

Standardization Education

by
Henk J. de Vries*

Abstract: In this paper, standardization education is studied by combining standardization practice and academic reflection on that with the area of (regular and continuing) education. The question, which people are to be educated in standardization, is answered by making use of a standardization model. The education should be related to the standardization tasks and competences necessary for carrying out these tasks. The preference for exemplary learning (real-life case studies) is based on Van de Lagemaat's theory on business education. The case-study approach is demonstrated by providing two examples of standardization education at higher vocational and university level. The contribution concludes by presenting how to develop a multidisciplinary standardization curriculum.

1. Need for standardization education

Is there any need for standardization education? Most countries in Europe offer education on standardization. This appears from an inventory carried out for BSI Education (*M & E Consultants*, 2001). Often this education is offered by the national standards body in the form of publications, web site information, courses and/or seminars. In general, however, very little effort is done in Europe related to standardization training and education (Borde, 2004). The number of textbooks on standardization has risen - some recent examples include Billotte (1997), Cargill (1997), Hesser and Inklaar (1997), Schmidt and Werle (1998), Shapiro and Varian (1999), Spivak and Brenner (2001), and Wenström, Ollner and Wenström (2000). However, related to the number of people that spend a certain amount of their time in developing or using standards,¹ this is just a

*Erasmus University Rotterdam, Rotterdam School of Management / Faculteit Bedrijfskunde, P.O. Box 1738, Room F2-54, NL 3000 DR Rotterdam, The Netherlands, e-mail: h.vries@fbk.eur.nl. Three anonymous reviewers and Manfred J. Holler gave helpful comments.

¹7000 experts participate in committees of NEN, the national standards body of The Netherlands. Outside NEN, other Dutch standards development activities apply, so the total number of people

beginning. In general, companies nor standardization bodies or other parties involved in standardization activities consider standardization as a profession for which professional education (and scientific underpinning) might be beneficial. Participants in standardization may have more or less clear ideas about what they need to be able to achieve their goals. The result is that standardization activities are carried out in a rather primitive way, no matter whether company standardization, standardization in consortia, or formal standardization is concerned.² But this is not considered a problem as long as the people involved, mostly technicians, do not know that improvements are possible and insights have been developed already. Unknown, unloved. 'The market' hardly asks for standardization education (or research), in some technical areas with an exception for education concerning the application of certain standards. In the United States, the Accreditation Board for Engineering and Technology specified that students in technical education must have a 'major design experience' that includes the use of 'engineering standards and realistic constraints' (Gorman, 2003). Some standardization experts, in academia as well as standards bodies, stress the importance of standardization education and take initiatives in this area (*ASTM Standardization News*, 2003; Hesser and Hartung, 2001; Hesser and Siedersleben, 2004; *ISO Bulletin*, 2003; MOCIE and KSA, 2003).

The importance of standardization is growing; reasons for this have been listed by De Vries (1999b, p. 3-4), followed by a listing of problems related to the existing standardization practice (*ibid.*, pp. 4-6). Some of these problems might be solved or partly solved if participants would have been better educated. So the preliminary conclusion may be that there are good reasons for considering the possibilities of standardization education in order to be able to underpin decisions on offering education, if any, in this area.

involved in standards development will be roughly about 1‰ of the size of the population (16,000,000), not accounting the number of people involved in developing company standards. Of course, the number of standards users exceeds this number. Indirectly, everybody has to do with standards.

²As far as the area of company standardization is concerned this can be concluded from studies carried out by Biesheuvel, Verkuyl and De Vries (1993) and Oly and Slob (1999); for the area of formal standardization it appears from Bonner and Potter (2000), De Vries (1999), and Verheul and De Vries (2002). A case study we carried out on de facto standardization for banking chipcards (De Vries and Hendrikse, 2001) suggests the same applies there: main stakeholders took wrong decisions.

2. Methodology

In this contribution we will use the standardization definition we developed in an earlier publication (De Vries, 1999b, Chapter 8): standardization is the activity of establishing and recording a limited set of solutions to actual or potential matching problems, directed at benefits for the party or parties involved, balancing their needs, and intending and expecting that these solutions will be repeatedly or continuously used, during a certain period, by a substantial number of the parties for whom they were meant. As this paper discusses education in standardization that preferably uses the results of scientific research, three 'worlds' will have to be combined: standardization practice, standardization research, and (regular and continuing) education. In the first two areas we build on previous own studies on standardization practice (Simons and De Vries, 2002; De Vries, 1999b) and on standardization research (De Vries, 2001). In the area of education, lots of scientific approaches are available. As standardization is primarily a business activity, we opt for a business education approach. From those approaches we choose the one of Van de Lagemaat (1986), because we share his basic assumptions: he builds his study on the same philosophic approach (namely, Dooyeweerd, 1955 and 1957) we used in the study on standardization research (De Vries, 2001) and in a study on (management systems) standards application (De Vries, 1999a).

