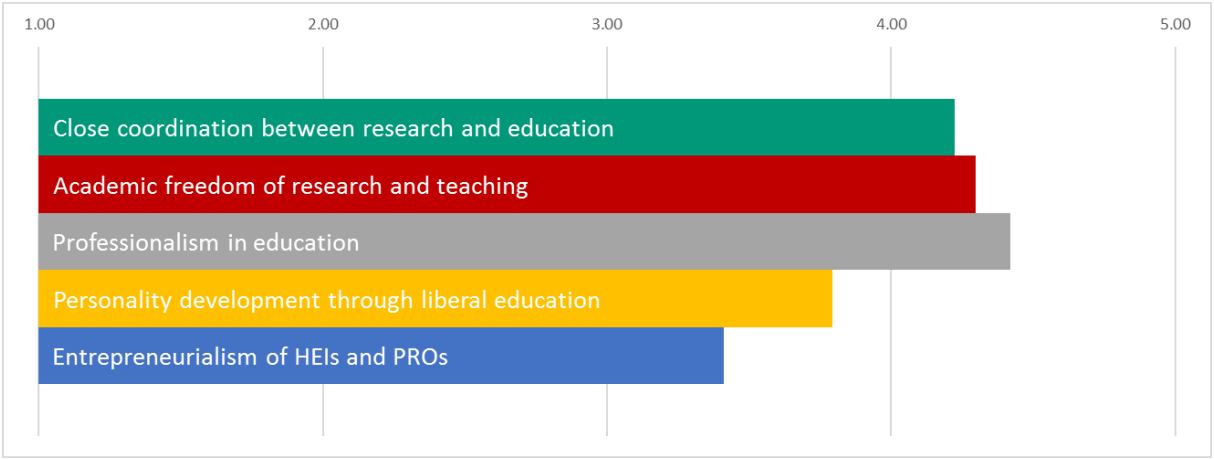


Figure 9: Average of importance (mean values) of professional orientation (1 = strongly disagree to 5 = strongly agree) (N=179)

The highest level of agreement receives "Professionalism in education is important" with almost all respondents giving a high or very high grade. The second most supported professional orientation is "Academic freedom of research and teaching is important" followed by perceiving the need of a close coordination between research and education. Significantly, the statement of personality development via liberal education receives less support. Finally and surprisingly, entrepreneurialism of HEIs or PROs is quite ambivalently assessed among the respondents of the survey in contrast to the survey by Lam (2011), whose respondents are in the majority supporting a hybrid attitude. In addition, it has to be mentioned that the correlation coefficient between the assessment of the five orientations is in general

below 0.50. Only the professionalism in education is correlated higher (0.60) with the academic freedom of research and teaching and their closer coordination.

Besides respondents' general professional orientation, it is important to elaborate on their activities in research and education related to standardisation.

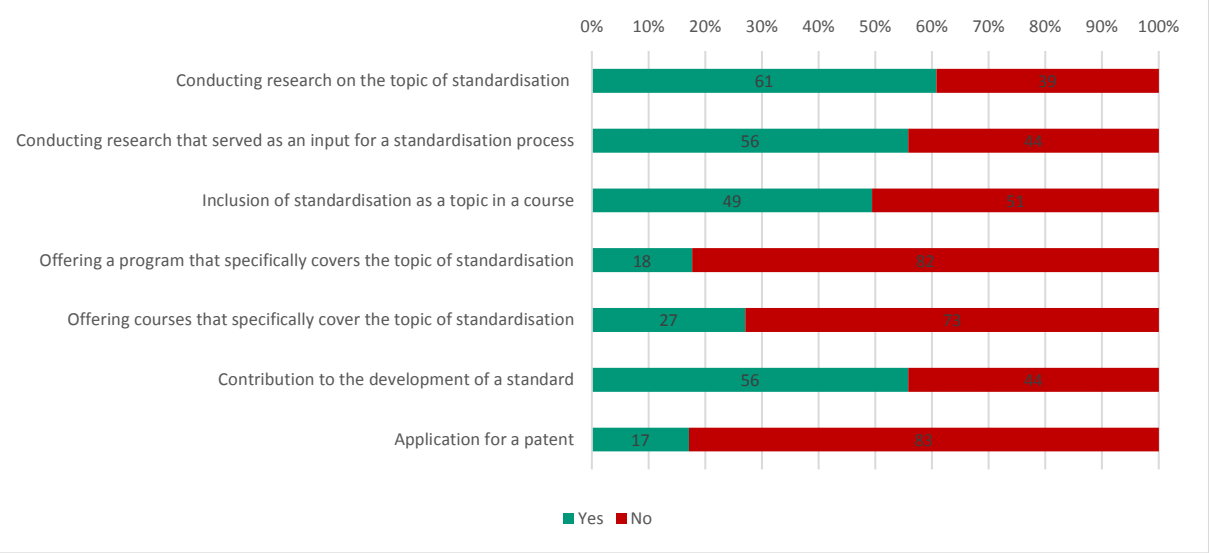


Figure 10: Standardisation related activities in the last 5 years

Overall, slightly more than 60% of the respondents have conducted research on the topic of standardisation within the last five years where most researchers have been published between one and ten papers. Slightly more than half of the respondents have done research that has served as an input for a standardisation process. Almost 30% of the respondents have conducted research, which has not been an immediate input for standardisation though related, i.e. these researchers perform more generic economic, legal or social science related research about standardisation.

More than 60% of the respondents have contributed to the development of a standard and being active in mainly one or two standardisation committees. This does not necessarily involve only drafting standards, but also includes giving strategic advice to members of working groups. It has to be noted that 85% of those conducting research as input for standardisation have eventually also actively contributed to standardisation, i.e. more than 10% of the researchers producing research results as input for standardisation are themselves not active in standardisation processes as active contributors in proposing new items, drafting standards or being even chairmen.

Almost 50% of the respondents included the topic in their offered courses, whereas just slightly more than a quarter provide courses that specifically address the topic of standardisation and around 17.5% even supply a programme on standardisation, e.g. a Master programme comparable to international management. Although we assumed a close relationship to patenting activities, only 17% of the respondents have applied for a patent in the last five years.

Looking at the correlation of the activities, we reveal that over 70% of the respondents conducting research on standardisation also include the topic in the courses they teach, whereas more than 87% of the respondents teaching standardisation also research in the field. Overall, we observe a close coordination between research and teaching in the field of standardisation. In addition, almost 70% of the respondents conducting research on or teaching standardisation contribute to the development of standards confirming BSI (2014). Finally, over half of the respondents among all those being involved in a least one standard-related activity have been researching, teaching and involved in standardisation activities. Therefore, we observe among our respondents not only a large overlap between research and teaching related to standardisation, but also to actively being involved in standardisation activities.

3.2.2 Drivers, barriers and solutions for conducting research in standardisation

After the section about the respondents' background, environment attitudes and activities the first section of the questionnaire is focused on the assessment of drivers, barriers and possible solutions related to conducting research on standardisation. In addition to the answers to the closed questions, specific answers of individual respondents to the open questions and insights from telephone interviews with a few respondents to the online survey complete the picture.

