German-Dutch Education & Training Programs for open sources with low activity – A Bilateral comparison of learning outcomes

JAN LEMBECK, JAN-WILLEM VAHLBRUCH
Leibniz University Hannover, Institute for Radioecology and Radiation Protection,
Herrenhäuser Strasse 2, D-30419 Hannover, Germany

HIELKE FREERK BOERSMA
University of Groningen, Health, Safety and Environment / Radiation Protection Unit,
Visserstraat 47/49, NL-9712 CT Groningen, The Netherlands

ERIK J. BUNSKOEKE
University of Groningen, Isotope Laboratory Life Sciences,
Nijenborgh 7, NL-9747 AG Groningen, The Netherlands

Summary

The results of the German-Dutch comparison signalize that the learning outcomes differ primarily with respect to the national legislation. Therefore, the analysis clarifies especially the impact of German legislation references and explains the thematic equalization of the German-Dutch subjects. Significant expertise discrepancies occur e.g. for the various waste management systems for radioactive material. Furthermore, the comparison of keywords identifies missing topics. All relevant expertise discrepancies are summarized by an additional training advice at the end of this report.

1 Introduction

This report actualizes and extends the report about the learning outcomes concerning the lowest level radiation protection courses published by Jack Haagen et al. in 2012 [1] by comparing the learning outcomes of the Dutch RPO-DRM (D) [2] and the German S4.1 Module that are listed in the German objectives catalogue [3]. Therefore, this project focuses on the harmonization of the draft learning objectives that are going to be finalized by the Dutch and German authorities. To support the bilateral recognition of RP-qualifications, significant variations in the RP training are highlighted. Further, the project includes additional training advices to compensate the different RP-expertises in both countries.

1.1 RPO-DRM (D)

Starting in February 2018 new application specific training programs for RPOs come into effect in The Netherlands. One of these programs, the RPO-DRM D, is intended for RPOs supervising isotope laboratories where only small amounts of radioactivity in dispersible form are used. This program should also allow RPOs to supervise low activity sealed sources used for e.g. calibration purposes. Finally the training program is also very suitable as instruction for radiation workers working with open (and sealed) sources autonomously. It is expected that many academic institutions in The Netherlands will use this acknowledged training program as the basic instruction of their radiation workers.

1.2 S4.1 Module

In Germany expert knowledge ("Fachkunde") is the necessary requirement to be appointed as Radiation Protection Commissioner ("Strahlenschutzbeauftragter"), who is responsible for the implementation and supervision of Radiation Protection. The requisite qualification in radiation protection shall be acquired through an education suited for the respective area of application, practical experience and successful participation in courses recognized by the competent agency [4]. S4.1 describes the expert knowledge group that is necessary to achieve the expert knowledge for Radiation Protection Commissioner who will supervise the handling of unsealed radioactive material in smaller amounts, e. g. in a smaller isotopic lab. Learning outcomes for the course are determined in Guidelines like the "Fachkunde-Richtlinie Technik StrlSchV" [5] and described more in detail in [3]. Additionally at least 6 months of practical experience are necessary according to the Guideline for the requisite qualification concerning Radiation Protection for technical applications [5].

2 Methods

To identify the gaps between the Dutch RPO-DRM D (Radiation Protection Officer – Dispersible Radioactive Material level D) and the German S4.1 Module a table was created to compare the various learning outcomes.

2.1 Keywords

In a first step to accomplish this comparative table, the learning objectives were compared by focusing on the keywords exclusively. As a result, congruent learning outcomes are identified. If the content differs significantly, the differences are marked and attached as supplements. As the German learning outcomes are in many cases more detailed several German subjects are assigned to one Dutch learning objective. Table 1 explains the characterization of differences in keywords.

Table 1: Characterization of keyword differences

Dutch subject	German subject	Explanation
radiotoxicity equivalent, Re*	-	The Dutch learning objective, marked by a red star "*", is not included in the German objectives catalogue.
Physics: electromagnetic radiation, (duality)*, wave/particle	Nr. 137 GH Nr. 135 GH	The Dutch learning outcome is more comprehensive than the German counterpart. The content variation is marked by red brackets "()" and a red star "*".
practical skills in sampling	Nr. 249 OG	To present which German subjects are not included in the Dutch RPO-DRM D, the content of the German learning outcome is presented in the column "Dutch subject" and is coloured in red.
characteristic X-ray radiation with the aid of an example	Nr. 151 GH	The German learning outcome is more comprehensive than the Dutch counterpart. The content variation is supplemented to the Dutch subject. The addition is coloured in red.
-	Nr. 160 OG (1*)	The German subject is a volunteer excursus.