According to Van de Lagemaat (1986, p. 28), business education has a two-fold purpose: disclosing the subject matter for students, and disclosing students for the subject matter. Applied to standardization education: the purpose of standardization education is to disclose the standardization phenomenon in a way the students can understand it and to act with students in a way that they get accustomed with standardization, get knowledge about it and are equipped for using this knowledge in standardization practice. In academic teaching the knowledge may be applied in science rather than in business practice.

In Van de Lagemaat's educational approach (1986, p. 183), four questions are leading: *what* is done in practice (in this case, by people involved in standardization), *how* is it done, *why* is it done, and *why* is it done *in this way*? Before these questions can be answered it should be clear, *who* are involved in standardization. In this paper we will only touch the answers to the first four questions. At first we will address the question, which people are to be educated. We will make use of a standardization model (See Figure 1.) Standardization education should be related to standardization tasks and competences necessary for carrying out these tasks. This education can be continuing education, including post-graduate education as well as regular education; we analyze for which categories of students standardization should be part of the regular curriculum.

Due to their research activities, many researchers no longer see reality as it is, but ‘see’ mainly the aspects related to their own (mono)discipline. This, of course, influences their education activities. In order to avoid such one-sidedness, Van de Lagemaat (1986) recommends to pay systematic attention to the diversity of aspects of phenomena and to use exemplary learning (real-life case studies) to demonstrate how the different aspects apply. In this way, a better picture of reality-as-such comes into existence. In this paper itself, the case-study approach is demonstrated by providing the examples of standardization education at the *Hogeschool van Amsterdam* (higher vocational education) and the *Erasmus University Rotterdam*. The aspect approach is presented by relating the aspects to the standardization model. The paper concludes by presenting how these approaches can be combined in developing a standardization curriculum.

3. Who is to be educated?

Self-evidently, people that might have a need for education in the area of standardization are primarily those who have a stake related to it and/or carry out

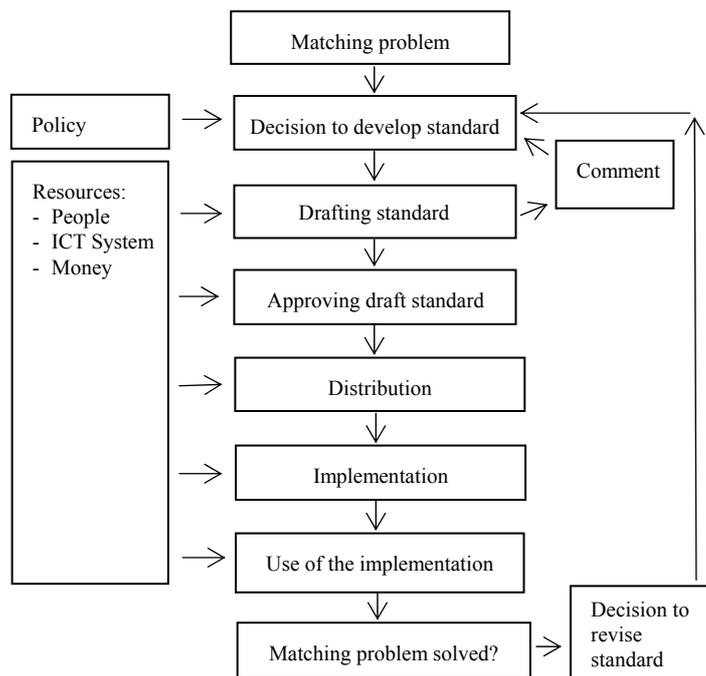


Figure 1. Processes in standardization

activities related to it. First we will discuss this in the area of company standardization, then we continue with (seen from a company's point of view) external standardization, and we conclude with experts from standardization organizations.

Figure 1 presents a simplified standardization model. The model shows the different processes needed for standardization, no matter whether this concerns company standardization, formal standardization, standardization in consortia or any other form of standardization. People can be connected to these processes and they may need education and training to be able to carry out these tasks.

3.1 Standardization within companies

Some companies have appointed a standards officer or a standardization department responsible for many of the tasks related to the processes in company standardization (Adolphi, 1997, pp. 138-178; Barnes et al., 1988, pp. 25-30; *British Standards Society*, 1995, p. 40) but often the standardization tasks will be divided among different people, sometimes with a central 'standards support' (Wenström, Ollner and Wenström, 2000, p. 28). Therefore, it is not possible to give a general answer to the question who should be educated, it depends on who carries out which task(s). These tasks include strategic standardization management, co-ordination of standardization activities, spotting developments, analyzing these developments, establishing priorities, ordering standards, making (company) standards, introducing standards, using (external and company) standards, standards administration, variety reduction, participation in external standardization activities, and evaluation of standardization activities. In a previous publication we have listed necessary competences (and assets) for carrying out these tasks (De Vries, 1999, Chapter 14). Education is a means to provide employees with the necessary competences.