3.2.2.1 Drivers

At first glance surprisingly, the respondents rank the opportunities for knowledge exchange or transfer as the most relevant drivers for conducting research in standardisation. However, since more than two thirds of the respondents conduct research on standardisaton, they obviously exploit the opportunities of knowledge transfer provided by being involved in standardisation. The second most important driver is the contribution to a public welfare or good in general followed by contributing content to standardisation work in particular. This intrinsic motivation of participating in standardisation in contrast to scientific publishing and patenting has already been revealed by Blind et al. (2018). In summary, these three most important drivers for conducting research in standardisation are highly correlated and closely connected to standardisation activities. This result is complemented by the above average assessment of the application of the research results and the development of professional networks, which are significantly higher rated by those respondents having contributed to the development of a standard. Only the fourth important driver is the multidisciplinarity of the research related to standardisation similarly rated as and highly correlated (0.57) with being interested in the subject per se. The relevance of multidisciplinarity, which is still more an obstacle than a promoter for academic careers, as a driver for research on standardisation is already an explanation for the difficulty of establishing standardisation in other scientific disciplines. Furthermore, the exploitation of synergies with teaching about standardisation is a not very relevant driver for conducting research on standardisation. Finally, research on standardisation is irrelevant as an opportunity to increase respondents' personal income or prestige.

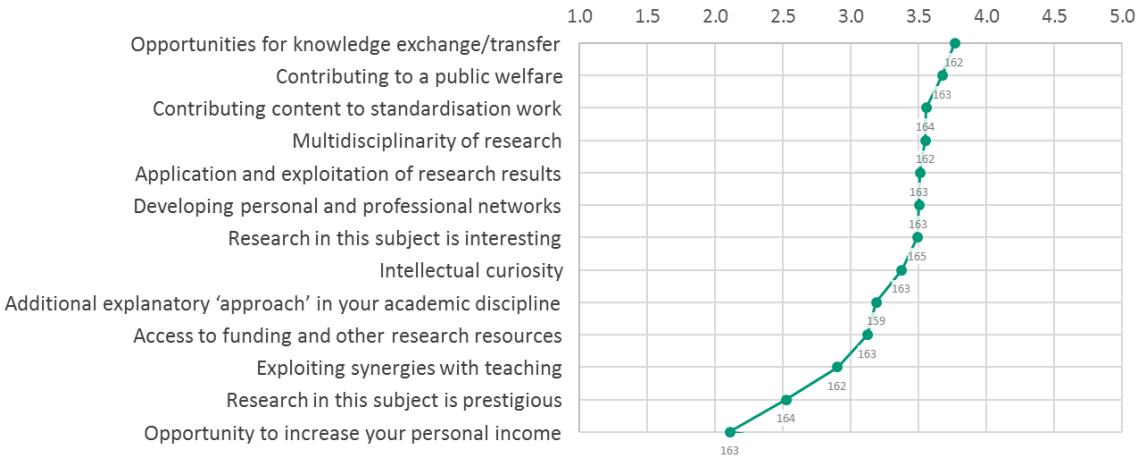


Figure 11: Actual of possible drivers for conducting research in standardisation (1 = very irrelevant to 5 = very relevant)

Assessment of drivers differentiated by discipline

The differentiation of the answers according to the disciplinary background of the respondents is only possible for an aggregate subgroup focusing on engineering due to the high diversity of disciplines. However, for this subgroup the contribution to standardisation work and the development of personal and professional networks are slightly more relevant than for the other respondents, whereas the access to funding plays a smaller role. The respondents working in PROs or HEIs focusing on IT confirm the high relevance of contributing to standardisation, but perceive in addition standardisation as an effective opportunity for knowledge exchange and transfer.

Assessment of drivers differentiated by country

The small numbers of responses per country (where the PRO or HEI are located) restricts analyzing the answers differentiated by the country. However, looking at the answers from Germany reveals that all drivers ranked as less relevant compared to all other answers. In contrast to the Dutch respondents where the subject as such and as a result of intellectual curiosity are more important drivers, yet where direct involvement in standardisation activities is perceived less important.

In addition to assessing the above-mentioned drivers, respondents provided several individual reasons for conducting research about standardisation. Firstly, the technological context obviously matters, i.e. respondents researching either in technologies requiring interoperability, e.g. Industry 4.0 or electric vehicles, or quality, e.g. health, are also more motivated to focus their research on standardisation. Secondly, respondents being active in the quality infrastructure point to links of standardisation to metrology and elements of conformity assessment, like certification. In addition, respondents mention that standards might also help to improve research itself and the competencies of students and professionals. Finally, several respondents stress that the existing research gaps provides interesting opportunities for performing research.

Assessment of drivers differentiated by activity

The further differentiation of the answers reveals that those active in conducting research or teaching standardisation rate in general all drivers as being more relevant, which is not surprising and supports the consistency of the answers.

Assessment of drivers differentiated by employing institution

An option to separate the answers between those respondents focusing on research versus the others more engaged in education is to consider whether the employer is a PRO or a HEI. This distinction is even more rigorous than the previous ones, especially by excluding those linking themselves to both types of organizations. However, we find no difference between those being employed by PROs and those working for HEIs with regards to the drivers for performing research. The only exception is the significantly higher assessment of the opportunity to exploit synergies with teaching, which is obviously less relevant for those respondents working for PROs who in general have no or little teaching obligations.

Assessment of drivers differentiated by professional attitude

The professional attitude of the respondents also has an influence on the assessment of the relevance of the drivers. In detail, those respondents supporting a close collaboration between research and education or entrepreneurialism of HEIs and PROs assess almost all drivers as being more relevant. The relationship to the other three statements reveals mixed patterns.

3.2.2.2 Barriers

Looking at the barriers, the three most important and highly correlated (more than 0.50) obstacles for the respondents to conduct research in the area of standardisation is the limited appreciation both within the scientific community – also confirmed by the lack of journals with a high scientific impact – and within their own organization.

At first glance, these answers are contradicting the high relevance of intrinsic motivations as drivers for conducting research. However, the low relevance of gaining prestige via research in standardisation is in line with the assessment of the barriers. In addition and more importantly, the motivation for conducting research in the field of standardisation is driven by the transfer of the results into standardisation processes and the development of personal and professional networks, which is more

appropriate for applied research. In contrast, the important barriers are more related to basic research and its results.

