

NDT Education at college and/or university level

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1. Introduction

After years of dedicated effort, the European Federation for NDT (EFNDT) is now a well-established association with a strong reputation in Europe and internationally. It provides a solid platform for more effective representation and support of not only the membership and the wider NDT community but also the activities that are for the sustainable development of NDT.

The EFNDT Board of Directors identified five strategy sectors for 2006-2009 and prepared an Action Plan. Task groups were organised to implement each strategy. One of the very important actions for Task Group 4 is stronger promotion of the value of NDT for safety purposes.

The promotion of NDT for safety includes increasing the awareness of the very broad scope of modern NDT methods and technology which integrates materials testing in all phases of production, and in in-service inspection, condition monitoring, anti-terrorism diagnostics and environmental diagnostics.

It is very important to understand that promotion to such a wide extent must include all related international bodies responsible for R&D in the NDT field, governmental as well as public.

So, how to tackle these problems? What can be done to increase awareness that NDT is already a reliable tool for safety and security and has the capacity to be even more valuable with wider implementation?

If one would accept the fact that knowledge is the best promotion, then we need to find answers to some questions, such as:

- How can young people can discover and learn about NDT?
- What can we do to support education?
- What can be done in cooperation with colleges and universities to open this very important and attractive profession to young people?

Task Group 4 of EFNDT committed itself to enquire into the possibilities of

enriching education for non-destructive testing and evaluation/diagnostics through higher education programmes at universities and colleges throughout Europe.

A preliminary inquiry into the state of education in NDT methods and applications was performed to assess what has been achieved so far.

A questionnaire on available NDT curricula/programmes was prepared and sent to all EFNDT members. The intention was to gather information from college and/or university level or equivalent institutions concerning the inclusion of Non-Destructive Testing topics in their engineering courses, including those courses that are entirely dedicated to NDT. Training Centres providing courses according to the specific requirements of NDT personnel certification schemes are not included in this survey.

Replies from 46 institutions of higher education were received, which is a very respectful number of institutions. Despite the effort taken, more replies are not expected soon and, therefore, the results will be presented for the time being.

Undoubtedly, the questionnaire fulfilled the preliminary purpose and the data obtained are of interest. The questionnaire identifies some similarities in both quantitative and qualitative domains, but also brings to light major differences arising from cultural, economical and other contextual factors.

In this review, the Tables are presented with results summarised and conclusions considered not only of the state-of-the-art but also some ideas for possible development of the task.

EFNDT Task Group 4 will continue its activities for educational benefits in the NDT field as well as sharing the best practice between higher educational institutions.

2. The questionnaire and the results

The 46 replies were received from 14 countries out of 29 Members of EFNDT.

Table 1 suggests the hardly believable fact that the NDT field – even including some general awareness of NDT – is not included at universities and colleges in half of Europe. Such a result is a warning

to us that it is necessary to improve the communications primarily between national societies and EFNDT and also between national societies and their academic communities.

Based upon the first and second question one can deduce that NDT penetrates mostly in university programmes and some colleges, predominantly owned by State/Government, and the depth of the field covered by curricula is mostly routine methods of NDT (Table 2).

The third question gives us some very interesting information which shows the penetration of the NDT field through duration of study, *ie* number of semesters that include NDT topics. It is evident that NDT topics were mostly included for one semester of study, with some being extended within to two or even more semesters.

The ECTS (European Credit Transfer System) is not used in more than half of the institutions, but it is very promising that 19 universities have ECTS credits and NDT topics included in the system.

From the questionnaire (Table 3), it is hard to extract what degrees are provided by the curricula/programme and it may be that the definition of the question was not exact, leading to some misunderstanding. The intention of the question named was to find out if some universities or colleges provide degree of Bachelor, Master and Doctoral in NDT. Some institutions answer positively for all degrees, however we have to question this since it is impossible to graduate in the degrees mentioned having duration and topics of study as presented. It is obvious that people understand the question as a general one for the institution but not related to specific graduation in NDT (NDT engineer...). This misunderstanding will be resolved in due time.

However, let us emphasise that this question demonstrates a very good progress for the NDT field, since it shows the potential of learning and practising of NDT at all levels at higher educational institutions.