3.2 External standardization

One of the standardization tasks mentioned above is 'participation in external standardization'. However, often this is not one person's task and responsibility. In its most extreme form the division of labour may involve six categories of people (De Vries, 1999, pp. 74-75): (1) a general manager who decides on the funding of the project; (2) a technical manager who participates in the supervising Technical Committee that decides on the standard; (3) a technical expert who participates in a Working Group that draws the standard; (4) other technical experts who feed him with additional experience and knowledge; (5) colleagues who implement the (draft) standard; and (6) users of the (draft) standard's implementation.

Next to people from companies, representatives from other stakeholders participate in external standardization. Examples include branch of business organizations, governmental agencies, consumer organizations, environmental pressure groups, trade unions, organizations in the areas of testing, certification and accreditation, consultancy, research institutes, and universities. Though their stakes may be different, their role as participants in standardization does not differ fundamentally from the role of companies. Therefore, the main elements of the standardization education that may enable them to participate effectively may be identical as well, though they may profit from additional specific knowledge, e.g. governmental participants may have a need for additional knowledge about relations between standardization and legislation. Scientists may have the additional task of pre-normative research; see, e.g. the programme on standardization and research of the European standardization organization CEN, 'CEN/STAR' (see www.cenorm.be). The International Organization for Standardization (ISO) and several national standardization organizations offer education for participants in standardization (Lagarde, 2003; Stern, 2003; Weisinger and Williams, 2003).

3.3 Standardization organizations

Not only participants in standardization may profit from standardization education, this applies for standardization organization officers as well. Standardization organizations support the standardization process by organizing it, performing secretariats for standardization committees, publishing standards and providing information related to standards and standardization. Many of them carry out other, non-standardization activities as well, especially in the area of certification; these will not be discussed here.

The processes related to external standards are essentially identical to those related to company standardization. The differences are related to the fact that different organizations are involved. Because of this, the way the activities are being organized is more complicated, with, for instance, complex committee structures and decision-making procedures. The main steps in developing national standards are (De Vries, 1999b, pp. 34-38): request, assignment to a committee, drafting, public comment, review of comments, approval, publishing, publicity, implementation, and evaluation. Activities of standardization organizations include professional advice concerning standardization methods and procedures, secretarial support (including: overall co-ordination, project management, editing standards, organizing committee meetings, assisting at committee meetings, taking meeting minutes, and gathering, structuring, sending, and filing documents), standards distribution, publicity, and providing standard-related information (De Vries, 1999, pp. 41-42).

In international standardization, the organizational situation is more complicated than in national standardization because both organizations at the national and international level are involved. Moreover, differences in language, culture and legal systems cause additional complications. However, the activities of standardization organizations are comparable to those related to national standardization, but, of course, have an extra dimension. Organizing an international meeting, for instance, requires more effort and expertise than a national meeting and reaching consensus may be more complicated due to cultural differences.

As in national standardization, the committee secretary is the spider in the web between all interested parties, but more diplomatic, inter-cultural and language skills are required. As a consequence, primarily committee secretariats are the people who need standardization education, but, depending on how the several tasks within the standardization organization are organized, other people need standardization knowledge as well for, e.g. publishing standards or providing publicity concerning standards. Again, it will be more fruitful to distinguish the different standardization tasks than to describe a general standards officer's profile. These tasks do not differ fundamentally from those in company standardization.

4. Regular education and/or continuing education

A lifelong career in standardization is an exception and is, in general, not advisable (Simons, 1999), so it is not necessary to have a vocational training in the specialism of standardization. Education in standardization should then preferably be offered in the form of continuing education. As far as the academic level is concerned this means: post-graduate teaching.

In general, standards users will make use of standards concerning their professional specialism, mostly one of the technical areas. Often, they get acquainted with some of the technical standards in their technical area during their regular education at the lower, intermediate or higher vocational level, e.g. standards for technical drawing or standards for safety of low voltage installations. This is (or should be) a self-evident element of education in their profession. However, new standards emerge and existing standards will be changed or withdrawn, so once they get really involved in developing or in applying standards in their professional life standards users will need continuing education as well. In fact they are better off when they have had some education in 'standards as such', though this is more difficult to achieve for lower vocational education than for the intermediate and higher level. Company experience shows that a main issue is the art of tracing the right standards (*Enjeux*, 1999; Kuiper, 1975). Winter (2002) complements this in an analysis of accidents caused by not applying available safety standards. The latter appears to be related not only to

unwillingness to apply them, but also to standards being unknown or being incomprehensible. It can be concluded that students will profit from standardization knowledge in later professional life as many of them will have to do with standards.