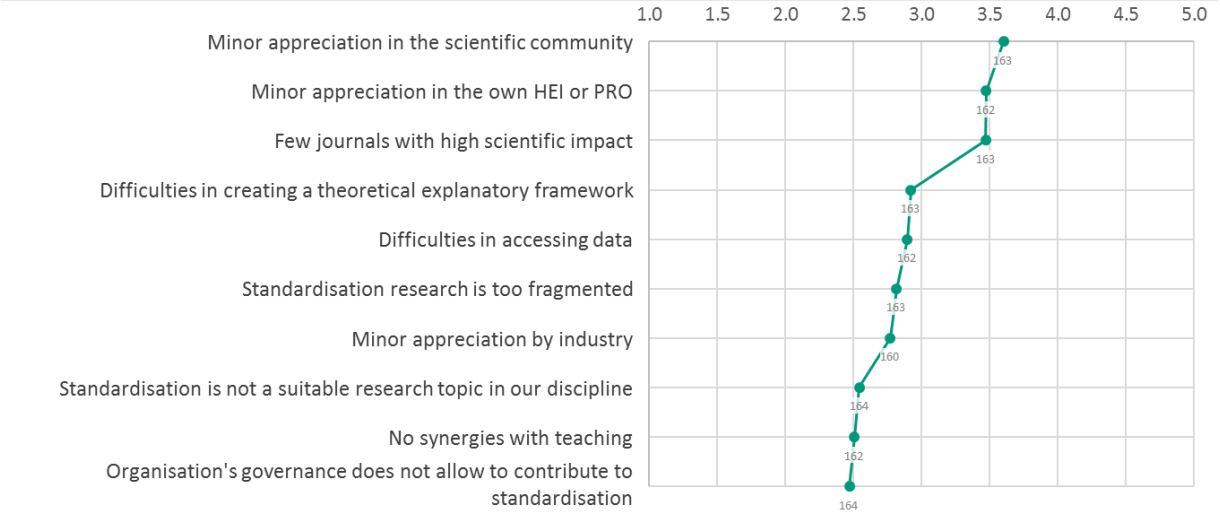


Figure 12: Barriers for conducting research in standardisation (1 = very irrelevant to 5 = very relevant)

All other barriers are rated below medium relevance (= 3) related to barriers. However, there are obviously difficulties in establishing a common theoretical framework or basis for conducting standardisation research, which might be connected due to the inherent fragmentation of standardisation research. It also has to be noted that researchers have difficulties in accessing data, e.g. about standardisation activities within NSBs. These assessments are significantly correlated (0.63) with those regarding problems in creating a theoretical explanatory framework, which indicates a close link between theory development and empirics. Whereas the missing appreciation by industry is still slightly relevant, standardisation is for most disciplines a suitable research topic and both missing synergies with teaching and hurdles of the own organization's governance are not a real problem. Additional barriers named by the respondents is the lack of funding not only for standardisation research, but also for attending and travelling to meetings of standardisation committees (see already Blind and Gauch 2009). However, it is also criticized that the work in these committees is quite time-consuming and dominated by stakeholders from industry and not considered to be scientifically leading edge.

Assessment of barriers differentiated by discipline

Considering respondents with an engineering background, it becomes obvious that they suffer more strongly by the lack of appreciation for the topic of standardisation within their own scientific community. However, their organizations do not hinder them as well as those working in a PRO or HEI with a focus on IT to contribute to standardisation activities.

Assessment of barriers differentiated by country

Again, the respondents from Germany do not only rate the drivers to conduct research on standardisation as being less relevant, but face barriers that are also less relevant. In particular, they perceive the missing external and internal appreciation as not so severe a problem. In contrast, the respondents located in Ireland are confronted with barriers that are more relevant. In particular, they rate significantly higher the problems related to the difficulties in accessing data or developing a theoretical framework for their research. In addition, their organizations generate more problems for those interested in contributing to the standardisation processes.

Assessment of barriers differentiated by activity

Differentiating the assessments according to the respondents' activities confirm the consistency of the answers, because the respondents conducting research or teaching on standardisation rate in general all drivers as being less relevant.

Assessment of barriers differentiated by employing institution

The separation of the answers according to the employing institution reveals that respondents working for HEIs assess all barriers related to performing research on standardisation as more relevant. The researchers employed by PROs face significantly less problems, which might be due to their better

funding. Furthermore, the latter perceive less problems of missing support by industry, which might also be explained by their stronger focus on basic instead of applied research.

Assessment of barriers differentiated by professional attitude
Furthermore, those respondents attributing a high relevance on academic freedom of research perceive almost all barriers as being less relevant. In contrast and surprisingly, respondents supporting the entrepreneurialism of HEIs and PROs assess the barriers as slightly more relevant.

3.2.2.3 Solutions

In a third step, we asked the target group to assess the effectiveness of various solutions to foster more research on standardisation. As expected, more public funding is perceived as the most useful solution. Here, the individual remark by a respondent that within standardisation applied research is increasingly being performed might be an addition legitimation for such a public funding. It is also interesting to have a closer look at the other options, which are rated very similar with the exception of the least useful offering personal financial incentives. This last observation is in line with the ranking of the drivers and the findings by Blind et al. (2018) about the motivations of researchers involved in standardisation.

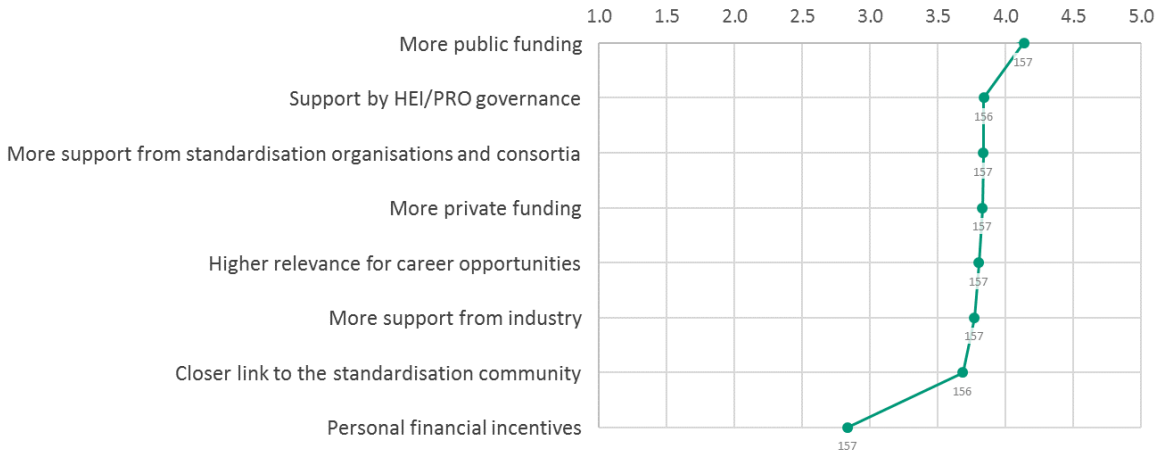


Figure 13: Solutions to foster more research on standardisation (1 = least useful to 5 = most useful)

The second most appropriate solution is the support by the governance of the PROs and HEIs, which reflects the high relevance of missing appreciation by the own HEI or PRO, but not necessarily the hurdles generated by the own organisation's governance. In this context, one has also to mention the higher relevance of standardisation research for career opportunities. Outside the HEIs or PROs, more support from SDOs or consortia is asked for, e.g. by making both standards and data about standardisation more easily accessible, combined with closer links to the standardisation community. Finally, more private funding in particular, which includes projects funded by industry, but also more support from industry in general, like interest in common research projects funded by third parties or providing access to company-internal data, has to be mentioned, which assessments are highly correlated (0.56). For example, it is also suggested to fund training about standardisation processes and the use of standards in industry. In an interview, the exchange of personal between standardisation and research organizations was suggested to improve the mutual understanding and eventually the collaboration.

