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THE QUALITY OF THE POST ACADEMIC COURSE 'MANAGEMENT of SAFETY, HEALTH and ENVIRONMENT (MoSHE) OF THE DELFT UNIVERSITY OF TECHNOLOGY

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SUMMARY

This article discusses the rise of European postgraduate courses in safety science, later expanded to include health and environment as well. The main focus will be on the content and quality of the *Management of Safety Health and Environment* (MoSHE) course of the Delft University of Technology, which content is organised by the Safety and Security Science Group.

The different MoSHE years show a varied picture of this post academic program. In the Netherlands the course is unique with a central focus on risk management and sustainability, supported by scientific developments in the areas of safety, health, environment, organizational science and psychology. In all year-groups the quality of the course was assessed with a short questionnaire, collecting opinions of course members on individual presentations and the course as a whole. Quality of the course was regularly discussed through the contacts of the course coordinator with module leaders, and at meetings of course committees, and leading to changes in content of modules. After MoSHE 1, 14, and 17 the course' structure, organization and content was changed radically. Only the quality system of the course remained implicit. Using the model of the European Foundation for Quality Management a first se-up for a quality system is presented

Over the years the academic nature of the program has changed substantially. This is one of the challenges for the future to find a balance between the domains taught and between an academic approach and practical skills. The course could benefit from a greater input of process safety and safety in high-tech-high-hazard sectors.

INTRODUCTION

This article provides a brief overview of the history of postgraduate courses of safety, health and environment, in some European countries. At the Delft University of Technology (TUDelft), such a program was started 1988 under the title ‘Management of Safety, Health and Environment, Risk Assessment and Control (MoSHE-RAC)’. This article focusses on the quality system developed for the MoSHE course. The following research questions have been leading:

1. How did postgraduate programs on safety, health and environment came about in and beyond Europe?
2. How was educational quality defined, and measured at the MoSHE course?
3. Which activities ensure the required quality of future MoSHE courses?

METHODS AND TECHNIQUES

Three sources were used for this study; publicly available literature, internal MoSHE documents and interviews with former course members, module leaders, lecturers, and members of course committees.

A literature search was conducted for 1950 till present, using ‘safety’ AND ‘education’, AND ‘graduate’ AND ‘postgraduate courses’ as search terms. Articles from the following professional and scientific journals appeared: Chemical Health and Safety, Education for Chemical Engineers, Journal of Engineering Education, Journal of Loss Prevention in the Process Industries, Journal of Occupational Accidents, Journal of Safety Research, Reliability Engineering and System Safety, Safety Science, and Safety Science Monitor. References from these articles were consulted in the Dutch Chemisch Weekblad (Chemical Weekly), Industrial and Commercial Training, Journal of Occupational Health and Safety Australia and New Zealand, National Safety Council Transactions, Monthly magazine for Labour, and Plant / Operations Progress.

The development of the MoSHE course over the years was studied, using internal information sources. Including the results of the independent audit of the Association of Dutch Universities (VSNU) (VSNU, 1998; Hale and Vergouw, 2000). MoSHE courses were divided into three groups, related to changes in the course structure and course management of the Safety Science Group. The first group were MoSHE 2-14, the second group MoSHE 15-17 and the last group MoSHE 18-19. The first MoSHE course was treated separately. After the first course drastic changes were introduced. While writing this article, MoSHE 19 was not yet completed.

A total of 27 interviews were conducted and five final course evaluations of course participants were used in this study. The interviews were semi-structured and covered topics such as the quality and updating of the course, the role of committees in the organization of the course, certification and the future of the program. From each group of MoSHE courses the number of participants and educational goals will be discussed, giving information of the endpoint for graduates. Separate paragraphs on structure and organisation of the course will show how this endpoint is reached. The

paragraph on results of interviews and comments from committee is dealing with the positive and negative criticism on the curriculum.

DEVELOPMENT OF POSTGRADUATE COURSES SHE IN EUROPE AND THE NETHERLANDS

Surprisingly, postgraduate safety courses do have an history. In literature, sixty years ago these type of educational programs were mentioned for the first time, which was seen as an important step forwards a recognition of industrial safety as a separate domain (Heinrich, 1956). This was an important issue, due to the high incidence of occupational accidents during WWII production (Gulijk et al., 2009). Heinrich, the author, considered safety as a 'state, free from danger'. Because such a state is almost unreachable, he suggested to use the term 'accident prevention'.

The start of academic safety courses

But in the scientific literature (post)academic safety courses were hardly a topic for publications. This slowly changed in the 1970s of the last century, when some university programs in occupational safety opened their doors. The Wuppertal University in 1974 was the first with a pre- and post-bachelor program, followed by similar programs in Finland, and at Aston University in Birmingham in 1978. The course in Industrial Safety at the Imperial College London started a few years later, comparable to initiatives at the University of Leuven, at Stockholm and the safety officer course at the Federation Ballarat University in Australia in 1980 (Nedved and Booth, 1982; Nolan, 1989; Culvenor and Else, 1997; Hale and Kroes, 1997; Arezes and Swuste, 2012). Major accidents as well as legislation were powerful promotors for these courses. A known report on safety regulation was the UK Robens report (1972). The report had a twofold message. First, those who cause the risks should manage them, and secondly, legislation was far too complex. Now companies from the process industries and upcoming nuclear sector had to move. Private parties had to become active in this domain.

At universities and colleges safety courses had a hard time, because regular programs of the Chemical Faculties were already overcrowded. Furthermore, scientific attention to this domain was only taken seriously in the mid-70s, after the major accident at Flixborough. Also Loss Prevention conferences were regularly organized from that period onwards, and the Briton Frank Lees published

his well-known series of books on ‘Loss Prevention in the Process Industries, hazard identification , assessment and control' (Lees, 1980).

The Chemical Engineering Department of the then Technical Highschool of Delft (THDelft) started in 1976 with the course Chemistry and Society, drawn according to a similar initiative at the Subfaculty Chemistry of the University of Leiden, eight years earlier. At the Delft course also social and societal aspects of the process industry were discussed. Three-year later an optional course on Industrial Hygiene started, later changed its name into Chemical Risk Management (1985). Similar to Lees’ concepts, risk identification, assessment and management were the main topics of the course. In Delft, courses Chemistry and Society and Chemical Risk Management were compulsory at pre-bachelor level (Lemkowitz and Zwaard, 1988; Lemkowitz, 1992).

Requirements for (post) academic courses on safety

The 1978 symposium ‘University Education and Research in Safety’, organised at THDelft was exerting pressure to organise an academic group on safety. One year later the Safety Science Group was established. The Symposium concluded with the statement that a separate and comprehensive course on safety at university level was necessary. 'University level, because other experts in working conditions, like the occupational physician, and the occupational hygienist were academically trained’. And ‘comprehensive, because safety experts should cooperated with many disciplines, as he or she should be able discuss from a safety point of view arguments with other disciplines’ (THDelft, 1978).

