

Introducing Learning Outcomes Based Engineering Curricula: A National and Institutional Perspective

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Abstract

In 2011, the National Qualifications Framework for higher education (NQF-HE) was introduced in Poland by means of an amendment to the Law on Higher Education. An institution that offers a degree programme in a specific field of engineering must now develop intended learning outcomes (LOs) for that programme and make them compliant with the generic LOs for engineering, defined in the ministerial regulation. The curriculum must then be designed so that each student who completes the programme achieves these LOs. To show how these regulations have affected institutions, we present the case of the Warsaw University of Technology where ca. 100 degree programmes had to be redesigned. University-level regulations, dedicated IT tools, information and training campaign intended for academic staff, organisation and outcomes of the work on the LOs development and redesigning the curricula are described. We also show the results of a nationwide survey on the NQF-HE related reforms, conducted recently by the Polish Rectors Foundation, focusing on responses obtained from 9 universities of technology and their 84 faculties.

Keywords: *qualifications framework, learning outcomes, curriculum development.*

1. Introduction

The higher education system in Poland has expanded significantly over the last two decades. The student numbers have increased from 400,000 in 1990 to nearly 2 million which means that a participation rate exceeding 50% has been achieved. This expansion has created many problems and challenges. Some of these problems have been solved as a result of changes at higher education institutions (HEIs) that followed the adoption of the new *Law on Higher Education* in 2005, but other problems have remained unsolved. [1]

One of these problems was limited autonomy of HEIs in developing and updating their programmes – the institutions, including the most renowned universities, could – until the very recent reforms – offer degree programmes only in the fields selected from the list of 118 fields of study (including 28 fields in engineering), predetermined by the Ministry. Moreover, for each of these fields, the contents of the curriculum was partially defined by means of so-called “standards”. An institution could, in principle, apply to the Minister for a permission to offer a programme in a field from outside the list, but a lengthy bureaucratic procedure discouraged many HEIs from taking such an initiative.

Degree programmes in engineering compliant with the ministerial “standards” were generally overloaded with theory. Also, they did not adequately account for the changes taking place in engineering education around the world. [2]-[4]

In this paper, we show how some of the problems in the system of engineering education in Poland have been solved, at least partially, through the development and implementation of the national qualifications framework for higher education. In particular, we describe how this framework has been implemented at the Warsaw University of Technology.

2. National Qualifications Framework for Higher Education

The National Qualifications Framework for Higher Education (NQF-HE) was formally introduced in Poland in March 2011, by means of an amendment to the *Law on Higher Education*. A few lower-level legal acts (ordinances) were then issued by the Minister, including the *Ordinance on the NQF-HE*.

The NQF-HE was developed so that to make it compatible with the overarching qualifications framework for the European Higher Education Area (QF-EHEA), but also with the European Qualifications Framework for lifelong learning (EQF-LLL) [5] [6]. It has three levels of qualifications, corresponding to the three Bologna cycles. In this paper, however, we do not consider the third-cycle qualifications (doctoral degrees); we focus on study programmes leading to the first- and second-level qualifications, corresponding to the Bachelor's and Master's degrees, respectively.

For these qualifications, the level descriptors that characterise competences of the qualification holder or, in other words, learning outcomes (LOs) he/she should have achieved upon completion of a degree programmes, are presented at two layers. At the higher layer, the “generic” LOs corresponding to the Bachelor's and Master's degrees are specified. At the lower layer, these LOs are described in more detail, reflecting the concept of qualification profiling, introduced by the Bologna Working Group on Qualifications Frameworks. The Group defined a profile as “*either the specific (subject) field(s) of learning of a qualification or the broader aggregation of clusters of qualifications or programmes from different fields that share a common emphasis or purpose (e.g. an applied vocational as opposed to more theoretical academic studies)*” [5]. Both concepts of qualification profiling presented in this definition are deployed, but the term “profile” is used only in the second sense. Being more specific, the level descriptors are specified (in the *Ordinance on the NQF-HE*) for:

- eight large subject domains, selected based on the OECD/EUROSTAT/UNESCO science and technology classification; one of these eight domains is *Engineering*,
- two profiles, corresponding to more theoretically and more practically oriented studies.

For each subject domain and each profile, the level descriptors are organised into three categories: knowledge, skills, and social competences, similar to those in EQF-LLL [6]. However, they also remain compatible with the Dublin Descriptors used in QF-EHEA [5], and with the descriptions proposed in the Tuning project [7].