Assessment of solutions differentiated by discipline
Focusing on the disciplinary background, the subgroup with an engineering degree does not differ in their answers from the other respondents. However, those respondents with a focus on IT or working in a PRO or HEI with a focus on IT would appreciate a stronger support by their organizations, but – compared to the others – less support from standardisation bodies or consortia.

Assessment of solutions differentiated by country
The respondents located in Germany do not only rate the drivers and barriers as being less relevant compared to the respondents working in the other countries, but perceive consequently the presented solutions as being less useful. In contrast, the respondents working in Ireland assess all solutions as

being slightly more useful than the other respondents, which is consistent with the higher relevance of barriers, they perceive related to conducting research on standardisation.

Assessment of solutions differentiated by activity
Differentiating the answers by the activities of the respondents reveals that those conducting research or teaching on standardisation rate in general all solutions as being more useful, because they would immediately benefit from the suggested measures.

Assessment of solutions differentiated by employing institution
Although the respondents working for HEIs perceive the barriers as more relevant, their assessment of the efficiency is only slightly higher, but does not differ significantly between the two groups.

Assessment of solutions differentiated by professional attitude
Finally, the professional attitude of the respondents has a strong influence on the assessment of the appropriateness of the solutions, i.e. a higher support of closer collaboration between research and education, of professionalism in education, of academic freedom and of entrepreneurialism of HEIs and PROs leads to almost all solutions being assessed as more useful. Only the attitude towards personality development does not correlate with the assessment of the solutions.

3.2.3 Drivers, barriers and solutions for providing teaching on standardisation

3.2.3.1 Drivers

In the second main part of the survey, the target group has been asked to assess possible drivers for offering courses on standardisation.

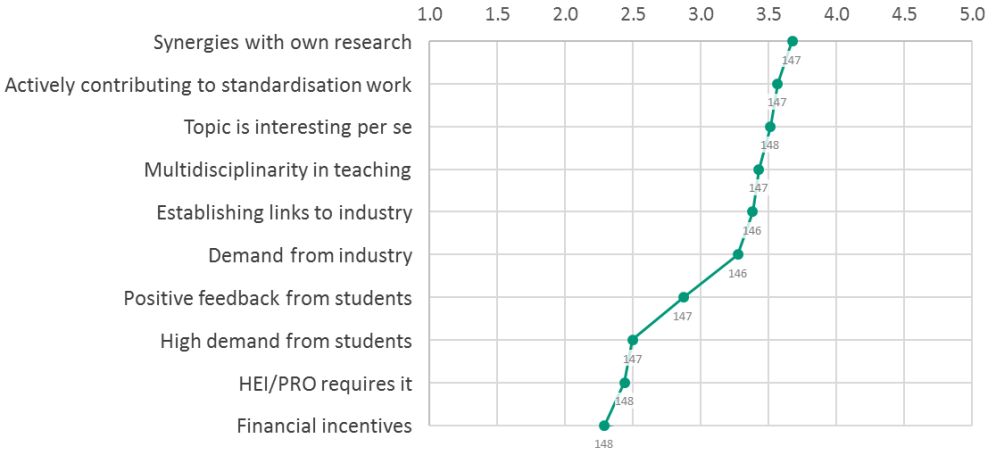


Figure 14: Actual or possible drivers for offering courses on standardisation (1 = very irrelevant to 5 = very relevant)

The most important driver are the synergies with own research on the one hand and the active contribution to standardisation work – another type of synergy – on the other hand. Obviously, standardisation research and work provide important impulses and for those respondents teaching on standardisation. Furthermore, the intrinsic interest in the topic and the multidisciplinarity in teaching follow in the ranking of the drivers. The third and highly correlated (0.78) couple of drivers above the threshold of medium average is the opportunity provided by teaching to establish links to industry, but also responding to the needs from industry (see Blind and Drechsler 2017). In this context, it is also mentioned that illustrative examples from industry or even common workshops with industry are encouraging to teach about standardisation. Finally, neither the positive feedback from students nor the demand from students are relevant drivers to offer courses on standardisation (see already Hesser and de Vries 2011). As expected, the answers to these two questions are highly correlated (0.77). Consequently, there is also no push from the own institution. And financial incentives play as in the case of standardisation research no role. The positive correlation (0.57) of the answers to these questions reveal that if there are requirements from the own institutions, then they are often connected to financial incentives.

Assessment of drivers differentiated by discipline
In particular, the respondents with a background in IT teach about standardisation, because the topic is interesting per se and they can exploit synergies with their own research. However, this is not reflected by a higher demand from students as a further driver despite the slightly higher demand from industry and the opportunity to establish both closer links to industry and to actively contribute to standardisation, which is also the case of the subgroup of respondents with an engineering background.

Assessment of drivers differentiated by by country
The lower ratings by respondents from Germany related to the drivers, barriers and solutions for performing research about standardisation is continued also for the drivers related to teaching about standardisation. In contrast, the Dutch respondents – in contrast to the participants from Ireland – are more driven by the interest in the topic and the synergies with the own research, but less by the links to industry and active standardisation participation.

Assessment of drivers differentiated by activity
The differentiation of the answers by respondents conducting research or teaching on standardisation reveals – as expected – that they rate in general all drivers as being more relevant. Furthermore, respondents working in smaller organizations rate the demand by and links with industry as more relevant.

Assessment of drivers differentiated by employing institution
Those respondents being employed by HEIs and consequently engaged in education assess the drivers for offering education about standardisation – in particular the demand both from students and industry – as more relevant compared to those researchers being employed by PROs. This finding has been expected, but underlines the consistency of the respondents' answers.

Assessment of drivers differentiated by professional attitude
Finally, their professional attitude has also an influence on their assessments, e.g. for those putting an emphasis on a close collaboration between research and education the synergy with research is even more important. Interestingly, the high share of respondents showing a high level of agreement related to professionalism in education is surprisingly less convinced related to almost all drivers, which is in contrast to the assessment of those respondents supporting entrepreneurialism of HEIs and PROs.

3.2.3.2 Barriers

The ranking of the relevance of the barriers for offering courses on standardisation reflects very well the ordering of the drivers. In particular, students are obviously more interested in other topics, which supports the low relevance of their demand as driver for proving courses on standardisation. Furthermore, there is a fierce competition among topics to be included in the curricula, which makes the inclusion of standardisation – being of limited attractiveness for students – quite difficult, especially since most faculties does not support it, which is according to Brennen et al. (2014) a major barrier for the introduction of new courses in general. The answers to these questions are consequently correlated. All other barriers, like other topics being more interesting for the respondents themselves, low demand from industry, unavailability of teaching material and missing synergies with the own research, are less than of medium relevance, but highly correlated (more than 0.50), i.e. either all these barriers together are of low or high relevance for the respondents. However, several respondents underline in their written comments, but also in the few interviews that the limited access to standards and the cost of developing teaching material is a severe barrier for teaching about standardisation. Here, the multidisciplinarity of the topic presents another challenge, because it has mentioned in the comments that the teaching material has to be adapted to each discipline.