Halfway 1980s the Safety Science Group started a survey on Dutch safety issues in regular courses of Dutch educational institutions. Surprisingly safety was neither at technical universities, nor at polytechnics part of the curriculum (Hale et al., 1989). Also at TU Delft there was no room for safety topics in mainstream education. Therefore preparations for a postgraduate course started, the 1988 'Management of Safety, Health and Environment, Risk Assessment and Control (MoSHE-RAC) course. Already existing safety courses abroad were structured along two axes; hazards and vulnerable objects, including humans. High-tech-high-hazard sectors were emerging, with their low probabilities and disastrous effects. And a growing focus on environmental impacts of industries was emerging. However, a third axis received too little attention, being identification, analysis and

solutions, including behavioural and organizational aspects. These three axes became part of the structure of MoSHE-RAC (Hale, 1987, 1989).

The 90s of the last century showed a steady production of scientific papers on (post)academic safety education, boosted by the 1994 Amsterdam International Conference ‘Education and Training in Occupational Health: the Gateway to Quality in Occupational Health and Safety'. The title of the conference suggested a focus on 'occupational', but safety of high-tech-high-hazard industries was addresses as well. Three topics were dominant in this period, tasks of professional safety and health experts, certification of these experts, and including occupational safety, and high-tech-high-hazard safety in regular academic programs, mainly at technical universities.

Tasks of professional safety and health experts in companies in various European countries were investigated by ISSA, the International Social Security Association. This overview was a major input for the second MoSHE-RAC course design (Hale, 1995; Storm and Hale, 1995). Next to duties and tasks of professional experts, also certifying bodies had their demands (Oortman-Gerlings and Hale, 1989a,b). Due to budget cuts and, more in general to a withdrawing government, certification of persons, and courses was a means of government to keep some level of control on safety in companies (Swuste et al., 2016a). Certification of courses had a major disadvantage, concerning the topics addressed in the course. From universities one might expect they kept track on the state of the art in their domain, or were a major player. Lacking this overview, certification bodies could put different emphases. Another disadvantage of certification was the demarcation of disciplines, allowing compartmentalization of safety professionals which was inconsistent with a desired flexibility in the fast-changing world of market forces, technology development and regulation (Hale and Storm, 1996; Swuste, 2008).

The previously mentioned resistance of universities against educating safety related topics was not only related to overcrowded programs, but also with the low quality of the academic safety research. Safety Science was too descriptive and hardly analytical (Nolan, 1991; Grossel, 1992; Gute et al., 1993). This changed in the 1980s, a time with a series of catastrophic major accidents in high-tech-high-hazard sectors with extensive media coverage. Slowly a socio-technical approach entered the analyses of occupational and major accidents, moving away from a solely psychological, or

technical explanation of causes. After the Bhopal disaster in 1984 the American Institute of Chemical Engineers (AIChE) established in 1986 the Center for Chemical Process Safety (CCPS). In the Netherlands risk analysis, and assessment became dominant, and research resulted in the series of so-called 'coloured books' on risk analysis, failure mechanisms and damage models. (Lees, 1980; CCPS 1988; Oostendorp et al, 2016;. Swuste et al, 2014, 2015, 2016a-c.).

At the 1994 Amsterdam Congress, a plea was held for an academic course of safety experts. The argument was not so much the status of the professional safety expert with respect to the occupational hygienist and occupational physician, as was concluded during the aforementioned 1978 symposium. The argument was the quality of the safety expert. The ever-changing technology, and aggressive market forces, urged companies for a need of professional safety, health and environment experts, able to analyse problems and provide solutions to situations not yet occurred before. Rule following behaviour would be less appropriate in such a context (Saari, 1995; Burdorf, 1995).

Safety training and competences in companies

Learning objectives of (post) graduate courses on health, safety and environment are one side of the coin. The other side is how companies organize these skills for their own staff and line management. Not many articles are discussing this topic. One exception is a paper from a Dutch multinational company in the life sciences and material sciences sector. There the need for training in these skills was assessed with focus groups, and accident analysis (Rouhof et al., 2009). The demand for these competencies was huge. However, there was a big variation of relevant courses followed by staff and line managers. Although accident analysis showed a deficiency in risk control measures and prevention of major accidents, company courses teaching HAZOP and SIL classifications only had a minimal interest amongst managers. It is sad to see an increased degree of ‘safety illiteracy’ amongst engineering students, the future process managers, as Saleh and colleague indicated (Saleh and Pendley, 2012), a conclusion that also could be drawn from the Dutch study mentioned above.

QUALITY OF EDUCATION

An exchangeable structure of courses of higher and university level was introduced with the Bologna Declaration of the European Union on June 19th, 1999. It included a credit system to promote the accessibility of the 'knowledge society' for European citizens and stimulate mobility between countries (European Higher Education Area, 1999; Bologna Working Group, 2005). The impact of the Bologna declaration on courses in the field of safety, health and environment was immediate and many programs were set up or expanded, often in cooperation with technical faculties of universities (Ludin and Jönsson, 2002; Garrigou and Peissel, 2008; Perrin and Laurent, 2008; Arezes and Swuste, 2012, 2013). Following Bologna, the European Network of Safety and Health Professional Organisations (ENSHPO) elaborated the harmonization of higher education, qualifications and certification requirements for the health and safety domain. After 2000, ISSAs' earlier study was continued, supported by publications of a classification of educational goals and an education credit system (EQF, 2008; ECVET, 2009; Hale and Ytrehus, 2004; Hale et al., 2005).

This European Quality Framework provided a classification into eight levels of knowledge, skills and competences. Level seven, was equivalent to a university master (see Table 1). Together with the European credit system to assess the workload for students to achieve the educational goals, these initiatives enhance the comparability of courses between European countries.

INSHPO, the international network, continued this development in her document 'The OHS Professional: A framework for practice - Role, knowledge and skills' (Pryor et al, 2015), and made a comparison with a GP. The academically trained occupational safety and health (OHS) professional has a similar role in companies. He, or she, is a generalist with knowledge of the unique safety multidisciplinary body of knowledge, concerning risks, hazards, reduction of occupational mortality and morbidity, injury and the associated social and financial losses.

Critical awareness of knowledge issues' from the EQF level seven is a concept that matches the academic critical reflection: analysing at a meta-level and assessing existing practices, arguments and situations and new knowledge and situations.

	In the context of EQF, knowledge is described as *theoretical and/or factual*.	In the context of EQF, skills are described as *cognitive* (involving the use of logical, intuitive and creative thinking), and *practical* (involving manual dexterity and the use of methods, materials, tools and instruments)	In the context of EQF, competence is described in terms of *responsibility and autonomy*.
Level 7	Highly specialised knowledge, some of which is at the forefront of knowledge in a field of work or study, as the basis for original thinking and/or research Critical awareness of knowledge issues in a field and at the interface between different fields	Specialised problem-solving skills required in research and/or innovation in order to develop new knowledge and procedures and to integrate knowledge from different fields	Manage and transform work or study contexts that are complex, unpredictable and require new strategic approaches; take responsibility for contributing to professional knowledge and practice and/or for reviewing the strategic performance of teams

Table 1 Learning Objective level 7, European Qualifications Framework (EQF), university master course

This critical reflection is difficult to learn. It requires an overview of academic knowledge of the domain, both historically developed, and currently applied, as well as a willingness to discuss one's own and divergent points of views on these topic. At MoSHE this can be achieved through interactive presentations, discussions, debates about current issues where opposing standpoints are presented, through presentations by course members, or through other formats of education (Swuste and Arnoldy, 2003; Kletz, 2006 Shallcross, 2013; Wybo and Wassenhoven, 2016).