Should standardization be included in the curriculum of non-technical education at the lower, intermediate or higher vocational level? We think it should, namely, in the areas of business and economic education. From a company's point of view, the main strategic standardization questions are:

- What should we do standard, what tailor-made? (In general, 'standard' is cheaper, but customer wishes differ, so we should not do everything standard.)
- In the case of 'standard': do we make our own specification or do we use an external standard?
- Do we take our external environment for granted, or do we want to influence it, e.g. by participation in external standardization?

These questions can be addressed in business and economics education; it depends on the vocational level to which extent it is possible. In our private life, as consumers and otherwise, we may have to weigh 'standard' and 'tailor-made' as well, so it could be wise to pay some attention to standards at secondary schools already. Another issue that might be addressed there is safety: the main issue consumer organizations ask attention for. Jamaica (*ISO Bulletin*, 1999) and Turkey (Icin, 1994) have experiences in teaching standardization at secondary schools.

At the academic level, students in law should be educated in standardization. In line with Dooyeweerd (1955, 1957), standards can be characterised by the juridical aspect, as they result from an agreement between parties. Often they play a role in a contract between parties. In practice, however, scientists in law pay more attention to other standardization issues, such as differences between formal and de facto standardization, standardization as a means of self-regulation, constitutionality, copyright of standards, liability of standards developing organizations, product liability, competition and antitrust law, and trade barriers related to standards (see, e.g. Stuurman, 1995).

We can conclude that people who need standardization education have to make use of continuing education but that regular education should provide basic standardization knowledge. This applies to a range of studies, from secondary schools to technical as well as non-technical studies at academic level. The form of this education will be discussed in Section 5, its contents in Sections 6, 7 and 8.

5. Exemplary learning

Van de Lagemaat (1986) advises to use the didactic principle of exemplary learning. This principle enables to realise a broad and practical disclosing process: disclosing students for standardization and disclosing standardization for students. In the example, students get acquainted with the standardization phenomenon in its real structure and with several aspects related to it, which helps to enclose standardization for them. Real-life examples appeal not only to the intellectual capacities of a student but to the student as a person as well, so they are of help in opening the students for standardization. They will discover that standardization cannot be understood by a 'rationalistic' technical and economical approach only, but that standards are developed and applied by interacting people with all sorts of habits. Of course, examples are not enough - there should be theory too, so that, through the example(s), the phenomenon as such becomes clearer.

The standardization education in the Netherlands applies this exemplary learning. At the *Hogeschool van Amsterdam* (higher vocational education) students have to spend 80 hours for a standardization module during seven weeks (Van Hulzen, 2001). After an introductory lecture they get a small exam in the second week in order to stimulate them to study theory from the outset. In proceeding weeks there are some more lectures and they have to study a textbook on standardization (Simons and De Vries, 2002). In the sixth week they have an open book examination. This is the theoretical part, though in the lectures as well as in the synopsis examples are studied as well.

The main practical part of the module concerns a case study to be carried out by groups of four students. They have to make an inventory of all standards necessary for a certain product or service. In the 2001/2002 course, this concerned the requirements for wind turbines to be built at the coast. In this case not only international, European and national standards apply, but also requirements from energy companies and, for instance, legal requirements in New Approach Directives and in the European Habitat Directive (Council of the European Communities, 1992). The latter is relevant as the mills are to be placed near a bird sanctuary. In the fourth week the students report orally their findings and the way they intend to continue and get feedback from other students and teachers. In the sixth week they hand over a written case report and in the last week they have a final oral presentation of their results. By doing such a case study, students learn how to trace relevant standards in a systematic way. The approach developed for searching standards³ makes them pay attention not only to technical aspects but also to, for instance, legal aspects, stakeholders and their stakes, and different

³Available, in Dutch language, at www.nen.nl → Onderwijs → Hoe vind ik normen?

standards setting organizations. Moreover, teachers provide feed-back in which they outline the broader context. Of course, it is not possible to teach all ins and outs of standardization in 80 hours but in this way the students get a basis for future involvement in standards and standardization.