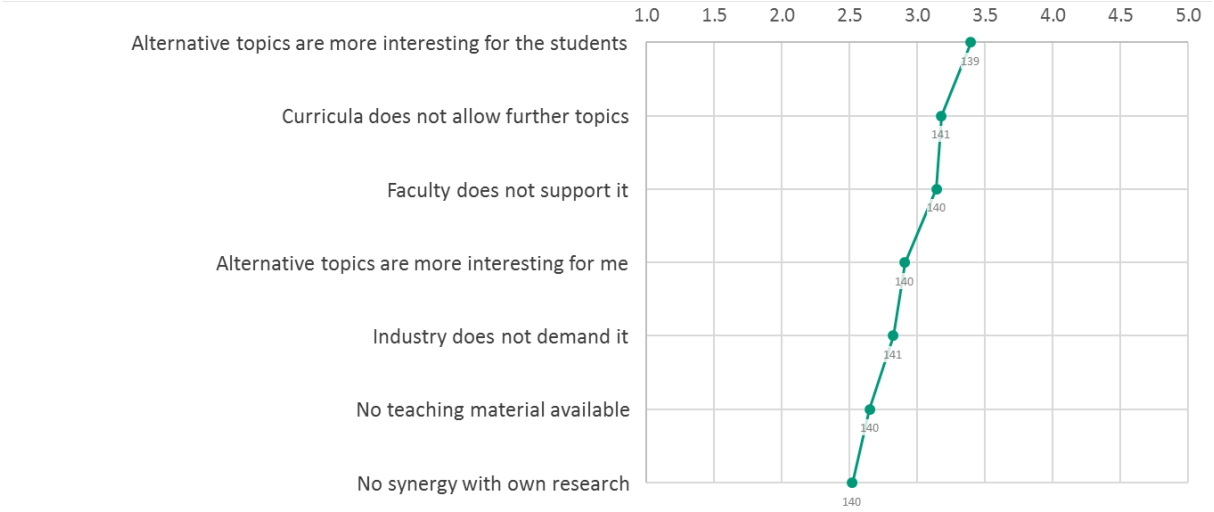


Figure 15: Barriers for offering courses on standardisation (1 = very irrelevant to 5 = very relevant)

Assessment of barriers differentiated by discipline

The answers of respondents with a background in engineering or IT do not significantly differ from the rest of the answers

Assessment of barriers differentiated by country

However, respondents located in Germany perceive on the one hand slightly less missing support from the own faculty to include standardisation in the curricula and on the other hand less lacking demand from industry as a problem. In contrast, the respondents from Ireland face in general all barriers as being slightly more relevant, whereas the Dutch respondents miss in particular the support of the own faculty to get the topic standardisation into the curricula.

Assessment of barriers differentiated by activity

The further differentiation of the answers into those conducting research or teaching on standardisation confirms the consistency of the answers, because they rate in general all barriers as being less relevant for them. However, respondents with a strong focus on teaching within the portfolio of their activities rate most of the barriers as more relevant.

Assessment of barriers differentiated by employing institution

Since education for respondents being employed by PROs is less relevant, they assess the barriers for offering education about standardisation as being less relevant compared to those researchers being employed by HEIs.

Assessment of barriers differentiated by professional attitude

The professional attitude of the respondents correlates only weakly with their assessment of the barriers. Only those respondents attributing a higher relevance to a close collaboration between research and education perceive the barriers slightly less relevant. Again, for respondents supporting professionalism in education the missing support of the faculty is less relevant.

3.2.3.3 Solutions

Finally, looking at the ranking of the solutions proposed to foster education on standardisation we observe no clear first-best option. Only providing personal financial incentives is not very useful. However, the respondents see more support from industry as the most promising solution highly correlated (0.80) with a stronger demand signal from industry. In this context, it is suggested to offer courses in industry – even for free – about the relevance of standardisation. In parallel, more support from standardisation organisations and closer links to the standardisation community are assessed in a similar and highly correlated way (0.72). For example, both researchers being involved in standardisation processes and standardisation organizations could be invited to present success stories to students. In addition to more external help, the respondents agree that standardisation has to be embedded into the theories of traditional academic disciplines, which is obviously conditioned by its multidisciplinary character a challenge. Finally, more courses would be offered, if it would be more relevant for the own career, the demand by students (a major barrier) and the support from the own faculty was higher. The latter two options are highly correlated (0.51), i.e. with a stronger support of the faculty the demand by students could be increased, e.g. by making standardisation courses obligatory.

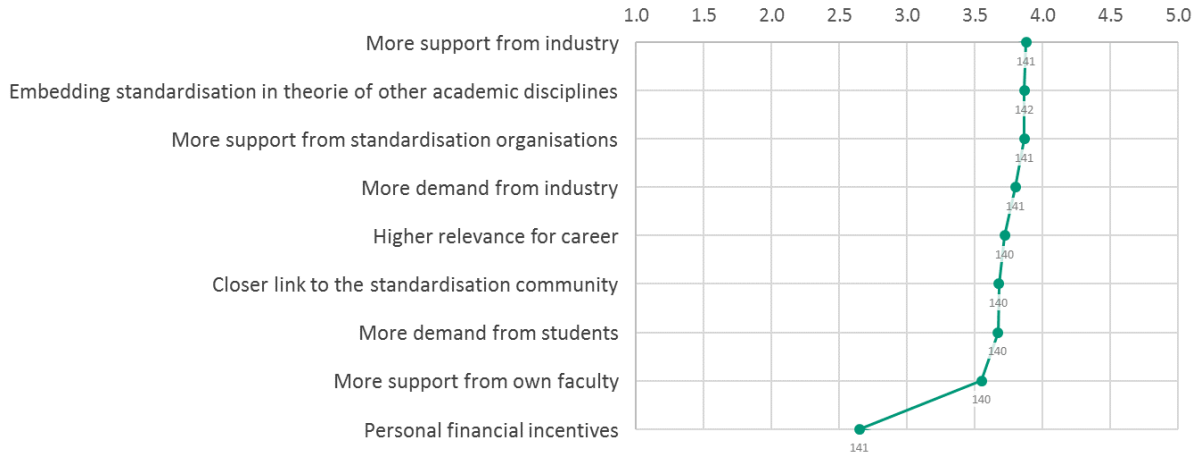


Figure 16: Solutions to foster more education on standardisation (1= least useful to 5 = most useful)

Assessment of solutions differentiated by discipline

The respondents with a background in IT or engineering would benefit in performing research about standardisation by a stronger support or demand by industry. In addition, the experts with a background in IT wish a higher relevance of teaching about standardisation for their career, whereas the subgroup focusing on engineering would appreciate a stronger support from the standardisation organisations.

Assessment of solutions differentiated by country

Whereas both the respondents located in Germany, but also in the Netherlands rate almost all solutions as slightly less useful than all other respondents, the Irish participants perceive all of them more useful in particular the support from standardisation organisations.