To establish educational goals is a first step towards educational quality. Around World War II many publications appeared upon the quality of products and production and this provides opportunities to use a similar approach to education. The Americans Shewhart (Shewhart and Deming, 1939), Deming (1982) and Juran (1951), were the pioneer of quality control. They shifted control from the end product to the manufacturing process. This process optimization involved a learning capacity of the organization. Employees and customers were assigned a major role in the quality control. The European Foundation for Quality Management (EFQM) in Brussels has drawn up a management model along these lines (Figure 1).

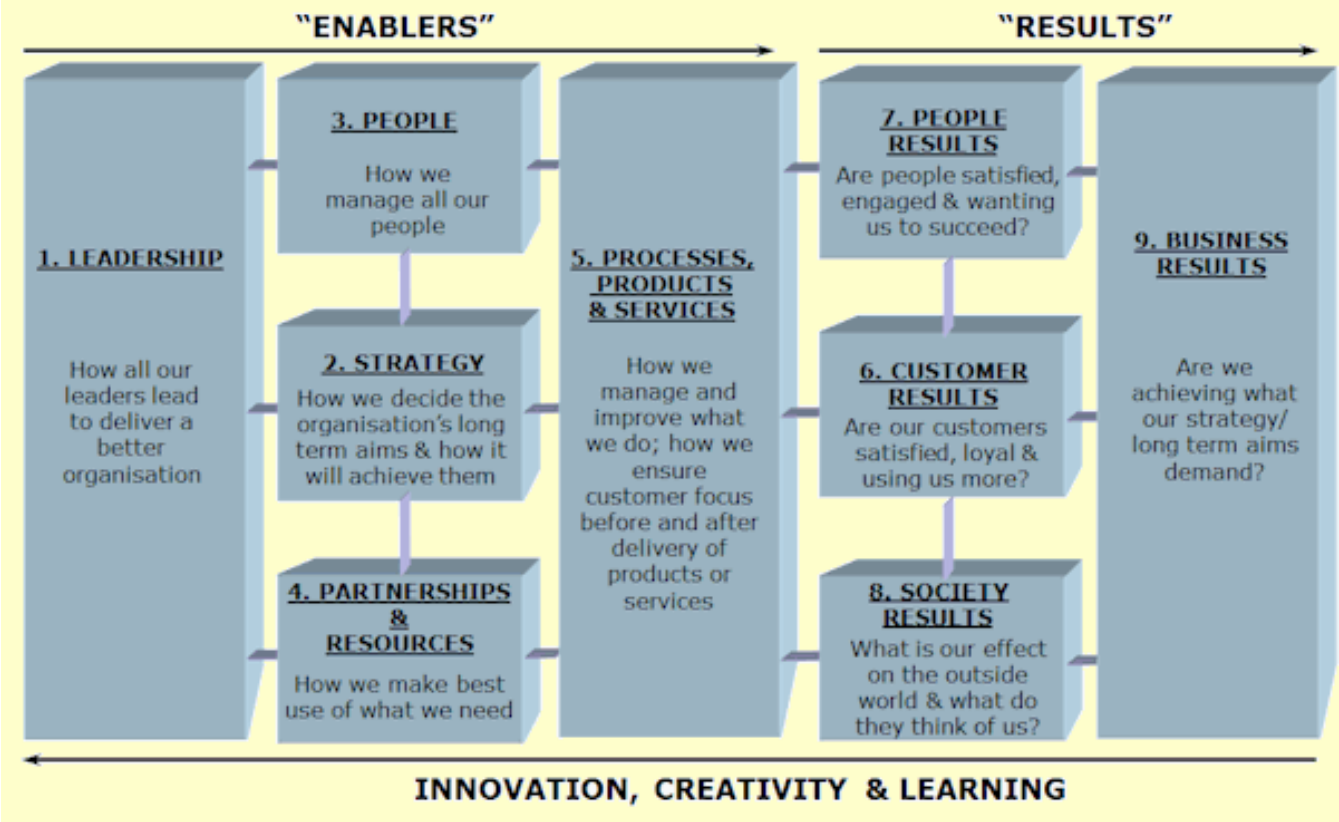

Figure 1 EFQM management model (after D&D Excellence)

A similar model was presented by the Dutch Quality Institute (INK), derived from the Dutch Ministry of Economic Affairs. The model is focused on continuous improvement, due to an ever-changing production, market, and customer requirements. Next to private organizations, the model can also be applied to public organisations and institutions, such as fire brigades, education and health care institutions and includes all areas of business operations (Wennink et al, 2001; NVAO, 2014). This will provide a framework for the assessment of organisational activities to ensure the quality of, for example education.

For this study an ideal-typical quality control of the MoSHE organization was based upon EFQM management model (Table 2). While presenting various MoSHE years, enablers and results will be discussed.

Enablers	Activity
leadership	Develop a vision on: 1) the future of the course in and outside TUDelft; 2) the position and relation with other safety courses; 3) the goal and content of the course; 4) the quality and quality assessment of the course.
people	Course management can guard and adjust the quality of the course. There is an adequate division between lecturers addressing practical and academic topics.
strategy	The purpose, design and assessment of quality requirements of the course are formulated and, if necessary the course can be adjusted.
resources	Financial means are present fora n adequate quality assessment.
processes, products & services	Structural communication between module leaders, course management and advisory board guarantee the knowledge and competencies presented in the course are up to date and in line with quality requirements.
Result	**Activity**
module leaders	Module leaders adjust the content of their module, and their homework to the goals and quality requirements of the course.
didactical format	Variations in didactical formats will enhance a critical reflection amongst course members.
appreciation by module leaders	Evaluation by module of each course year.
appreciation by course members	Evaluation by course members of each module, and each course year.
appreciation by companies	Evaluation by companies, which have send their employees to the course.
result	Graduated course members will enhance the level of safety of their companies.
learn and improve	Adjustment of the course, based upon in- and external sources.

Table 2 Ideal typical quality control of MoSHE courses

MoSHE COURSE

MoSHE year 1[1988-1989]

The first MoSHE-RAC year started with 8 course members and aimed to teach course members the state of the art of methods and techniques to develop a policy to evaluate for risks of technological systems. ‘Risks include risks to health, property and environment ' (MoSHE, 1988). The course consisted of four blocks (Table 3). The first block gave the structural framework of the rest of the course and the opportunity for course members to discover gaps in their knowledge on essential basic disciplines. These disciplines were taught on an individual basis in the second block. The third block was the core of the program. After this block three different specializations were offered, from which course members could choose. These specializations were put on the market as short courses.