At the Erasmus University Rotterdam a module of the same size (80 hours during 7 weeks) is provided for business students as part of the specialism ('master') Innovation Management. Here we use the same book, but at the written examination the students are not allowed to take this with them. During the lectures we present examples and they perform role-playing in a standard development case: they have to agree on the standard format they use themselves for the case they have to analyze. The given case is to make a strategic standardization advice for a company. They know this company already from previous assignments in Innovation Management. The student group can get in-between feedback from the teachers and has to present their findings orally and in a written report. The company receives the report as well, which invites to think about standardization in a strategic way - a nice spin-off. In fact, 80 hours is not enough for this course. In order to be able to draw a more complete picture on standardization and to raise the quality of the strategic advice, 120 hours are needed.

Both at the *Hogeschool van Amsterdam* and the *Erasmus University Rotterdam* it appears to be difficult to attract students. Standardization sounds dull. The yearly number of students per school is in-between 10 and 30. During the lessons they become enthusiastic. They discover that standardization is an interesting and important topic. In the afterward course evaluation they appear to appreciate this course very much. At the *Hogeschool van Amsterdam*, where students are not accustomed to multi-disciplinary courses, the multi-disciplinary character appears to contribute to the attractiveness of the course.

6. Basic module

In order to prepare students for the various situations in their future life where they may get involved in standards development or use, a basic learning module on standardization ideally should take the variety in situations into account and, therefore, address: (a) the company, inter-company, national and international level; (b) different business sectors; (c) different subject matter areas, technical as well as non-technical ones; (d) different kinds of standards; (e) the different processes of standardization; (f) the different aspects of standards and standardization; (g) the characterisation of standardization as such; and (h) the importance of standardization (for the different stakeholders).

This seems impossible: the first six issues in fact constitute a six-dimensional matrix of standardization topics, more complicated than the well-known three-

dimensional 'standardization space' developed by Verman (1973, p. 33).⁴ However, in practice it may be easier, as: (1) the company, inter-company, national and international level are not totally different - broadly speaking the processes are identical; (2) differences in kinds of standards remain and include more diversity than Verman's listing suggests (Verman, 1973, pp. 33-34; De Vries, 1999, Chapter 9) but the processes related to developing and applying them do not differ fundamentally, so in fact these differences do not have to be treated as an extra 'dimension' but can be a separate topic in a standardization course; (3) standardization differs per business sector, but these are practical differences, not fundamental ones and in some sectors, not all kinds of standardization apply; and (4) the same applies to subject matter areas: practical differences, no fundamental ones.

The topics 'characterisation of standardization' and 'importance of standardization (for the different stakeholders)' should be included as well. In the case of international standardization, two other elements have to be added to the model presented in Figure 1: the selection of a standards developing organization, and the development and spread of standards-related information. The picture can be really complicated. For instance, in the case of ISO standards, national Standards Developing Organizations (SDOs) are involved in both developing and distributing the standard and providing information on the standard. In case of an ISO/PAS (Publicly Available Specification), one organization develops the specification and, subsequently, ISO approves this specification and includes it in its standards collection.

7. The aspect approach

The next step is to relate the different aspects to the dimensions and topics mentioned. First we give a short elucidation of the aspect approach developed by Dooyeweerd (1955; 1957), by applying it to standards. A standard has a certain number of pages - an arithmetic aspect. It may be available for free or at a certain price - an economic aspect. It may be beautifully or awfully designed - an aesthetical aspect. Dooyeweerd lists 15 aspects: the arithmetic, spatial, kinematical, physical, biotic, feelings-, logical, historical, linguistic, social, economic, aesthetic, juridical, ethical and faith aspect. Related to each aspect there are

⁴Verman distinguished the dimensions: 1) Subject (engineering, transport, housing / building, food, agriculture, forestry, textiles, chemicals, commerce, science, and education), 2) Aspect (nomenclature & symbols, specification, sampling & inspection, tests & analysis, grading & classification, simplification & rationalization, code of practice & byelaws, packaging & labelling, and forms & contracts), and 3) Level (individual, company, association, national, and international).

'laws' that should be honoured. For instance, mathematical laws of adding, subtracting, multiplying, etc, apply to the arithmetic aspect and are given. For the logical and later aspects, these 'laws' are normative principles that man, in his freedom, can obey, ignore or oppose, e.g. economic laws.

We have made the exercise of applying these aspects for analyzing feelings of uneasiness related to the implementation and use of a well-known standard for quality management systems: ISO 9001:1994 (De Vries, 1999b). This exercise shows that the aspects approach can be used both as a checklist in order not to forget aspects that might be relevant, and as a normative tool of how to do things 'better,' in this case to get standard's implementations that cause less uneasiness.