2.2 Teaching extent

In Germany, a learning outcome is classified by two parameters in order to describe an appropriate extent of teaching: the qualification level and the number of significance. The number of significance rates the importance of a subject from 1 (more or less insignificant but nice to have) to 3 (most significant). Thereby, the rating determines the schedule of the German RP course. The number 1 implies an optional implementation of a learning outcome in the RP training while the number 3 leads to an essential inclusion. The qualification level describes how comprehensive the learning outcome has to be implemented and is specified by the use of didactic operators as, for example: "to mention", "to comment on", "to estimate" etc. The qualification level in combination with the number of significance is compared with the Dutch Qualification Descriptors that uses the teaching categories "knowledge", "skills" and "competences" according to the EQF [6] to specify the Dutch teaching extent.

2.3 Legislation references

The German learning objectives that refer directly to the German RP ordinance [4] or to other German regulations as shown in table 6 (Appendix) refer to the corresponding legislative text. The table highlights all affected subjects. The detailed analysis includes also the degree of the impact of the legislative text on the content. Table 2 explains the approach used to highlight the German legislation references in the comparison.

Table 2: Characterization of German legislation references

Dutch subject	German subject	Explanation
exclusion/ exemption	Nr. 118 OG, GH	If a German subject refers directly to the German radiation protection ordinance, the learning outcome is printed in blue.
waste handling	*Nr. 312 OG*	If a German subject refers directly to other German regulations e.g. DIN-norms, the learning outcome is printed in *blue (italic).* These specific references are listed in table 6 seperately.

2.4 Experiments

Furthermore, the comparative table indicates the subjects supported by experiments. The course providers are responsible for the application and the arrangement of experiments [5]. The comparison is limited and bases on the information of the Dep. of Health, Safety and Environment / Radiation Protection Unit of the University in Groningen and the Institute for Radioecology and Radiation Protection of the Leibniz University in Hannover. Colours to indicate the learning outcomes connected to an experiment are explained in table 3.

Table 3: Identification of experiments

Dutch subject	German subject	Explanation
liquid scintillation counters	Nr. 207 GH, OG	The Dutch subject is exercised additionally by an experiment that is offered by the Isotope Laboratory Life Sciences of the University of Groningen only.
practical skills in release of contaminated work areas	Nr. 307 OG Nr. 309 OG Nr. 308 OG Nr. 310 OG	The German subject is exercised additionally by an experiment that is offered by the Institute for Radioecology and Radiation Protection (IRS) of the Leibniz University of Hannover only.
Practical skills in contamination measuring	Nr. 242 OG, Nr. 270 OG Nr. 244 OG, Nr. 289 OG Nr. 241 OG, Nr. 185 OG	The compared subjects are exercised additionally by an experiment that are offered by the respective course providers.

3 Results

In table 4 the full comparison of the learning outcomes of the German S4.1 Module and the Dutch RPO-DRM D course is presented.

Table 4: Comparison of the learning outcomes of the German S4.1 Module and the Dutch RPO-DRM D