MoSHE 1[1988-1989]

I	introduction, scope of SHE problems, legislation, standards, parties involved	1 week
II	basic disciplines, (bio) chemistry, particle physics, statistics, organisational science, psychology	2 weeks
III	core program, risk identification, evaluation, management and policy	7 weeks
IV	specializations	
	generalist, legislation, policy, eternal relations, organisational changes	4 weeks
	risk manager, HAZOP, PRA, HFA/Design, software safety, external safety - environment	4 weeks
	safety training and education, risk perception and behaviour, responsibilities	2 weeks
project		6 months

Table 3 Structure of the first MoSHE-RAC course

MoSHE years 2-14[1990-2008]

MoSHE years 2-14, number of course members, and educational goal

From the second year of MoSHE-RAC, the number of course members rose to 15-18 per course. After MoSHE 9[2000-2001] the number went up to 20 course members of the two-year course. 20 was considered to be the maximum, and a waiting list of curse members was born. During this period, the educational goal of the program was reformulated, SHE aspects and integrated approach were mentioned.

The course presents an overview of the best available methods and techniques to develop, implement, manage and evaluate policy in relation to safety, health and environment (SHE). The focus lies on the integration of these approaches and techniques in a coherent and systematic policy. Management aspects and human factors form an integral part of the program. The course is based on an analysis of the tasks of the safety manager. The program meets educational requirements of the Working Condition Law Article 19, later changed to the terms of the SKO registry.

MoSHE years 2-14, structure of the course

Compared to the first year, the structure of the course was changed radically. The specializations were abandoned, as well as the base disciplines (Table 5). The core program now consisted of three blocks, a format that was maintained for thirteen consecutive MoSHE courses.

MoSHE 2[1990-1991]-14[2006-2008]		
I	general principles, risk assessment and control	2 weeks
	principles of assessment and control	
	risk assessment and evaluation techniques	
II	toepassingen, veiligheid, gezondheid, duurzaamheid en risico management	3 weeks
	occupational and environmental hygiene and health	
	accident analysis and prevention	
	hazard and risk analysis for safety and environmental risks	
III	SHE management en beleid	4 weeks
	SHE management and organisation	
	initiating and realising lasting behavioural change	
	decision making and influence, organisational processes	
	environment and sustainable strategy	
thesis		4 months
mini-project from MoSHE 6[1996-1997] onwards		1 week

Table 4 Structure of MoSHE years 2-14

MoSHE years 2-14, organization of the course

The Safety Science Group department was responsible for the programs' content. The director and the coordinator of the program had expertise in the areas of risk management, occupational and

process safety, health, and organizational behaviour, and to a limited extent in the environment. The project manager of Delft TopTech Studies arranged the logistics: the hotel arrangements, the position of the program within TU Delft, publicity, and maintained contacts with companies for the recruitment of new course members. During the first five MoSHE courses, the program director, the coordinator and the project manager were closely involved in the implementation and design of the course. Afterwards the coordinator and the project manager took over this task, while the director focused on external contacts. He was also the chair of the examination committee, the advisory board, managed his own module and supervised thesis of a number of course members.

New in this scheme were the module leaders, which organized individual modules. These module leaders were selected, based on their specific knowledge and network as input to the module. This module leaders had expertise in the areas of risk management, process and occupational safety, sustainability, environment, health, and organizational behaviour. Five of the nine modules were led by module leaders from the Safety Science Group. Seven and a half module were directly aimed at the SHE field, including the hazards and risks of so-called high-tech-high-hazard sectors and risk management. One and a half module treated more general sociological and organizational psychology topics. That was true of the entire module ‘initialization and realising lasting behavioural change’ and half of the module 'decision making and influence, organizational processes’. The other half was devoted to cost aspects of safety and to safety culture. Throughout the year the coordinator and the project manager had a direct contact with course members and module leader. The coordinator had overall picture of the content of the course, oversight of results from homework and evaluated with the module leader his or her module and advised changes in future module content and lecturers.

Almost half of the lecturers of the years 1-14 were either staff members of the safety Science Group, so-called core lecturers, or lecturers from others universities or research institutions. This group presented 60% of the lectures of the course. The other half of the lecturers came from industry or from consultancy firms. Government organizations took care of 5% of all presentations. The course had different educational formats: lectures on theoretical topics, tutorials where course members in small groups worked on cases and presented their results, discussions on current safety, health and

environmental issues where opposite positions were presented, homework, self-study and finally thesis research. The first six modules of this first group of course years had homework assignments, which were generally very broadly defined. Course members were asked to apply the content of the module on problems in their companies. This homework was assessed by the module leader.

The course was completed with a thesis, preferably on a problem that the course member expected within a period of several years within his or her company. Course management provided a preliminary assessment of the thesis, a few months before the final submission date, so the thesis could adjust before it was sent to the board of examiners. Two examiners read and assessed the thesis in detail. The oral exam was the final conclusion of the course. The thesis was the main topic of the exam, where the most important aspects of course were applied in a practical study. Another point was the degree to which a course member was supposed capable of leading a department of safety, health and environment.

From MoSHE $6^{1996\text{-}1997}$ onwards a mini project, later called the health and safety advisory project, became an integral part of the course. With participants from the occupational physician course of the University of Amsterdam (CorVu) and the 'health, safety and welfare adviser course' (VGWA) from the same university, one-week advisory projects were performed in selected companies by mixed groups of 4-5 course members. During this project the collaboration with occupational physicians and other occupational health experts was central, as well as the analysis and solution of the problem raised by the company concerned. Course members presented their results and got feedback from the company, as well as from course management. Cooperation with the CorVu and VGWA ended in 2004 when the VGWA course ceased to exist. After that, the mini project continued only with MoSHE course members under the name SHE Health & Safety Project (SHEAP).

Written evaluations from course members about the quality of the course were available. These evaluations were collected from each lecture, each module and from the mini project with questions on the form of the lecture, the quality of its content and its relevance to the daily work of the course member. These evaluations were discussed along with the experiences of the coordinator during meetings of module leaders and the advisory board. On average between 20% and 25% of the

teaching materials, the module design, the lecturers and the mini project was changed or updated each course year (Hale and Vergouw, 2000).

The majority of course members passed the course successfully. Some failed due to illness, job change or due to retirement. Table 5 shows the distribution of the MoSHE years 1-7.

graduated (n = 90)	90
stopped, illness, pension, change of jobs (n = 9)	9

Table 5 Numbers and percentage of graduated course members MoSHE 1-7

In 1998, the Association of Dutch Universities audited safety courses also on behalf of the certification regime of the Foundation for Certification of Competence (SKO) (VSNU, 1998). MoSHE was part of this audit as the only postgraduate course. The report concluded on the MoSHE course that:

- the course had a good balance between theory and practice;
- course members were encouraged have their own experience as an input for the course;
- the program had a clear organizational structure to manage its content, adaptation and renewal of the program;
- the course paid attention to interdisciplinary collaboration, with the mini project an example;
- the self-tutorial MOSHE was a good starting point for the further development of a quality system of the course.

The audit committee recommended a further development of interdisciplinary projects and modules within the course program.