Assessment of solutions differentiated by activity

The differentiation of the respondents according to their activities reveals again that respondents conducting research or teaching on standardisation rate in general all solutions as being more useful. In addition, those respondents focusing on teaching perceive the proposed solutions as more useful as the average. Furthermore, respondents from smaller organizations need more external support from industry, SDOs and the standardisation community.

Assessment of solutions differentiated by employing institution

Since education for respondents being employed by HEIs is much more relevant than for employees of PROs, the former are much more convinced about the efficiency of the proposed solutions, in particular those linked to increased demand both from students and industry.

Assessment of solutions differentiated by professional attitude

Finally, the professional attitude of the respondents has an influence on their assessment of the solutions, i.e. respondents endorsing a closer collaboration between research and education and entrepreneurialism of HEIs and PROs assess almost all solutions as being more useful.

As a kind of consistency check, the respondents as actual or potential providers of courses on standardisation have been asked about the relevance of certain competencies related to standardisation for graduating students. The list of compentencies have been identified by Blind and Drechsler (2017) and assessed by over two hundred experts from industry and the public sector representing the demand side. Figure 17 reveals impressively the very similar ranking, which shows that at least not the wrong priorities on teaching contents are the reason for the low demand of industry for education on standardisation. However, the competencies related to process and technical aspects of standardisation processes and standards are rated much higher than the need to understand their impacts, which is of much more strategic relevance both for the management level in industry, but also policy makers and consequently also HEIs .

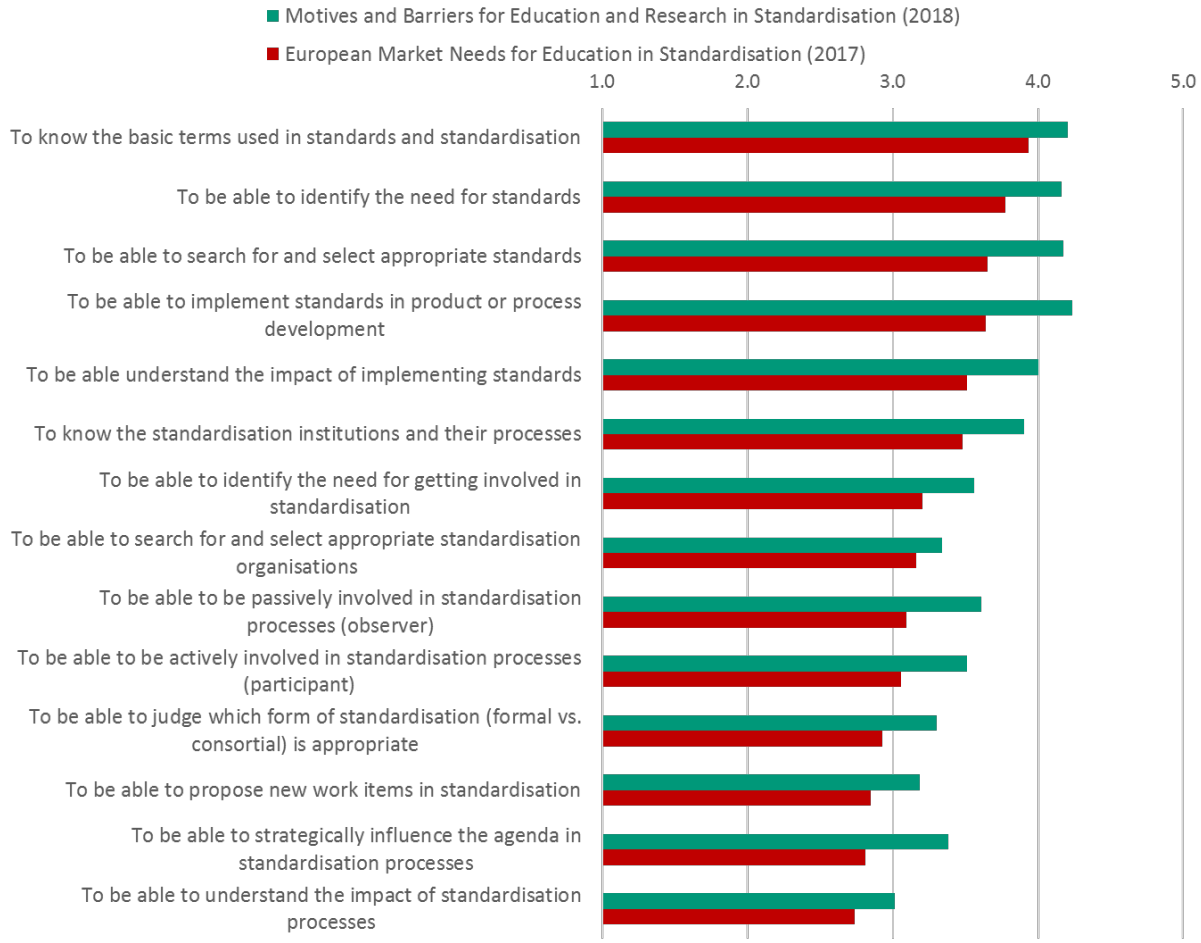


Figure 17: Relevance of competencies related to standardisation for graduate students (2018: least relevant [1] to most relevant [5]; 2017: Not relevant for handling my work tasks [1] indispensable for handling my work tasks [4], data sclaed up to 1-5

3.3 Summary

In this final section, we summarize the findings of the empirical study and compare them with the few relevant studies from the literature.

Regarding conducting research on standardisation, knowledge exchange and transfer have been identified as major drivers, but also the contribution to public welfare in general and standardisation in particular. This intrinsic motivation has already been identified by Blind and Gauch (2009) focusing on nanotechnology and recently by Blind et al. (2018) where scientific publishing and patenting were compared based on the assessments of researchers working in an institute of materials research. Obviously, research on standardisation has a very multidisciplinary, but also applied character, which makes standardisation activities as a transfer channel and network opportunity very interesting, particularly for engineering and IT

The major barriers for not performing research is a lack of internal and external appreciation which again supports the findings of Blind and Gauch (2009) and Blind et al. (2018), as well asBlind and Mangelsdorf (2009) whose study focused on participants in standardisation from the German machinery and electro-technology sectors.

Morepublic but also private funding is suggested as most appropriate solution. However, a change in the internal governance to support research on standardisation and more support by SDOs is also requested.

The major drivers for education on standardisation are synergies with research, contributing to standardisation as a topic per se, its multidisciplinary nature and eventually links to and demand from industry. The latter two are highly correlated, i.e. the closer the links the higher the demand from industry, which calls for a more intensive integration of industry into the teaching of standardisation. This confirms also the recent findings by Hewitt-Dundas and Roper (2018), who identify the engagement with business in addition to both the availability of financial resources and the financial pressure as driver of programme innovation, i.e. the introduction of new programmes and the withdrawal of existing programmes in UK universities. In addition, Brennen et al. (2014) show, based on case studies, that changing demand for higher education is reflected in the provision of new programmes.

However, the missing interest by students and support by their own faculty makes the integration of standardisation into the curricula difficult again supporting Brennan et al. (2014), who show that the lack of institutional support including a missing autonomy or a restrictive regulatory framework is hindering the introduction of new programmes into the curricula.