Question 4 (Table 4) is not an unexpected result, since the intensity of the methods covered by curricula/programmes are very close to the statistics as it is in NDT implementation all around. So we can see ultrasonic methods as the leading

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Table 1

Questionnaire sent to National NDT societies	Austria	Belgium	Belarus	Bulgaria	Croatia	Czech Republic	Denmark	Finland	France	Germany	Greece	Hungary	Ireland	Italy	Moldova	Latvia	Netherlands	Norway	Poland	Romania	Russia	Serbia	Slovakia	Slovenia	Spain	Sweden	Switzerland	Ukraine	UK	Total
Reply	1	2	0	0	3	0	0	0	5	6	1	8	0	1	0	0	2	0	0	0	10	2	0	1	0	2	0	0	8	52
1.1 Type of institution																														
College					1				1		3						2												6	13
University	1	1			2				5	5	1	5		1							10			1		2			7	41
Other		1																				2								3
1.2 Institution-ownership																														
State/government	1				2				5	6	1	8		1			2				10	1		1		2			8	48
Private		2																												3
Other					1																									1

Table 2

2. The depth of field covered by curricula																														
NDT-routine methods	1	2			3				5	6	1	4					2				10	1				2			8	45
Evaluation/Interpretation		1							5	4	1	3	1	1			2				10	1		1					8	38
Material characterisation	1				2				5	4	1	6	1	1			2				10	1		1					7	42
Inspection/quality control		1			2				5	4		2			2		2				10	2		1		1			7	39
Management in NDT					1				2	1				1			1				10								7	23

Table 3

Questionnaire sent to National NDT societies	Austria	Belgium	Belarus	Bulgaria	Croatia	Czech Republic	Denmark	Finland	France	Germany	Greece	Hungary	Ireland	Italy	Moldova	Latvia	Netherlands	Norway	Poland	Romania	Russia	Serbia	Slovakia	Slovenia	Spain	Sweden	Switzerland	Ukraine	UK	Total
Reply	1	2	0	0	3	0	0	0	5	6	1	8	0	1	0	0	2	0	0	0	10	2	0	1	0	2	0	0	8	52
3. General data about curricula/programme																														
Duration: number of semesters																														
1	1								2		1	3					1							1	2				6	17
2		1			1				2	3		1									x									8
3										1											x									2
4										1		1					1				x									3
6					1				1	1		1																	1	5
7					1							1																		2
8																													6	6
10					1					1				1																3
ECTS credits																														
Yes	1				3				5	3		4												1		2			1	20
No		2								1	1	3		1			2				10	2							6	28
Other									2		1																		6	9
Type of courses																														
Classroom	1	2			2				5	6	1	7		1			2				10	2		1		2			7	49
Hands-on (laboratory)	1	1			1				5	5		7					1				10	2		1		2			6	42
Degree provided by curricula/programme																														
Bachelor BS									3	5		4		1							x			1					1	15
Master MS		1			1				1	4	1	3		1							x					1			6	19
Doctoral PhD					1				1	1		1		1							x					1			6	12
No univ degree	1	1			2												2					2								8

method in the educational system, then comes magnetic and electromagnetic methods, liquid penetrant, radiography and visual methods. It is very interesting that infrared/thermographic methods have such a high score. The breadth and depth of technologies encompassed by NDT is increasing and many member societies now cover condition monitoring and diagnostic technologies as well as traditional NDT.

Results of question 5 (Table 5) about application/sectors covered by curricula are also as expected, since the application responds to the industry and strategy of the development of the country concerned.

Question 6 (Table 6) was written with the purpose in mind to find out what related subjects support NDT education and diversity of implementation.

Question 7 is looking for suggestions as to how one could or could not develop teaching of NDT. The suggestions given were mostly focused on the entire interest of the university that answered. The most popular demands were to improve exchange of experience and information at the international level, extending the domain of education, finding possibilities to use modern, multimedia demo or educational software and through better cooperation with

NDT companies, including more hands-on educational possibilities. There were also suggestions to organise the certification system for NDT engineers recognitions based on the level 3 of qualification and certification.

Answers related to question 8 (Table 6) about cooperation of universities and colleges with national NDT societies were rather positive and some of the cooperation is very considerable and successful, resulting in exchange of experts and consultancy in curricula. Even those not having experienced such contact expressed interest in working on it.