MoSHE years 2-14, results of interviews and comments from committees

The importance of quality and quality assessment of the course became apparent during interviews with module leaders and members of the advisory board, and examination committee. The course was aimed to stimulate a critical attitude amongst course members, not to take everything for granted,

and to teach course members to bring unprecedented SHE challenges to a solution. Interviews with course members indicated they had acquired these knowledge and skills, they had discovered scientific literature, and the course provided them with a 'helicopter view' of the SHE domain.

The quality of the course was only formalized through the evaluations of course members. The topic was discussed in meetings with module leaders, course management, and in detail with the coordinator. Changes in modules and in the design of the course were topics of meetings module leaders and the advisory board. Interviewees came up with suggestions for measuring quality by assessment of learning objectives, or through output of students. The day-to-day evaluation of lectures by students could be replaced by an evaluation by lecturers, and module leaders. Course members' evaluations were too much focused on the form of the presentation of the lecturer. Another option was to allow students to keep a journal to track their progress in relation to their expectations of the course, and the formulated educational goals. Finally, an internal audit was proposed by an auditor with an overview of the course content.

Opinions were divided on the exam at the end of the course. Most module leaders and members of advisory board and examination committee felt that course members should not fail their exam, and selection of course members suitable for the exam should take place at an earlier moment during the course. One module leader argued that the possibility to fail the exam should be open for MoSHE.

A member of the advisory board and the examination board makes the observation that the MoSHE course could give more attention to the organisation of process safety and safety of high-tech high-hazard technologies. These technologies require a complex organisation to manage their processes, which was a strong point of MoSHE. The course was compared to an MBA program for SHE and logically would MoSHE be benchmarked with other MBA programs. Within companies there is often a clear separation and hierarchy between the (process) engineers, responsible for safety of these complex technologies and the SHE department. The SHE department is mainly responsible for occupational safety.

On certification opinions were divided. External members of the advisory board and the examination committee saw an added value in certification, as a guarantee for quality and to increase

the status of the course. Others, academic module leaders, warned for a flight in administrative processes and for a requirement for certified lecturers. Because academics were not certified, this could mean that there lecturers, and module leaders were excluded from the course.

MoSHE years 2-14, contacts with other safety expert courses

From MoSHE 9[2000-2001] onwards the coordinator had close contact with of the post polytechnic education Higher Safety Studies (HVK), first organized by TNO Work and the Foundation of Post Polytechnic Safety Studies (SPHOV) and later taken over by SPHOV. Following the audit of safety courses by the Dutch certifying body, the Foundation for Certification of Competence (SKO), there were possibilities to explore collaboration in courses' contents, as well as in in future marketing of the courses. For example, MoSHE course members could follow some more technical modules and HVK, and HVK students management-oriented modules at MoSHE. Finally organizational collaboration was investigated whereby MoSHE and HVK could be combined in one organization, developing a variety of modules. Each course member could thus follow an individual training plan. None of these proposals were elaborated when the HVK's course coordinator was replaced.

MoSHE 15-17[2008-2012]

MoSHE 15-17, number of course members and educational goals

This second series of MoSHE years, like the first series, had an average of 20 course members per year. Some parts of the course structure remain unchanged; SHE Health & Safety Project, the variation in teaching methods, supervision of theses and examination. Other parts were modified, such as the educational goals, the structure and the organization of the course. The educational goals of MoSHE 15 was reading as follows:

> The course aims to find the participant's contribution to SHE management in a broad and appropriately deep understanding of the essential knowledge of the field. It also aims to enable the participant to harness knowledge through skills of systematic inquiry, critical evaluation and

problem-solving. Lastly, the course aims to encourage the participants in the pursuit of high ethical standards and mature, sustainable management of SHE.

A graduate will be able to:

- rigorously investigate situations and analyse problems relating to SHE;
- Identify and evaluate the SHE implications of business process changes;
- integrate SHE management into business processes creatively and systematically, rather than having SHE management as an add-on;
- get SHE considered at a strategic level and as an integrated part of business strategy;
- create a SHE strategy that is synchronised to the business strategy and developed with respect to organisation, planning and implementation;

The broad spectrum of lecturers and participants gives this programme a (inter)national dimension and provides an overview of worldwide practices in SHE management. Participants will build up a professional, international network made up of fellow participants, alumni, lecturers and specialists who will be supportive for future work connections. On successful completion of the assignments and a master's thesis, carried out within the own organisation, the graduate will receive a Master's degree from Delft University of Technology.

Compared to the first series various elements were added, like 'high ethical standards', 'sustainability management', 'relationship and integration of SHE business processes', and the 'international network', as well as the Master title. These master title was not a Master of Science, but the unprotected title of Master of Safety Health and Environment.

MoSHE 15-17, structure of the course

In 2006 the MoSHE Improvement Project (MIP) was started under the guidance of a 'consultant management support and organization development' and a member of the Safety Science Group. The argument behind this project was the open ending of previous MoSHE courses. The curriculum was not cyclical enough. The integration of knowledge and skills from the different modules was not

an explicit part of a final module. Furthermore, the topics of environment and health were, according to the new director, underexposed. The MoSHE course was too much content focused, the state of the art of scientific discipline was too central. The demand side, which problems course members were facing during their work, and what goals they had while entering the course was too weak. In short, the learning track of course members, their desired skills and change management approaches had been neglected in the first series of course years. This led to a structure shown in Figure 2. The first block 'orientation and organization' gave a general overview of the topics of the course, similar to the first module from the first series of MoSHE years. Topics such like risk concepts, culture, management, business ethics and the legal and administrative items were dealt with.