Since the barriers are more severe internally, more external support, support by SDOs and an increase in demand from the private sector are perceived as useful solutions. Nevertheless, the researchers also have to do their “homework” by embedding the topic of standardisation in a more convincing way into the theories or toolboxes of the various academic disciplines.

Combining the assessments related to research and education about standardisation with the characteristics of the respondents, some additional insights can be derived. Firstly, the strong intrinsic motivation of experts involved in standardisation, doing research and providing teaching about standardisation has to be noted. This might be an important component to take into account for the derivation of solutions. Secondly, the high synergies between research and education on standardisation, but also the active involvement in standardisation is an important aspect to be considered. Thirdly, researchers being employed at HEIs face more problems in general than those working at PROs. Fourthly, as indicated in the answers to the open questions there are obviously between synergies between standardisation, conformity assessment and metrology within the whole Quality Infrastructure (Guasch et al. 2007), which are an interesting opportunity to integrate other institutions and their resources in possible solutions.

4 Recommendations

Based on the survey results, qualitative insights from the comments - to the open questions and a validation workshop with the members of the ETSI Strategic Task Force 515 “Design and Development of Teaching Materials for Education on ICT Standardisation” and the representatives of three national SDOs in Leipzig, the following general recommendations can be derived including specific measures for PROs, HEIs, SDOs, industry and other stakeholders before eventually the possible implications for the Joint Initiative of Standardisation JIS are elaborated.

4.1 General Recommendations

Firstly, despite the very comprehensive approach to address researchers possibly interested in performing research and offering teaching, the number of responses to the survey remained rather low in particular by respondents involved in both research, education and standardisation itself. Therefore, there is a generic need to promote the visibility of standardisation as a subject for research and teaching.

Secondly, there is a high level of fragmentation within the standardisation research community due to the high degree of multidisciplinarity. Indeed, the single disciplines are unable to build a critical mass. Therefore, all interested and relevant academic disciplines should be invited to contribute to a common comprehensive theoretical framework as basis for further future research activities. Such a common framework would increase the visibility and acceptance of standardisation in the different scientific disciplines.

Thirdly, the awareness of students about the relevance of knowledge about standardisation is limited. In addition to the promotion of attending voluntarily courses, the introduction of basic modules about standardisation focusing on the main elements (see Blind and Drechsler 2017) in obligatory courses,, such as those initiated by Danish Standards in collaboration with the faculties of the Danish universities, could trigger a basic awareness leading to a greater interest among students overcoming the major problem of missing students’ interest. This increased awareness might eventually change the perception of the respondents in the sense that students’ interest will become an important driver for offering education about standardisation.

Fourthly, even before addressing the issue of standardisation within HEIs it is necessary to teach teachers in secondary and tertiary schools to include basic elements about standardisation within the curricula e.g. of social studies pushing the awareness of the important role of standardisation and standards for society in general.

Fifthly, support measures should address both standardisation research and education, but also consider their activities in standardisation due to the large overlap of the activities and the strong positive synergies. From an economic perspective, both the standardisation research and teaching and the active involvement (in standardisation) contribute to a public or at least a club good, i.e. the development of a standard. Therefore, publicly funded support can be justified in general and particularly with the case of health, environmental and safety standards, because they generate positive externalities, i.e. even a double dividend.

Since standardisation plays a more important role for both standardisation research and teaching for engineering in general and IT in particular, the highest benefits of support measures can be expected here in the short term, because there are also the closest links to industry in general and standardisation activities in particular. Country-specific characteristics, like the focus on engineering or IT, should be taken into account as well as the general level of development of research and teaching about standardisation. Countries with an established infrastructure in standardisation research and education could share this with those countries missing these institutions, e.g. in the context of the principle of twinning projects.

Sixthly, standardisation is a central instrument of the national or European Quality Infrastructure, which has also the character of a public good. Therefore, support measure should consider the synergies with conformity assessment and metrology. For example, the European Metrology Programme for Innovation and Research (EMPIR) as integrated part of Horizon 2020, the EU Framework Programme for Research and Innovation has already included pre- and co-normative programmes to support timely metrology research to underpin the quality and to accelerate the development of a draft specification (to be used for European or International standards). This kind of collaboration should be continued and expanded to push PROs and HEIs to intensify their activities in standardisation research and education. In particular, since Fenton et al. (2018) have shown that international standards are only partly refer to in scientific references.

Seventhly, standardisation is an important instrument for SMEs (Blind and Mangelsdorf 2013) or Start-Ups (Abedelkafi et al. 2016). Since governments have recognized market or system failures related to SMEs and Start-Ups, they are supporting education in particular related to entrepreneurship. Therefore, public support programmes to develop and establish university curricula about entrepreneurship, but also entrepreneurship at universities, like EXIST in Germany, should explicitly incorporate the support of participation in standardisation and not only the support of patent applications or trademark registrations.

Eighthly, supporting instruments and initiatives should integrate the resources already available at SDOs. Here, the access to standards and Technical Committees not only for researchers focusing on and academics teaching about standardisation, but for researchers in general has to be facilitated by the SDOs of the Member States, if this not already the case. However, these solutions should and could be shaped in a way that they are not challenging the running business models of the SDOs. By opening the SDOs for researchers, the latter become also more attractive for companies due to the important motive of knowledge sourcing (Blind and Mangelsdorf 2016). Nevertheless, companies already active in research and having a potential interest in standardisation should be integrated in such support schemes, e.g. the Germany Federal Ministry of Economic Affairs and Energy has launched a program WIPANO to support knowledge transfer via patents and standards, which is funding not only research organizations, but also companies developing their research further towards standards.

Ninthly, industry companies and other stakeholders, e.g. governmental and non-governmental organizations, active in standardisation, but also the SDOs themselves have to signal much more explicitly their demand for graduates educated in standardisation, but also standardisation research more proactively to PROs and HEIs. Here, the public sector could play the role of a forerunner, because the executive bodies, like the European Commission or at national ministries, have a significant demand for graduates with a background in standardisation to develop and implement standard-related public policies, e.g. focusing on technology transfer. This pioneering role might also trigger the expansion of the contents of the programmes and courses about standardisation from a rather technical or engineering focus to a much broader economic, legal and eventual socio-scientific spectrum.

Industry funded research about standardisation or guest lectures by industry representatives, but also by governmental officers and even researchers active in standardisation, might be a signal to students to attend courses related to standardisation, because there is obviously a demand for standardisation-related competencies (Blind and Drechsler 2018). Furthermore, internships offered to Master or PhD students by industry, the public sector and SDOs are a further step to make research and- through the high level of synergies- also teaching about standardisation more attractive. From previous studies (e.g. Blind and Mangelsdorf 2009; Blind and Drechsler 2017)) the need to raise awareness for the advantages of standardisation within companies has been confirmed. Since this is challenging for the mostly small standardisation departments, Blind and Drechsler (2017) already recommended a closer interaction with the R&D departments, which rely on more resources and have in general already existing collaborations with research organisations, including universities. Our findings of the high synergies between research and education in standardisation endorse this recommendation, i.e. the existing research collaborations of companies should be leveraged to research and eventually education activities, e.g. guest lectures or internships, focusing on standardisation.