The legal regulations associated with the Polish NQF-HE require that for each degree programme, the intended LOs be developed by the HEI that offers the programme, so that to comply with the relevant level descriptors. This means that the intended LOs for any programme in engineering and technology must “cover” all the LOs in the level descriptors for the subject domain of *Engineering*. In addition, the *Law* states that the intended LOs must be relevant to the labour market and consistent with the mission of the HEI and its strategic plan.

To strengthen the links of HEIs with the labour market, HEIs are also required:

- to perform an analysis of the labour market needs as a prerequisite for the development of a new degree programme,
- to engage external stakeholders, including employers, in the process of developing intended LOs and designing curricula, and to engage practitioners in teaching,
- to track graduates' careers.

The regulations state also that the curriculum must be designed so that the student can achieve the intended LOs defined for the programme and that the institution must develop and effectively use appropriate methods to verify that these LOs have actually been achieved by each student who receives the degree. Requirements are also imposed on the minimal number of ECTS points associated with elective courses (curriculum flexibility), and on the minimal number of ECTS points associated with curriculum components that aim at the development of skills (engineering skills and transferable skills).

All these regulations look quite restrictive, but in fact they have brought a much needed academic autonomy to HEIs. Institutions are now free to decide on the names and the contents of the programmes, as long as the intended LOs for these programmes comply with the NQF-HE and the curriculum makes it possible for the students to achieve those LOs.

The amendments to the *Law on Higher Education*, stating that all study programmes offered by HEIs in academic year 2012/13 and later have to comply with the NQF-HE regulations, left HEIs with little time to redesign their programmes. Therefore, in parallel with the last phase of the NQF-HE development and after that, a comprehensive consultation, information and training campaign was organised by the Ministry and the Foundation for the Development of the Education System to prepare academic community for the coming reform. Members of the national team of Bologna experts and other experts who participated in the NQF-HE development (almost 200 academic staff members were involved in various projects, partially supported by the European Union funds, leading to the NQF-HE development) served as instructors for more than 100 conferences, seminars and workshops that took place around the country, with an estimated participation of more than 16 000 members of academic and administration staff.

3. Learning outcomes for degree programmes in *Engineering*

An essential part of the NQF-HE regulations is the specification of level descriptors (learning outcomes) for eight large subject domains. These descriptors were developed based on international „standards”. For *Engineering*, competences of an engineer specified by the following organisations or networks were taken into account [8]:

- EUR-ACE (EUROPEAN ACcredited Engineer project),
- IEA (International Engineering Alliance),
- ABET (Accreditation Board for Engineering and Technology, USA),
- JABEE (Japan Accreditation Board for Engineering Education),
- SBS (Subject Benchmark Statements, UK) for “Engineering” and “Computing”,
- CDIO (Conceive-Design-Implement-Operate initiative).

The number of learning outcomes statements in level descriptors for *Engineering* (for both profiles and for each category of competences), specified in the *Ordinance on the NQF-HE*, is given in Table 1.

Table 1. Number of LOs for *Engineering* in the NQF-HE [9].

	first-level qualification (Bachelor’s degree)		second-level qualification (Master’s degree)	
	academically oriented profile	practically oriented profile	academically oriented profile	practically oriented profile
knowledge	11	11	11	11
skills	16	19	19	19
social competences	7	7	7	7
total	34	37	37	37

The level descriptors for *Engineering* include some LOs that were either ignored or inadequately covered in typical engineering programmes offered by the Polish universities of technology before 2012. Examples are given in Table 2.

Table 2. Selected LOs in level descriptors for academically oriented first-cycle programmes in *Engineering*.

	The graduate has the following competencies:
knowledge	<ul style="list-style-type: none"> - has basic knowledge on management, including quality management, and on running business - knows and understands basic concepts in intellectual property protection; knows how to use sources of information on patents

skills	<ul style="list-style-type: none"> - is able – when formulating and solving engineering problems – to account for their systemic and non-engineering aspects - is able to develop a business plan
social competences	<ul style="list-style-type: none"> - correctly identifies and resolves ethical dilemma associated with professional activities - is aware of the role of an engineer in the society; understands the need to inform the society and formulate opinions, in particular through media, on achievements in technology and other aspects of engineering; makes an effort to do that in a commonly understandable way

The level descriptors for *Engineering* form a basis for the development of a degree programme in any specific field of engineering. The first step in this process is the formulation of intended LOs.

The hierarchy of learning outcomes relevant for the development of intended LOs for a degree programme is illustrated in Figure 1. It shows that in the process of LOs development the institution (faculty) – besides the requirements imposed by the NQF-HE regulations – can take into account:

- example LOs defined by teams of experts involved in the NQF-HE development,
- LOs statements suitable for a group of programmes, proposed by any formal or informal group of experts (for example, LOs for the area of electrical and computer engineering, applicable to programmes in power engineering, industrial electronics, microelectronics, telecommunications, etc., proposed by the deans of relevant faculties).