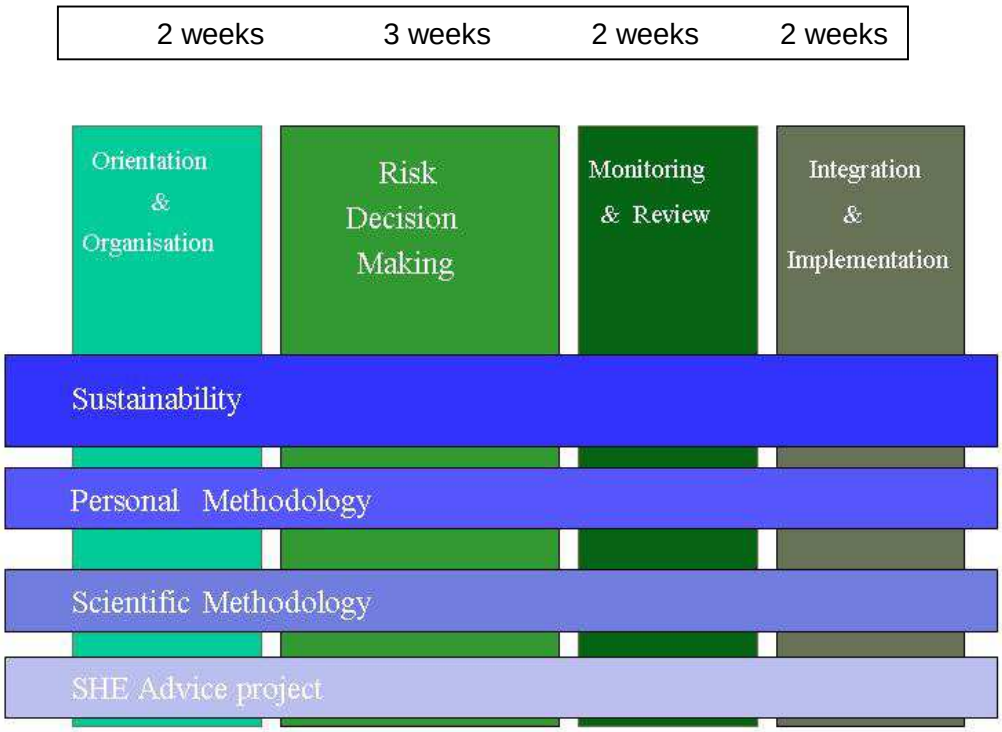

Figure 2 Structure of MoSHE years 15-17

This module also introduced topics covered in each block; sustainability, personal and scientific methodology. The second block, ‘risk decision making' presented the contextual and technical aspects of risk decision-making. In this block, safety, health, and environment were lectured one week each. ‘Monitoring and review’, the third block gave an overview of methods, and techniques to measure SHE performance, and to detect deviations to meet SHE goals of a company or

organization. The fourth block, ‘Integration & Implementation' was intended to integrate knowledge from previous blocks, aiming to train course members to be effective SHE managers. With this last block the cyclic nature of the course was restored. Three transversal themes and the SHE advisory project were elements running as a red thread through the course. The concept of sustainability gathered management of social, environmental and economic topic together. In a business context, this was referred to as the ‘triple P’s; people, planet, profit'. The personal methodology focused on learning process of course members and their unique professional development, while the scientific methodology dealt with scientific methods. As a result the course member was trained both in a role as investigator, and as interrogator.

MoSHE 15-17, organization of the course

The program director of the new program have expertise in risk management and process safety. The coordinator in this course structure was replaced by usually two coordinators per block and per transversal theme. As a result 12 coordinators were active, including the one of the Health and Safety SHE Advice Project. Only four coordinators came from the Safety Science Group, and two from another university and a research institution. The advantage of coordinators per block and transversal theme was clear. They had expertise in the areas of risk management, occupational and process safety, health, environment, sustainability and behaviour, and they only had to manage a limited number of lecturers. But the disappearance of the role of a central coordinator, attending the entire program had a major disadvantage. No-one had a full overview of the course any more. To compensate, meetings block, and transversal coordinators were organized. Here the relations were discussed between the blocks and educational goals were defined for every lecture. New was the introduction of intervision and a so-called learning logbook. Intervision with course members, aimed at learning and sharing one’s work-related problems was set up in the early evening on Mondays. Course members kept a learning logbook to monitor their development and to evaluate.

Table 6 is showing an overview of topics of the two series or MoSHE years. The proportion of process safety and, in particular, occupational safety, is reduced in favour of the two new topics, the so-called personal and scientific methodology.

safety, occupational	28	19
safety, process	22	18
safety, total	50	37
health	11	10
environment	11	13
risk management	28	31
scientific methodology		2
personal methodology		8

Table 6 Time in percentage spent on topics per series of MoSHE courses

This second series of courses showed a larger percentage of course members leaving the course without being graduated. Delft TopTech initiated a so-called mini MoSHE for graduated HVK students. Those students could obtain a MoSHE graduation, while following a limited number of MoSHE modules. This streamlined program started with six students. Their examination results are summarized in Table 7.

graduated	90 - 91%	51 - 82%	3
no exam	9 - 8%	11 - 18%	1
additional assignments			2

Tabel 7 Results of exams of course members of the first two series of MoSHE courses, including the mini-MoSHE

MoSHE 15-17, results of interviews and comments from committees

A number of topics from the first series of MoSHE were also mentioned during interviews of the second series, like more attention to process safety and the absence of explicitly formulated quality system for the course. Students had positive reactions. The course had taught them using scientific literature and a critically reflection on information provided. Again the advisory board gave the remark that course management should have a natural affinity with the pillars of the course; including SHE, process safety, health, environment, sustainability, risk management, and organisational behaviour.

Without this background course management could hardly be expected to control on the quality of modules and selection of module leaders.

The advisory board criticized the mini MoSHE. Commercial arguments from Delft TopTech would have prevailed. The mini MoSHE had failed as a full course for graduated HVK students. The initiative was no longer continued. On the other hand the unique character of the complete MoSHE course was several times emphasized by the advisory board. The course filled a gap in the need for SHE managers at companies and governments. The scarcity of courses for global SHE Managers was a recurring theme during discussions in international professional networks. Thereby also the quality of these courses was a topic.

MoSHE 18 - 19[2013-2017]

MoSHE years 18-19, number of course members and educational goals

Although course members were positive about MoSHE year 18, there was a substantial decline in the number of course members. The course started with 12 participants. The reason for this decline was not entirely clear. Governmental budget cuts had put a stop on potential course members and possibly for companies a similar argument applied.

The educational goals of this series of courses was not different from goals set for the previous series.

MoSHE years 18-19, structure of course

After MoSHE 17 of the structure and organization of the course was changed again. The reason was threefold. First there was a lack of cohesion between the different blocks of the course. Secondly, topics such as process safety and risk decisions of the course, only had a limited depth. And finally the balance between theory and practice was limited as well as learning objectives of the program blocks and sessions. An external consultant, which was attached as co-leader of one of the modules, led to the changes. As a starting point for the revision a future course member was defined, expecting to have 5-10 years of experience with SHE in one or more small, medium or large companies or

organizations. A MoSHE graduate would have sufficient knowledge and skills to function as SHE manager. He or she would be able to:

- provide functional leadership to risk management SHE processes;
- establish, implement and support relevant policies, standards and procedures, processes and techniques;
- act as a direct advisor to the CEO;
- implement together with colleagues a proactive SHE management and relevant improvement programs;
- be responsible for the quality of SHE advice and have access to relevant SHE expertise;
- have an understanding of cross-border influences;
- be independent.

Competence in this approach would have two complementary aspects, both the academic knowledge and also practice skills. Both aspects were prerequisites for adequate competence. The structure of the program is shown in Figure 3. The structure of the different blocks followed basic elements of a risk management system. Strangely enough, the health module was placed in the ‘implementation’ column. ‘Risk management’ is a logical place for this module.

MoSHE years 18-19, organization of course

From MoSHE 18 onwards a new selection of potential course members was implemented for those with only a bachelors’ degree of a graduation from a Polytechnic. In previous years they were admitted to the course, but now they had to follow a pre-master's program. The Faculty had a one year pre-master program for its PhD students to teach them the necessary academic skills. Delft TopTech organised a very slimmed-down pre-masters of only 4 days with statistics, philosophy of science and research and design as topics. For MoSHE 19 Delft TopTechs’ pre-master was abolished. The topic of academic training, which was already introduced during MoSHE 18 as scientific methodology, had a larger share in the course.