Let's take the example of the linguistic aspect. According to Dooyeweerd (1955, 1957), this aspect concerns symbolic signification. It is related to more than just language. For example, reserving the best parking place, next to the company's main entrance, for the general manager is a powerful form of non-verbal communication that reveals something about the organization's internal relationships. The normative principle for the linguistic aspect is clarity. Applied to standards and standardization: the linguistic aspect concerns communication related to the development of a standard and the informative function of the standard itself. The normative requirement of clarity means that standards should be easy to understand by the persons for whom they are meant and the development of these standards should be transparent for those interested in it. Honouring this normativity is not self-evident - in The Netherlands the Ministry of Economic Affairs has started a project to enhance the recognisability and knowability of standards and standardization (<http://www.nen.nl/nl/act/spec/kenb/index.htm>).

It can be disputed whether or not these aspects should be presented in a systematic way to scholars as advised by Van de Lagemaat (1986). In fact it is a philosophical approach that is not specific to standardization and may be applied everywhere. Another option is to leave this approach to the researchers and teachers when developing a curriculum. The different scientific disciplines can be related to the fifteen aspects (De Vries, 2001) and their findings should be used in a standardization curriculum. Therefore, a multi-disciplinary approach to standardization is the preferred solution. The aspects themselves should not constitute a standardization curriculum. Such a curriculum could better be built on the basic standardization model. This does not exclude the possibility to pay attention to a specific aspect in a specific learning module. Of course, this will also depend on the target group of the module. For scholars in law, for instance, the juridical aspect will get more attention, for economists the economic aspect will be more important. But everyone needs to get an overall-picture, so a multi-disciplinary 'one-size-fits-all' curriculum could form the basis for standardization education.

8. Basic module structure

In designing a standardization curriculum it is important to distinguish between teaching the subject matter and providing access to further data and information on that subject matter. The teaching module should enclose the phenomenon for students and should enclose the students for the phenomenon. Additional to this, other data and information could be made available so that scholars with specific questions concerning specific issues may find their way. A teaching module should show the way to such sources. The Internet seems to be the ideal medium for the latter, whereas for a basic teaching module contact with a real-life teacher may be more suitable, with support in the form of, for instance, textbooks, videos and the Internet. Moreover, in the case of a specific standard, the stage of standards development or standard's implementation is important: at an early stage simple 'awareness-information' may suffice, whereas at later stages there may be a need for sophisticated tools, such as, software, check-lists, or, for instance, courses or consultancy (Winter, 2002).

The above model may provide the skeleton for a basic module on standardization. In our experience, the best thing to start with are simple examples of standards, such as McDonald's, credit cards, light bulbs, cameras and films, units of measurement, petrol, paper sizes, barcodes, wine classification and traffic signs. In these cases, standards benefit consumers directly and that is why everybody understands their importance. At a later moment, business-to-business examples should be added. After these examples, generalisation to the concepts of standards and standardization is possible, including general advantages of standardization, definitions, decision-making in standardization, different types of standards, and different ways to arrive at standards.

To a certain extent it is possible to apply the aspect-approach here. For example, in our courses in The Netherlands we mention requirements for 'good' standards. Initially, these were seven requirements, just derived from practical experience. By applying Dooyeweerd's aspect approach we discovered that we had forgotten the requirement that a standard should be clear for the intended target group - a criterion related to the linguistic aspect. Moreover, now we are able to underpin the other requirements not only from practice but also from theory. In our course we do not mention this underpinning, we just present the listing of requirements.⁵

⁵A standard should: (1) solve a matching problem; (2) meet user needs; (3) aim at being repeatedly or continuously used by a substantial number of the parties for whom it is meant; (4) in general, not be changed within three years; (5) not contradict other standards; (6) be backwards compatible to preceding standards; (7) not hinder future developments ('forwards compatibility'); and (8) be understandable for the intended users.

The next step in our courses is to explain (formal) national standardization. This is no longer the most important level of standardization. Yet we start with it, as it is the easiest one to explain: easier than standardization at regional, global, company or intra-company level. In the USA, where it is more difficult to talk about national standardization, it would perhaps be easier to start with standardization in a certain sector of industry. In Europe, the topic of national standardization encompasses all elements of the above standardization model. Again, examples can be used to illustrate the topic. One of our examples concerns the development of a national standard for bicycles. We explain why the standard has been developed, which parties were involved, with which stakes, and which elements have been included in the standard.

After having discussed the national level, it is relatively easy to discuss formal standardization at the international level: ISO and IEC.⁶ ITU⁷ differs slightly from ISO and IEC - information on ITU might be part of an additional database without being part of the curriculum. The European level can be added after the national and global one, as knowledge of both is necessary to understand it. Standardization in other regions of the world is less complicated than the European one, so information can be made available without adding the topic to the curriculum. However, in education outside of Europe, standardization in the applicable region should be mentioned, of course.