Questionnaire sent to National NDT societies	Austria	Belgium	Belarus	Bulgaria	Croatia	Czech Republic	Denmark	Finland	France	Germany	Greece	Hungary	Ireland	Italy	Moldova	Latvia	Netherlands	Norway	Poland	Romania	Russia	Serbia	Slovakia	Slovenia	Spain	Sweden	Switzerland	Ukraine	UK	Total
Reply	1	2	0	0	3	0	0	0	5	6	1	8	0	1	0	0	2	0	0	0	10	2	0	1	0	2	0	0	8	52

Table 4

4. NDT methods covered by curricula/programme																													
Ultrasonic methods	1	2			3				5	6	1	5	1				2				10	1	1	1	2			8	48
Acoustic methods	0	0			1				4	3	1	2	0				1				10	0	1	0				7	30
Liquid penetrant methods	0	2			3				5	4	1	5	0				1				10	1	1	0				8	41
Magnetic methods	0	2			3				5	4	1	6	0				2				10	1	1	2				8	45
Radiographic methods	0	2			3				5	5	1	4	0				2				10	1	1	1				8	43
Nuclear methods	0	0			0				2	0	1	0	0				0				0	1	0	0				0	4
Visual optical methods	1	2			3				4	5	1	6	0				2				10	2	1	0				7	44
Infrared/thermographic	0	0			1				5	2	1	1	0				0				10	0	0	0				7	27
Radar methods (eg GPR)	0	0			0				0	1	0	0	0				0				0	0	0	0				7	8
Electromagnetic methods	0	1			3				5	4	1	5	1				2				10	1	1	2				8	44
Leak testing	0	0			1				3	0	1	0	0				2				10	0	0	0				0	17
Non-linear methods	0	0			0				0	3	0	0	0				0				0	0	0	0				7	10
Analytical methods	0	0			0				0	2	0	3	0				0				0	0	1	1				7	14
Other methods*	0	0			0				1	1	0	0	0				0				0	0	0	0				6	8

Table 5

5. Applications/sectors covered by curricula																													
Aerospace	0	1			2				4	3	0	1	0				0				10	1	1	1				7	31
Shipbuilding/offshore...	0	0			3				3	0	0	0	0				2				10	2	1	0				7	28
Automotive industry	0	0			1				3	3	0	1	0				1				10	1	1	0				7	28
Production technologies	0	1			2				3	5	1	6	0				1				10	1	1	2				7	40
Railway	0	0			0				3	1	1	1	0				2				10	2	1	0				7	28
Power plants	0	1			1				3	3	0	2	0				2				10	2	1	1				8	34
Pipelines and process...	0	1			2				4	1	1	3	1				2				10	2	1	1				7	36
Pressure equipment/...	0	1			1				2	2	0	4	0				2				10	2	1	1				8	34
Civil engineering	1	1			0				2	2	1	3	1				0				0	1	1	0				7	20
Art and restoration	0	0			1				0	1	1	1	1				0				0	0	0	0				0	5
Security and safety...	0	0			0				0	2	0	1	0				0				10	1	0	0				0	14
Other sector/app...*	0	0			0				1	1	0	1	0				0				0	1	0	0				0	4

Table 6

6. Other subjects included by curricula/programme																													
Condition monitoring	0	0			2				3	5	0	6	0				1				10	0	0	2				7	36
Production/...	0	0			3				3	4	0	3	0				0				10	1	1	0				7	32
Quality system/quality...	0	2			3				2	2	0	5	0				1				10	1	1	1				7	35
Environment management	0	0			0				0	0	0	3	0				0				10	0	0	0				1	14
Accreditation and certification	0	1			2				2	0	1	2	0				2				10	1	0	1				7	29
Reliability of inspection	0	1			3				4	2	0	2	0				2				10	2	0	1				8	35
Risk management	0	0			1				1	2	0	2	0				2				10	0	0	0				1	19
Risk based inspection	0	0			0				1	1	0	1	0				1				0	0	0	2				1	7
Integrity assessment	0	0			1				2	1	0	1	0				2				0	0	0	0				7	14
Forensic applications	0	0			0				0	0	0	2	0				0				0	0	0	0				0	2
Automated inspection...	0	2			1				2	2	0	0	1				2				10	1	0	1				8	30
Detection-threat entities...	0	0			1				2	0	0	1	0				0				10	0	1	0				0	15
Other subjects *	0	1			0				1	0	0	1	0				0				0	0	0	0				0	3

Do you have any cooperation/contact with your National NDT Society?