It must, however, be emphasized that such examples or proposals can only serve as guidelines for the interested faculties – they should not lead to imposing “standards”, precluding desirable diversification of the programmes offered by different institutions.

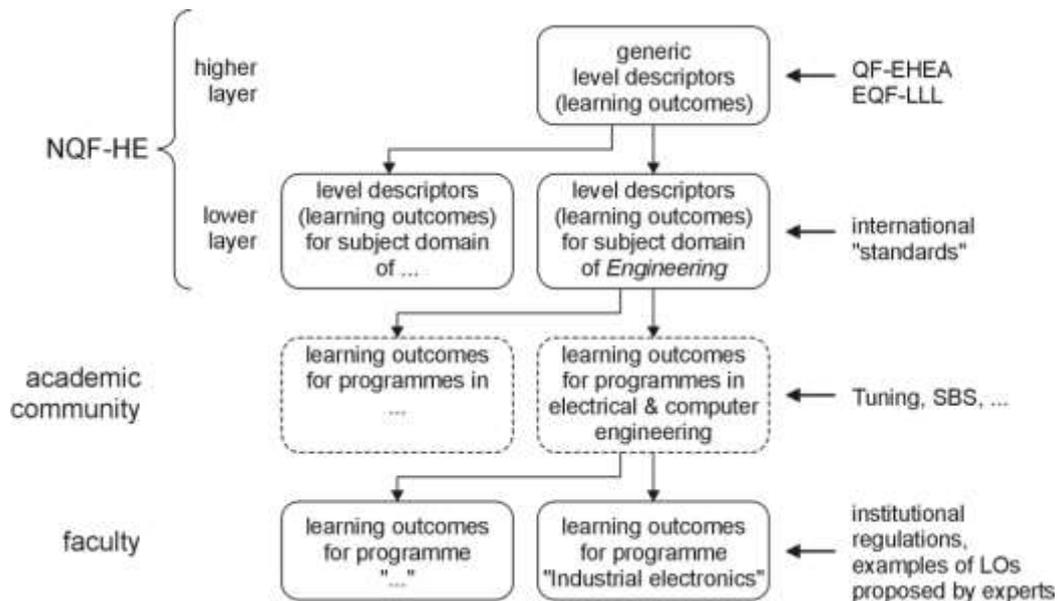


Figure 1. The hierarchy of learning outcomes (adopted from [8]).

4. NQF-HE implementation at WUT

The key step in the process of NQF-HE implementation at the Warsaw University of Technology (WUT) was the Resolution of the WUT Senate of 26 October 2011. This resolution specified, *inter alia*:

- the deadlines for actions to be taken by individual and collective bodies at the level of university and at the level of its organisational units (faculties),

- requirements to be satisfied by degree programmes, supplementing the legal regulations; an example would be the specification of the minimal number of ECTS points associated with math and science courses, courses in humanities and social sciences, foreign language training, etc.,
- recommended LOs statements (an interpretation and extension of LOs specified by the ministerial regulation for *Engineering*) for topical areas of math, physics, humanities and social sciences, foreign languages, etc., common for all engineering programmes at WUT.

Other institution-level regulations, issued by the Rector, defined, *inter alia*, the requirements for the course (module) documentation, with such fields as “intended LOs” and “methods for verification of LOs”.

To support academic staff in redesigning degree programmes, several seminars, workshops and other forms of training were organised. A dedicated web site with FAQs and counselling services, were offered to organisational units (faculties) and individual members of academic staff. The ICT unit developed an interactive tool that supports the presentation of programmes (by coordinators nominated at each faculty) and individual courses (by course coordinators – members of academic staff) in a unified form.

The work on the redesigning of a particular degree programme, taking place at the faculty, included:

- defining the intended LOs, compliant with the NQF-HE level descriptors for *Engineering* and with the requirements imposed by the WUT Senate,
- redesigning the curriculum; the resulting curriculum must have complied with the legal requirements and internal WUT regulations and, at the same time, must have guaranteed that the student could achieve the intended LOs,
- development of effective methods that would allow the faculty to demonstrate that each student who completed the programme had achieved these LOs.

In most cases, to satisfy all the requirements, substantial changes in curricula were necessary – modifications of existing courses and introduction of new courses to “cover” all the intended LOs for the programme. In fact, some work had to be done for all the courses comprising the curriculum, even those whose contents fitted well into the new requirements, as for each course it was required to:

- define the intended LOs,
- develop appropriate teaching methods and techniques that would allow students to achieve these LOs,
- develop appropriate methods to check whether the intended LOs have been achieved by the students.