Tenthly, PROs and HEIs have to adapt their incentives schemes and governance to acknowledge the research and teaching about standardisation to attract internally more researchers. Very few PROs have

already included the contribution of standardisation in their mission statement and consequently in their reporting system not only covering scientific publications and patents, but also the contribution to standards (Zi and Blind 2015; Blind et al. 2018). However, this approach has to be extended to a much larger number of PROs and HEIs.

In summary, obligatory lectures on standardisation, will increase the awareness of the students in the short term, promote the demand by industry in the medium term and could be complemented by the education of teachers about standardisation in the long term. The above-elaborated demand-oriented approaches together with these supply driven initiatives could help overcoming the present vicious cycle.

Since many of the experts involved in standardisation research & teaching are very intrinsically motivated and at least a significant share have an 'entrepreneurial' spirit to tackle the existing barriers and to try possible solutions to overcome them, they are an important source of support for possible initiatives.

Finally, successful examples show that a longterm support (like the Chair of Standardisation at the Erasmus University in Rotterdam funded by the Dutch Standardisation Institute NEN or the German Standardisation Panel performed by the Chair of Innovation Economics at the Technical University of Berlin and funded by the German Standardisation Institute DIN) for the development of an eco-system of researchers, teachers, SDOs, experts, companies and other stakeholder (involved in standardisation) has to be assured to allow a self-sustaining combination of research, teaching and the active involvement in standardisation, like the longterm funding of regional or technological clusters.

4.2 Recommendation for general further actions for the work of JIS and the EC policy

Guided by the shared vision for European standardisation of the Joint Initiative on Standardisation (JIS) aimed at improving the current European standardisation system, we are able to derive some recommendations based on the findings of our study. In order to do so, we structure our recommendations according to the three domains and the related relevant actions identified for improving the European Standardisation System.

4.2.1 Awareness, Education and Understanding about the European Standardisation System

The first domain for improving the European Standardisation System is focusing on awareness raising and education.

The envisaged study on the economic and societal impacts and benefits of standards under Action 1 should consider the synergies between research, teaching and active involvement in standardisation in its analysis. In addition, the results could reveal interesting and illustrative insights and examples to illustrate the impacts of standardisation in practice to be used for teaching material.

Action 2 aims to improve the link between research and innovation through standardisation. Again, the survey has shown a large overlap between being active in standardisation and both performing research and teaching about standardisation. In order to exploit this synergy, researchers should receive a basic education in standardisation in general. In particular, the education programmes offered by HEIs should also provide contents focusing on standardisation as a link between research and innovation.

Action 3 aiming at developing programmes of formal education and vocational training should take into account the findings of our survey, i.e. about the drivers to offer such courses, the identified barriers and the priorities in the solutions (see section 4.1).

Action 4 intending to improve standardisation awareness in public authorities could benefit from the programmes developed under Action 3. In addition, public authorities could signal their demand for graduates with competencies in standardisation to the HEIs, e.g. by giving guest lectures, offering internships or funding projects on standardisation in collaboration with PROs.

4.2.2 Coordination, Cooperation, Transparency and Inclusiveness

Following the basic dimension on awareness, education and understanding, the second domain of the JIS is trying to improve the transparency and exchange of information to improve the effectiveness of legislators' use of the European Standardisation System. Therefore, Action 6 asks for the establishment of a roundtable. As already argued by Blind and Drechsler (2017), more education leading to better competences related to standardisation will improve the effectiveness of the intended information exchange among the various stakeholders. In addition, the requirements of the round table related to education requests should be taken into account in shaping the education programmes under Action 3. Finally, our results reveal the multidisciplinarity of standardisation research, which could enrich the discussions at the roundtable, e.g. about the links of standards to the regulatory framework in the European Union.

Stakeholder collaboration is crucial for the efficient implementation of Regulation (EU) 1025/2012 and addressed in Action 7. Better-educated representatives of stakeholder groups will improve this collaboration. Consequently, the education programmes under Action 3 are relevant. Therefore, the insights of our study to facilitate their establishment should be used.

The needs of markets, regulations or public policies for standards are addressed in Action 8. Exploiting the obviously high overlap between standardisation related research and involvement in standardisation more researchers in standardisation could contribute to a better performance in terms of quality and timeliness of European standards, in particular linked with policy and regulations. This is already requested and implemented by the European Metrology Programme for Innovation and Research (EMPIR), which could be opened up to more organizations with other disciplinary backgrounds.

Since Action 9 asks for a more inclusive and effective participation of all relevant stakeholders, representatives of PROs and HEIs should also be addressed, e.g. by facilitating their access to standards and standardisation processes. This could also lead to a better representation of environmental or social interests by researchers active in these specific areas.

Action 10 expands the focus of promoting stakeholder participation to all categories at the national level, because contributions from all stakeholders are considered to be pivotal in order to produce state-of-the-art standards. Researchers could contribute to a better science and technology base of standards, which is obviously not in all areas already the case (Fenton et al. 2018).

Already under Action 4, the intention is to improve the awareness of standardisation to public authorities. Among those public procurers are explicitly addressed in Action 11 by asking for an increased use of standards in public procurement to achieve a more efficient implementation of the new procurement directive. Since standards, in particular those based on leading edge research insights and technologies might be able to push innovation via public procurement (Blind 2008), the more intensive involvement of researchers already addressed under Action 10 is also important for the success of Action 11.

4.2.3 Competitiveness and International dimension

The third domain of actions for improving the European Standardisation System is addressing competitiveness and the international dimension.

Action 12 is pushing the development of service standards. It can be promoted by programmes in formal education and vocational training addressing standardisation to be developed under Action 3 taking the specific needs of the service sectors into account.

The successful European regulatory model based on the complementarities of general regulations specified by harmonized standards is intended to be promoted outside the EU under Action 13, e.g. at ISO and IEC level. Since researchers and teachers active at PROs and HEIs in the Member States having either an international background or are used to collaborate with other researcher world-wide, they have good starting positions to represent the European interests at the international standardisation

committees. DG CONNECT has already launched with “Supporting European Experts Presence in International Standardisation Activities in ICT” a funding scheme, which is also accessible for researchers focusing on ICT standardisation.

Standardisation is challenged by digitisation, but can also support the digitisation of European industry as claimed under Action 14. Researchers and teachers focusing on standardisation can contribute to this objective by being actively involved in standardisation with their expertise, which is often based on an engineering degree. Even teaching of standardisation could benefit by digitalisation, e.g. by offering online courses.

Finally, the better representation of the interests of SMEs in Europe in international standardisation processes called for in Action 15 could be supported by researchers becoming active in standardisation. They could provide more science- and technology-based solutions for future standards as a counter force against the positions of the already dominant players in the market.

Overall, research and education about standardisation is a crucial input for the success of the majority of the planned Actions under the JIS. In addition, more and better educated stakeholders will contribute to a higher likelihood of their success and a broader impact. Consequently, this aspect has to be systematically considered in the planning and performance of all other Actions by supporting research and education about standardisation.

5 Literature

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