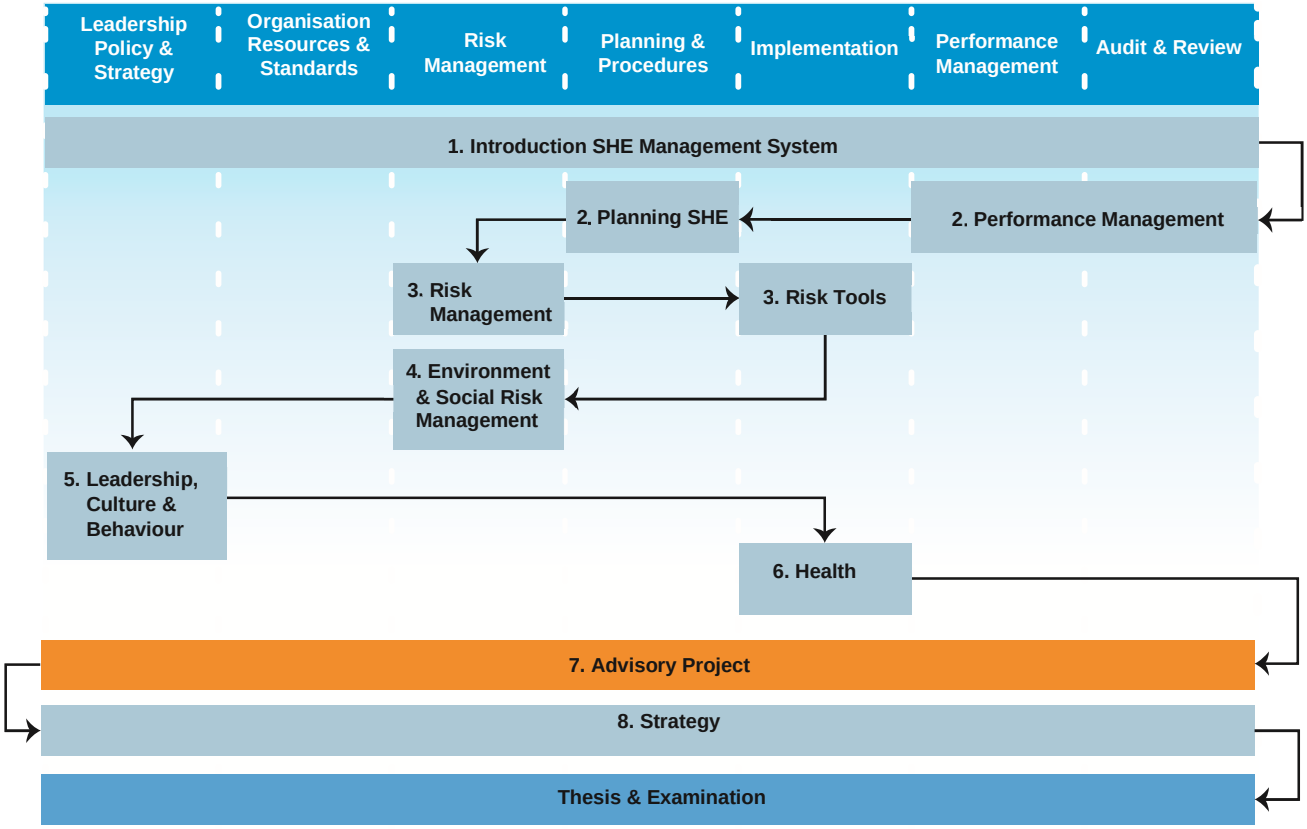

Figure 3 Structure of MoSHE years 18-19

Other changes from MoSHE 18 onwards were related to module leaders, module teaching materials and new topics added to the course. A PhD, or being active in a PhD program became a requirement for module leaders. MoSHE 19 was the first course where almost all teaching materials were distributed through the e-learning system of TUDelft. An exeption were books, distributed during modules. New topics were introduced in the course as part of the module ‘planning and procedures’, like contractor management, supply chain management and competence management, scenario planning and financial management. The course also provided individual coaching, as was initiated during MoSHE 18. A central coordinator was re-introduced to improve the integration of topics and blocks and provide course management with a general overview of the course.

Table 8 shows the topics of the three series of MoSHE courses. MoSHE 19 was still running during the production of this article. Therefore table 9 only shows exam results till MoSHE 18. The results are somewhat disappointing. More than half of the course members of MoSHE 18 were not

graduated. This is a worrying development. An investigation into the reasons of the delay seems necessary.

safety, occupational	28	19	33
safety, process	22	18	8
safety, total	50	37	41
health	11	10	8
environment	11	13	10
risk management	28	31	17
academic skills		2	6
personal methodology		8	11
statistics			6
others			2

Table 8 Time spent in topics (percentage) per series of MoSHE courses

graduated	90 - 91%	51 - 82%	3	5
no exam	9 - 9%	11 - 18%	1	3
delay				3
additional assignment			2	

Table 9 Results of exams of course members of all series of MoSHE courses

MoSHE years 18-19, results of interviews and comments from committees

Similar points as the first and second series were mentioned again; more attention to process safety, the lack of a formalised quality system of the course, and the uniqueness of the MoSHE course. The reactions of the course members were positive again. The versatility of the course was mentioned, as well as the learned critical reflection and scientific approach. Members of committees, module leaders and course management had a different opinion on this last point. Increasingly the course had become less technical and academic, and over the last years had developed more and more as a professional course. Module leaders experienced a rather low control on the content of their modules by course management. For them, that was agreeable, and they had lots of freedom in the design of their module.

This series of courses was substantially different qua content, structure and organisation then previous series. The competencies of SHE managers in companies were leading for changes made. In concluding the current director noticed that the quality of a course can be defined with these competence levels. Have graduates achieved this? A state-of-the-art of teaching materials offered is required, presented by top lecturers with a program where presented topic are integrated.

MoSHE years 18-19, future developments

Two separate certifications of the course were prepared. The first one was for SKO, and the course was re-admitted to the list of educational institutes for personnel certification of safety expert. The second one was for the Dutch Flemish Accreditation Organisation (NVAO), which was necessary because TUDelft decided to transfer MoSHE to the Faculty of Technology, Policy, and Management. TUDelft only issues a Master of Science (MSc) title for graduates. The master title associated with the MoSHE course of Delft TopTech was an unprotected one. Graduated course members of MoSHE could only get an MSc title when MoSHE was NVAO certified. Several conditions must be fulfilled. One is the size of the course. A MoSHE course was 60 ECTS, and 120 ECTS was required. Another requirement is the assessment against the so-called Meijers criteria, the criteria for TU's program where seven competency areas defined (Meijers et al, 2005):

1. competent in one or more scientific discipline (s);
2. proficient in research;
3. proficient in design;
4. a scientific approach;
5. have basic intellectual skills;
6. proficient in cooperation and communication;
7. take into account temporal and social contexts.

It is expected that the review of these criteria for MoSHE are not problematic. The admission of course members is another problem. Course members with only a bachelor's degree can no longer participate in the course. This would rule out a large portion of future trainees.