This means that all members of academic staff were involved in the process of NQF-HE implementation.

Each programme developed at the faculty and formally adopted by the faculty council was subject to a thorough two-level review at the university level. It was first examined by a designated member of the special expert group, and subsequently by one of the three high-level coordinators nominated by the Rector.

The reviewing team did a tremendous job on the assessment of 96 degree programmes (50 first-cycle programmes and 46 second-cycle programmes) within a period of 3 months. The outcomes of this assessment were discussed at several meetings of the Senate Committee for Education that took place in March-May 2012. After the necessary corrections, all the programmes were formally approved by the WUT Senate and were offered to students who started their education in October 2012.

Given the pressure of time, it should not be a surprise that the faculties decided to postpone substantial transformations of their programme portfolios and simply adjust the existing programmes to the new regulations which, as discussed above, was by no means a trivial task. These adjustments resulted in quite diversified solutions. This is best illustrated by differences in general characteristics of the set of intended LOs developed for different programmes, presented in Table 3, where programmes with a minimum and maximum number of LOs in each category (knowledge, skills, and social competences) are shown. It can be seen that the number of LOs for the second-cycle programmes is generally lower than for the first-cycle programmes, but this can easily be explained by observing that some of the competencies (and

associated LOs) required for a Master’s degree holder can be obtained during the first-cycle studies (are part of intended LOs for the first-cycle programme).

Table 3. Number of intended LOs for degree programmes at WUT.

	knowledge	skills	social competences	total
first-cycle programmes				
minimum	13 20	21 15	5 7	39 42
maximum	35 18	34 16	7 13	76 47
second-cycle programmes				
minimum	10 14 16	19 16 19	2 3 1	31 33 36
maximum	24 15	26 28	10 10	60 53

Disregarding such differences, some positive features of the redesigned curricula can be observed:

- increased flexibility (more elective courses), as required by the ministerial regulation,
- a shift towards student-centred teaching (fewer lectures, more project-based learning modules, etc.),
- new, more comprehensive methods to check whether the intended LOs, especially in the category of skills, have been achieved by the student.

The work done at WUT was highly evaluated by the community. As a means of promoting the NQF-HE implementation at HEIs, a special fund was established in the higher education budget for 2012. This fund was used by the Ministry to award – on a competitive basis, based on peer-reviews – grants to faculties that successfully introduced innovations in NQF-HE implementation and in enhancing their internal quality assurance systems, so that to adjust them to the new, LOs oriented approach to teaching. In this competition, WUT was quite successful. Among 62 awarded faculties there were four WUT faculties; each received ca. 250 000 euro to support initiatives aimed at the improvement of teaching quality.

The successful introduction of the redesigned programmes in October 2012 does not mean that the shift towards LOs based curricula has been completed. The work on the refinement of teaching techniques and methods for verification of LOs, and also on the reorientation of the internal quality assurance system towards LOs is still in progress. An important and optimistic observation is that the WUT community clearly demonstrated the willingness to make improvements – a one-day seminar on experiences in implementing the NQF-HE, including the presentation of good and bad practices by external experts, organised at WUT in April 2013, attracted many members of academic and administrative staff.

5. NQF-HE implementation - national perspective

As the case of the WUT illustrates, the NQF-HE implementation has been quite a challenging task for the Polish HEIs. To learn more about this process, the Polish Rectors Foundation – a think-tank linked to the Polish Rectors Conference (CRASP) – conducted a study on the NQF-HE related reforms. It was based on a survey in which 46 HEIs and their 327 faculties took place, including 9 universities of technology and their 84 faculties. The results of this study are presented in [10].

The survey addressed, *inter alia*, the general perception of the NQF-HE concept and related regulations by the academic community: HEI authorities, i.e. rectors and deans, and “ordinary” academic staff. The responses obtained from the universities of technology and their faculties are summarised in Table 4 (they do not differ significantly from the responses obtained from other HEIs that took part in the survey). It should be explained that the questionnaires were filled in by the representatives of HEI authorities, and

therefore the data for academic staff do not reflect the opinion expressed directly by academic staff, but rather the opinion of authorities on how they perceive the attitude of their staff.