Once the formal standardization has been explained, it is possible to pay attention to de facto standardization. After this it is easy to mention hybrid forms, such as sectoral standardization. Next, standardization within companies can be discussed. As this includes the company use of external standards and the company's strategy in influencing external standardization, it should not be on an earlier place in the curriculum. Knowledge of company standardization is necessary before the subsequent topic can be discussed: intra-company standardization, especially standardization in supply chains (see Koehorst, De Vries and Wubben, 1999, for a case study).

After this 'tour d'horizon' it is possible to focus on the different elements of the model and its extensions in the case of external standardization. For instance, the element 'Choice of organizational form' that is additional in external standardization refers to the topic of 'markets' and 'committees', the element 'Standard development' may mention methods and theories of standards development, 'Standard implementation' is best illustrated by telling about those standards for which implementation is the most difficult: standards for management systems.

⁶IEC = International Electrotechnical Commission; see <http://www.iec.ch>.

⁷ITU = International Telecommunication Union; see <http://www.itu.int>.

In this way, the six dimensions are projected on the ‘one dimension’ of a standardization course with a start and an end. In mathematics there are many ways to project a six-dimensional object to a one-dimensional space. Taking this parallel, there are many ways to project the six-dimensional standardization topic on a one-dimensional course. Of course, a part of the information is lost in this way, but nevertheless a course results that covers the most relevant topics. The Internet possibility of hyperlinks provides the possibility to add an ‘extra dimension’. On the other hand, this may hinder getting a clear picture of the phenomenon; without a start and an end the reader might get ‘lost’. In fact, hyperlinks may be used to find additional materials but are less suitable for the main course. For each topic in the main course, Van de Lagemaat’s four basic questions should be addressed: *what* is done in standardization practice, *how* is it done, *why* is it done, and *why* is it done *in this way*?

9. Theory and practice

The above approach helps to get a systematically structured basic course. However, it is not enough for developing such a course. Practical knowledge about actual issues is necessary as well. For instance, in the EU and EFTA countries, many European standards are linked to European legislation in the form of ‘New Approach Directives’.⁸ More than 50% of the products have to meet the requirements laid down in these directives and conformity to the related standards is the easiest way to demonstrate conformity to these ‘essential’ requirements. So a basic standardization module in Western Europe has to pay attention to this. In the case the above model is applied in a systematic way, the New Approach will be ‘discovered’ at least in several ways when discussing standardization at the European level: (1) One of the stakeholders is the ‘government’ at the European level: the European Commission. When discussing their stakes, the New Approach will appear to be one of the topics, related to their wish to have one single market without barriers to trade (the economic aspect) and related to their role in legislation (law aspect). (2) When discussing the legal aspect of standards, their relation to law setting at the European level is one of the topics to be investigated.

However, the importance of the New Approach does not appear from the systematic approach in designing the curriculum, but just from practice. Given this importance, there may be a wish to give such a topic full attention. Then it is the question, where to place such a topic in the curriculum. In fact, there are two possibilities: at the place where you ‘discover’ it, in this case, when discussing

⁸See, for instance, <http://www.NewApproach.org>.

European standardization, or somewhere separate, in an ‘annex’, to which the central body of the curriculum refers.

Other topics that might be treated in this way include: (a) standardization and innovation (related to the characterisation of standardization as such as at first sight standardization and innovation seem to exclude each other, which appears not to be true; the topic can subsequently be related to standards application, subsequently to the stakes of stakeholders and, next, to the way of standards development); (b) macro-economic benefits of standardization (related to the stakes and the evaluation of standards use, economic aspect); (c) standardization and intellectual property rights (juridical and economic aspect of standards, with implications for the choice of standards developing organizations and for the way of standards development); and (d) the problem that many available standards are not used in practice. The Y2K problem with data representation in computer systems would not have existed if the international standard ISO 8601 (ISO, 2000)⁹ had been applied systematically.

A practical way to complete this inexhaustive list is to examine existing standardization curricula,¹⁰ discuss the importance of the presented topics, and place them within the basic skeleton or in the list of ‘annexes’. A second source is provided by the available scientific literature, mapped by De Vries (2001). Finally, there can be pragmatic considerations to determine the breadth and depth of the curriculum. It depends on the level of the students, the available time, the level and experience of the teacher(s), and the availability of textbooks and other materials.¹¹

10. Academic teaching in standardization

Students may have standardization as a part of their academic curriculum. This may be especially the case in (De Vries, 2001, pp. 96, 98-99): (1) sciences related to the topics to be standardized: technical sciences, but also healthcare

⁹Predecessors of this standard have been available since 1971.