YES	0	1			3				4	5	1	1	0				2				10	2	1	1				8	39
NO	1	1			0				1	1	0	5	1				0				0	0	0	1				0	11
Other																													

3. Relevant consideration

The decentralisation and diversity of the higher educational system in Europe poses difficulties in approaching and influencing the problem of NDT education at the university/college level. Even within one country, the situation may differ significantly. The main reason for this is the policy of Research and Development (R&D).

Research and development follows the principles of the freedom of scientific research and creativity, of intellectual property protection and free competition between scientific programmes and proposals. Also, the strategy of R&D is mostly determined by a national research programme whose main goal may be to create a scientific and technological system that has to serve as a key factor in social and economic growth of the country. The national research programme conducted within scientific institutions and nationally supported research projects within higher educational institutions is very much influenced by the educational programmes. International support, such as for example from the European Research Council, with its grants, is even more focused on education with its programmes on the priority list for the country, region or field of implementation.

The increasingly important role of NDT in public security and safety technology development and implementation as well as in environment protection could be accomplished only if the educational system will ensure the synergy between research and education.

Moreover, the academic community needs to maintain interactive relationships, not only with its economic and social environment but worldwide in order to link research and skills development for solutions of the problems named. Universities, colleges and even schools are responsible for educating for the future. For that reason the educational system should be flexible and regularly update its knowledge. Universities, colleges and schools should introduce NDT as part of the education

equipping students with capabilities that are needed to deal with global issues.

The quality of education is another cause for concern. Some of the problems relate to the shortages of qualified lecturers, materials, books and equipments. Many countries have created an external quality assurance system with the overall purpose to control compliance with standards, provide assessment or quality audit and accreditation.

The higher education system in Europe is undergoing major transformations with growing levels of mobility of student and faculties. These forces challenge the systems for better regulation and recognition of credentials.

New curriculum profiles, which are consistent with the requirements of NDT for Public Security and Safety and Environmental protection, should be defined and offered. Because of that the NDT society-university/college partnership is increasingly considered as a way forward in higher education in NDT. Open schools and virtual universities and colleges represent new institutional models.

EFNDT's scientists and experts with their knowledge and well-developed routes of cooperation offer a valuable and constructive contribution to NDT education development.

4. Setting a new standard

For the knowledge-based society that Europe is building to remain workable and safe, we have to share knowledge. Within the educational system there is evidence of change and those with a high level of education recognise the imperative for better quality. This is a hope for NDT.

It is understandable that organisations of scientists, such as national and international academies as well as professional societies, have a significant impact in the promotion of research and education. Therefore, it is expected NDT scientists and experts will develop links with organisations of influence in R&D for upgrading NDT education throughout universities and colleges.

There are presently international, regional and many related standards and recommended guidelines on the subject of qualification and certification of non-destructive testing personnel, along with the highly regulated business of qualification and certification of NDT personnel. International harmonisation of training and certification procedures ensures uniform levels of competence and this is the subject of so many years' work and enormous endeavour in the NDT community.

Since the progress of any technical field and achievements of research and development in any application depends upon the knowledge and capabilities of the people involved, it is obvious that we should once again go through a similar road of cooperation dedicated to support best practice in the NDT qualification, but this time on the level of higher education.

For the time being it will be a great opportunity and progress if in our conferences we provide space for articles and features on NDT education at universities/colleges. Let us start with 10th European Conference in Moscow, 7-11 June 2010.

Students are not only intellectually curious, they also have a strong interest in helping to create a better world. Let us combine this approach with the best quality of our knowledge in a mutual goal of setting a new standard of excellence in NDT engineering education.

5. Appreciations

Along with the EFNDT Board of Directors and Task Group 4, the author wishes to express her gratitude for the overwhelming help of EFNDT friends in this study.

Special thanks go to the university and college professors and associates concerned about fulfilling the questionnaire, the important starting step in this efforts.

Insight is also thanked for publishing this article which, it is hoped, gives a valuable insight in the state-of-the-art of NDT education.