Table 4. Attitude towards the NQF-HE implementation in universities of technology.

	positive	moderately positive	moderately negative	negative	difficult to say
university level (9 universities)					
authorities	44.4%	55.6%			
academic staff		22.2%	55.6%		22.2%
faculty level (84 faculties)					
authorities	22.6%	56.0%	13.1%	4.8%	3.6%
academic staff	2.4%	35.7%	38.1%	8.3%	15.5%

Looking at Table 1, it can be seen that the general perception of the NQF-HE implementation is moderately positive. It can also be seen that – as expected – the authorities demonstrate a more positive attitude towards the reform than academic staff. It is, however, interesting that the authorities at the level of faculty (deans, vice-deans) who are less enthusiastic about the reform than the university authorities (rectors, vice-rectors) perceive the academic staff less critical towards the changes than their counterparts at the institution (university) level.

The moderately positive attitude towards the NQF-HE does not mean that the community does not see difficulties associated with its implementation. The following issues were pointed out by the survey respondents:

- problems with legal regulations: inconsistent terminology and unclear statements in legal acts combined with a limited support by the Ministry in resolving controversial issues; also unnecessary over regulations resulting in excessive bureaucracy,
- significant time pressure, resulting in limited opportunities to thoroughly consult the proposed solutions with stakeholders (employers etc.) and to introduce necessary corrections and improvements,
- difficulties resulting from insufficient engagement of some members of academic staff (as with any reform, part of the community, failing to recognise its potential benefits or having little interest in teaching, perceived the work on the NQF-HE implementation as an unnecessary burden, jeopardising their other, particularly research related activities; however, as the work was progressing, a shift from an openly demonstrated resistance to at least partial acceptance was observed at many HEIs).

Regarding the organisation of the work, some institutions took a centralised approach, coordinating the activities undertaken by individual faculties, while others delegated the major responsibility to faculty level. In either case, seminars, workshops and other forms of training, dedicated websites, counselling services, and – in many HEIs – dedicated software tools supporting the development and documentation of the new curricula were offered to individual members of academic staff (such software tools were available in 6 out of 9 universities of technology that took part in the survey).

As expected, different HEIs took different approaches to the NQF-HE implementation. This refers, *inter alia*, to the development of intended LOs for degree programmes, and in particular – to the number of LOs defined – in total and in the three basic categories (knowledge, skills, social competences). As shown in Table 5, the number of intended LOs varies from 29 to 106 for the first-cycle (Bachelor) programmes and from 15 to 75 for the second-cycle (Master) programmes. A more thorough analysis of the survey responses reveals that significant differences occur not only between universities, but also between faculties within a particular university and – quite surprisingly – also between different programmes within a particular faculty.

Table 5. Number of intended LOs for degree programmes at universities of technology.

	knowledge	skills	social competences	total
first-cycle programmes				

minimum	11 14	11 17	7 5	29 36
maximum	48 16	49 32	9 15	106 63
second-cycle programmes				
minimum	6 8 16	6 5 19	3 3 1	15 16 36
maximum	30 11	38 22	7 16	75 49

The outcomes of the survey indicate that despite the pressure of time, some institutions decided to take advantage of the opportunity created by the new regulations and introduced new degree programmes or significantly redesigned the existing ones. Furthermore, the survey shows that a substantial number of engineering faculties plan to introduce degree programmes in new fields of study in the near future. Being more exact, 38.1% of faculties declared that they would offer new degree programmes in 2014 or 2015, and next 14.3% of faculties declared that they would consider such a move.

The outcomes of the survey indicate also that some opportunities created by the NQF-HE have not been exploited sufficiently. This is, in particular, the case of profiling the degree programmes (according to the *Law*, each programme must be either academically or practically oriented). The responses clearly indicate that the overwhelming majority of programmes offered by the universities of technology have been designed as academically oriented. The fact that only one university of technology decided to offer a few practically oriented programmes is somewhat surprising, taking into account that in Poland there are relatively few non-university HEIs that offer practically oriented engineering programmes.

6. Conclusion

The formal introduction of the National Qualifications Framework for Higher Education in Poland has created an opportunity for institutions of engineering education to restructure their programme portfolio and to redesign individual degree programmes. The results obtained so far appear encouraging. The responses to the survey conducted recently by the Polish Rectors Foundation and information gathered from other sources indicate that – at least at some institutions, including the Warsaw University of Technology – desirable changes in curricula can be observed. The redesigned curricula are more flexible and more compatible with the international standards. They also appear more relevant for the labour market, as they focus on the development of skills, including transferable skills, and on raising awareness of non-engineering aspects of engineering work. The teaching has become more student-centred.

It must, however, be stressed that there is still a long way to go. The formulation of intended learning outcomes for degree programmes and subsequent redesigning of curricula was just the beginning of a long lasting process. Much is to be done for improving teaching methods and techniques, so that to guarantee that these learning outcomes are actually obtained by the students.

How all these reforms will affect the quality of engineering education in Poland is too early to say – and is something to be followed closely in the years to come.

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