¹⁰For instance the curricula of the Chair of Standardization at the University of the Federal Armed Forces Hamburg (Hesser and Czaya, 1999), the Internet modules of the same Chair (<http://www.pro-norm.de>), the course of the International Center for Standards Research, Boulder, Colorado, USA (Bloomfield, 1999, p. 20), the course on strategic standardization of the Catholic University of America, Washington (ASTM Standardization News, 1999; <http://engineering.cua.edu/StandardsCenter>; Purcell and Kelly, 2003), and the masters on standardization, quality, certification and testing at the university of Compiègne, France, <http://www.cefi.org/fraMAST/235.html>).

¹¹The topics addressed in the standardization course at the Erasmus University Rotterdam can be seen at <http://web.eur.nl/fbk/dep/dep6/bpm/standardcontents.doc>.

sciences (medicine, dentistry, veterinary medicine) and business science (standards for management systems); (2) business science, because standardization is a tool of management; (3) science of public administration, as governments increasingly have to do with standards in their roles of stimulating business performance and international trade, creating a legal foundation for standardization, carrying out standardization activities themselves, supplementing, simplifying, or improving the legal system with standardization by making references to standards in laws, using standardization for specific public sector tasks, and using standardization to improve general administration performance; (4) economics, as standardization is, by its nature, an economic activity and it is necessary to understand standardization in order to understand the 'old' (for instance, Taylor) and 'new' (for instance, network-based) economy; the world's best-selling standardization book is an economic study (Shapiro and Varian, 1999); (5) law, as explained above.

The above applies not only to students but, of course, also to researchers in these fields: they need a basic knowledge of standardization. More specifically, they and researchers from other disciplines¹² may study certain aspects of standardization or certain elements of the standardization phenomenon, or the phenomenon as such. A problem with academic studies is that, due to the necessary scientific abstraction, there is a danger that they, though consistent within their assumptions, are too far from reality. According to Hesser and Kleinmeyer (1998, p. 65) this applies to standardization research as well. After having discussed the contributions of engineering sciences, law and economics in standardization research, they conclude that each of these disciplines presents perspectives on standardization from a very narrow point of view.

Van de Lagemaat and Dooyeweerd have observed that many researchers no longer see reality as it is, but 'see' mainly the aspects related to their own (mono-)discipline. As a consequence, they may draw conclusions on, in our case, standardization, without having any overview of the phenomenon. For instance, the lessons Shapiro and Varian (1999) draw on 'standards wars' concern compatibility standards and need not apply to other standards; the authors seem to be not aware of these. This applies to many economists that write about standardization. In the area of law, main conclusions in the doctoral thesis of Elferink (1998) are wrong because the author has chosen an inadequate definition of standardization and has not understood the (economic) nature of the standardization phenomenon. A multi-disciplinary academic course for students from different faculties would have the advantage of avoiding one-sidedness not only for these students but for staff as well. The course at the *Hogeschool van Amsterdam* mentioned before attracts students from different faculties, technical as well as non-technical.

¹²De Vries (2001) has provided a complete listing of these disciplines and the underpinning thereof.

11. Summary and conclusions

Many people that get involved in standardization in their professional life lack the (standardization) education that would enable them to carry on that task in a professional way. In general, neither regular nor continuing education pays attention to standardization in a systematic way, though there are exceptions, especially in some specialistic technical areas. In order to be able to investigate standardization education we have combined (knowledge of) standardization practice and academic reflection with the area of (regular and continuing) education. For the first two areas, we have built on our own previous studies, for the second one on Van de Lagemaat (1986). The purpose of standardization education appears to be to disclose the standardization phenomenon in a way the student can understand it, and to act with students in a way that they get accustomed with standardization, get knowledge about it and are equipped for using this knowledge in standardization practice. In academic teaching the knowledge may be also applied in further research on the standardization issue.

We have presented a model that shows processes related to standardization and standards. People carry out tasks related to these processes. Standardization education should be related to these standardization tasks and to the competences necessary for carrying out these tasks. The model itself can be used to form the skeleton for a basic education module on standardization. Of course, specialistic education may be useful as well, but, based on the educational theories of Van de Lagemaat, the importance of getting familiar with the phenomenon as such should be stressed.

The issues that should be addressed in standardization constitute a six-dimensional matrix of standardization topics. This structure makes it difficult to design a course with a consistent roadmap from the start to the end. However, based on the model and combining a theoretical and a pragmatic practical approach it is possible to arrive at a multidisciplinary standardization curriculum. We did not do this exercise in this paper, but the paper provides building blocks for developing such a curriculum.

Standardization education should primarily be continuing education. We have analyzed for which categories of students, reaching from secondary schools to universities, standardization should be part of the regular curriculum. Standardization courses with a well-structured order from start to finish should be completed with reference works for which the Internet can be used. It is suggested to develop curricula and reference works in co-operation between academia, standardization bodies, business experts and experts from other organizations, such as governmental and consumer organizations.

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