DISCUSSION AND CONCLUSIONS

During the interviews more than once the unique character of MoSHE in the Netherlands was mentioned. The central message of the course is a practical and comprehensive approach to risk management and sustainability. This message is supported by scientific knowledge and developments in the areas of safety, health and environment, management science and psychology. The knowledge areas and practical skills of an academically trained SHE manager were described and elaborated in a document of the International Network of Safety and Health Practitioner Organisations (INSHPO), see Table 10 (Pryor et al., 2015).

A. understanding hazards and risks	1. personal skills
B. understanding risk controls	2. professional practice
C. safety and health management skills	3. professional technical
D. professional role and functioning	
E. underlying technical and behavioural disciplines	
F. underlying management science	

Table 10 Knowledge areas and practical skills fora n academically trained SHE manager

Both companies and the government need managers who are able to analyse problems and find solutions for situations never occurred previously. Within companies graduates have a position similar to a general practitioner in the medical field. They should have sufficient specialist knowledge to use it and to transfer this to management of their business. They need to know when to consult and refer to experts and where to find these experts.

Students who sign up for the MoSHE course will operate at various levels of competence. The program aims to deliver graduates who can function on the level of 'do without help' (see Figure 4). The question is how this competence level can be reached how this can be tested.

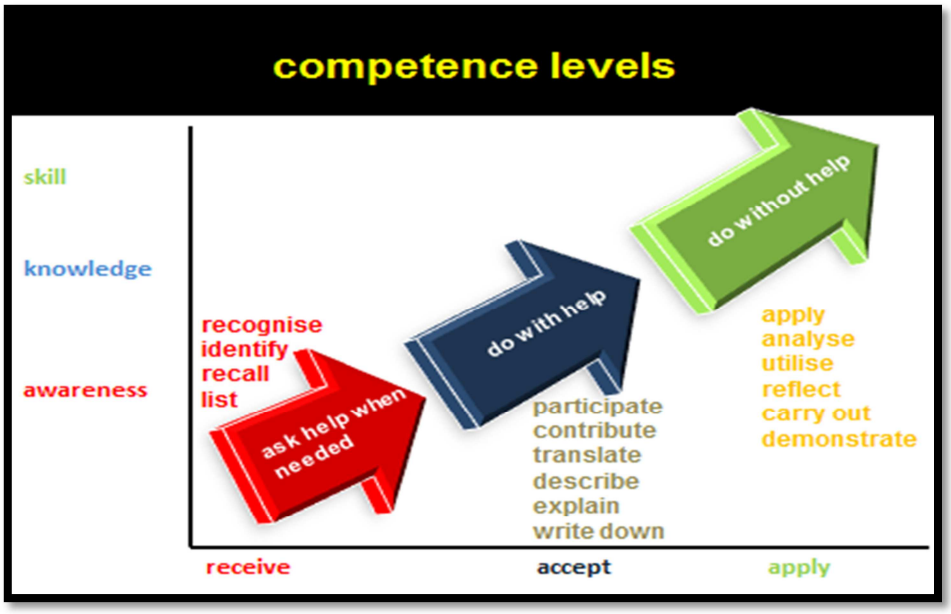

Figure 4 various levels of competence

The 1970s of the previous century saw the rise of (post)graduate courses on safety in various countries. Major accidents in high-tech-high-hazard sectors, together with legislation were major drivers for these courses. Almost a decade later safety became safety science when various research groups in this domain entered the academic world in various countries. MoSHE started in the late 1980s as a port-academic course. The course had three major revisions. After MoSHE 1 its academic focus remained, but its structure, and organisation changed radically. And the course was successful for the period 1990-2008. From MoSHE 15 onwards course became more commercialised, and course management had less affinity and expertise with the course content. These series lasted till 2012. MoSHE 18 introduced the last revision, and the course was structured along the elements of a risk management system and the expected competencies of SHE managers. A central coordinator with an overview of the course content, and close contact with course members was and is a crucial element of the course organisation. The same argument goes for the course management, where a natural affinity in expertise is required to exercise sufficient control over selection of module leaders, and content of modules.

During the 24 years of MoSHE, and many changes made in content, structure and organisation of these course, no course management had implemented a formalised quality system.

As a start, an ideal typical quality control, based upon Figure 1 and Table 2 could have the following elements:

Enabler, leadership

- For all three series of courses, educational goals and content of the course are defined.
- During MoSHE 2-14[1990-2008] an extensive contact with other safety courses – HVK was established. These contacts should be renewed.
- The quality of the course has been a serious topic, given the many changes to its content. Course management does not have a clear vision how to assess this quality. During VSNU audit of the first series input was given. For obscure reasons this advice was not followed.

Enabler employees

- To monitor the quality and adjust the program it is imperative that the course management has proven expertise in the areas covered by the program. In the first series of courses this expertise was available. Gradually this expertise declines during the second and third series. As a result of the disappearance of the central coordinator the control on the quality of MoSHE 15-17[2008-2012] shifted to the block coordinators and committees of the course. Course management gave little guidance to the course, which was also the case during MoSHE 18-19[2013-2017].
- The division between academic and professional lecturers shifted in later years to professional lecturers. Whether or not this ratio is in balance, should be determined in a further investigation.

Enabler policy and strategy

- Continuously the training was updated. Presentations were set up differently, lecturers were changed, the structure of modules have been adapted and the entire program was extensively modified three times. Quality arguments will have played a role here, but that was difficult to track down.

Enabler resources

- No resources were made available for a quality system.

Enabler processes

- The impact of the module leaders, course commissions, and the advisory board was limited. During MoSHE 15-17[2008-2012] 12 course coordinators contributed to the complexity of course management. For future MoSHE years a greater involvement of both committees is desirable.

Result area module leader

- Integration of knowledge and skills from the various modules is a challenge that has been addressed adequately in none of the MoSHE years. Modules were presented as stand-alone activities. This alignment and integration deserve explicit attention for future courses, which is also true for ratio of academic knowledge and practical skills. The question is whether the program should give much attention to statistics, personal skills and strategy. Mostly students in their businesses will be trained in these topics. For statistics, the question is what kind of expertise is needed for a SHE manager?
- Educational goals were prepared for both the entire course as for individual models. This created a paper reality (Pryor, 2016). An evaluation of the module goals, and whether these goals were achieved, was omitted. Homework of course members was left to the module leader. In the first series of MoSHE courses, course management had insight in progress made in homework. In later series this overview was absent.

Result area educational methods

- All years experienced a wide variety of educational methods to change a traditional passive listening attitude of course members into an active participatory attitude. Classical lecturers were interspersed with group work, student presentations, challenging lectures and discussions.

Result Area appreciation by module leaders and course members

- For the quality assessment course members' evaluations and observations of coordinators were used.

Result area appreciation by society and result

- Evaluations of companies of course members on effects of the course were conducted by Delft TopTech. The results were not known. In itself it was strange the Safety Science Group did not put energy into these contacts. A good relationship with companies is in the interest of both.

Cross-field learning and improving

- The dynamics of the content and structure of the program has always been large.

EPILOGUE

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