Dutch learning outcome	German learning outcome	German didactic operator	German RP Module	Number of significance	Dutch teaching category		
General					K	S	C
Structure and content of the nuclide chart	Nr. 144	to explain	GH,OG	(1),(2)			
The functional principle of accelerators and plasma equipment	Nr. 136	to explain	GH	(1)			
atom structure	Nr. 134	to describe	GH	(2)	X		
ionization, excitation	Nr. 135	to explain	GH	(2)	X		
proton / neutron ratio	Nr. 134	to describe	GH	(2)	X		
radioactive decay, half-life	Nr. 141	to explain	GH	(2)	X	X	
	Nr. 139	to explain	GH	(2)			
decay formulas and decay constant	Nr. 143	to calculate	GH, OG	(2), (3)	X	X	
mother-daughter connections	Nr. 142	to explain	GH, OG	(2)	X		
specific activity	Nr 140	to explain	GH	(1)	X		
α-, β, γ-decay, electron capture, internal conversion	Nr 142	to explain	GH, OG	(2)	X		
characteristic X-ray radiation with the help of an example	Nr. 151	to explain	GH	(1)	X		
Bremsstrahlung radiation with the help of an example	Nr. 151	to explain	GH	(1)	X		
decay schemes	Nr 142	to explain	GH, OG	(2)	X		
nuclear reactions	Nr. 146	to explain, formulate	GH, OG	(1)	X		
	Nr. 157	to explain	GH	(1)			
energy spectra α-, β-, γ-emitters and Bremsstrahlung	Nr. 254	to explain	OG	(1)	X		
	Nr. 243	to execute	OG	(2)			
	Nr. 253	to explain	OG	(1)			
	Nr. 255	to explain	OG	(2)			
	Nr. 138	to describe	GH	(2)			
Penetrance	Nr. 145	to explain	GH	(2)	X		
inverse square law	Nr. 181	to exercise	GH	(2)	X	X	
	Nr. 182	to calculate	GH	(2)			
half-thickness	Nr. 183	to exercise	GH	(2)	X		
interaction mechanisms for α-, β-, γ –emitters	Nr. 145	to explain	GH, OG	(2)	X		
	Nr. 339	to mention	GH	(2)			
Basic competencies					K	S	C
physics (including electromagnetic radiation, (duality)*,	Nr. 137	to explain	GH	(2)	X		
wave/particle)	Nr. 135	to explain	GH	(2)			
biology (human anatomy, physiology, DNA, cell division)	Nr. 166	to explain	GH	(2)	X		
epidemiology (risks)	Nr. 169	to describe	GH	(2)	X		
	Nr. 170	to evaluate	GH	(2)			
justification	Nr. 49	to explain	GH	(3)	X	X	
	Nr. 198	to evaluate	GH	(2)			
optimalisation/ALARA	Nr. 49	to explain	GH	(3)	X	X	
	Nr. 338	to explain	GH, OG	(1)			
dose limits	Nr. 49	to explain	GH	(3)	X		
	Nr. 92	to mention	GH	(2)			
	Nr. 90	to mention	GH	(3)			
	Nr. 91	to mention	GH	(2)			
exposure situations (planned, existing, incident)	Nr. 298	to explain	OG	(2)	X		
	Nr. 162	to describe	OG	(1*)			
procedures /work situation	Nr. 296	to explain	GH, OG	(2)	X		
	Nr. 232	to estimate	GH	(2)			
	Nr. 112	to present	GH	(2)			
radiochemistry	Nr. 160	to mention	OG	(1*)			

	Nr. 161	to explain	OG	(1*)			
Natural radioactivity					**K**	**S**	**C**
U- and Th-decay chains	Nr. 199	to mention	GH	(2)	X		
natural radionuclides	Nr. 199	to mention	GH	(2)	X		
cosmic radiation, terrestrial radiation	Nr. 197	to explain	GH	(2)	X		
doses as a consequence of natural radioactivity	Nr. 197	to explain	GH	(2)	X		
radon	Nr. 199	to mention	GH	(2)	X		
Detection	Nr. 204	to explain	GH	(2)	**K**	**S**	**C**
	Nr. 255	to explain	OG	(2)			
gas-filled detectors					X		
- ionization chambers	Nr. 207	to describe	GH, OG	(2)	X		
- proportional counters	Nr. 207	to describe	GH, OG	(2)	X		
- Geiger-Müller counters	Nr. 207	to describe	GH, OG	(2)	X		
scintillation detectors					X		
- ZnS	Nr. 207	to describe	GH, OG	(2)	X		
- NaI-detector	Nr. 207	to describe	GH, OG	(2)	X		
- plastic scintillators	Nr. 207	to describe	GH, OG	(2)	X		
- liquid scintillation counters	Nr. 207	to describe	GH, OG	(2)	X		
- thermoluminescence detectors	Nr. 207	to describe	GH, OG	(2)	X		
semi-conductor detectors such as Ge, Si, CCD, etc.	Nr. 207	to describe	GH, OG	(2)	X		
dead time, geometry, self-absorption	Nr. 268	to explain	OG	(2)	X		
	Nr. 275	to mention	OG	(2)			
counting efficiency, (intrinsic-)	Nr. 275	to mention	OG	(2)	X		
	Nr. 243	to execute	OG	(2)			
counting statistics	Nr. 273	to explain	GH, OG	(2)	X		
minimal detectable activity / counting rate	Nr. 244	to imply	OG	(2)	X		
spectrometry, pulse height analysis	Nr. 253	to explain	OG	(1)	X		
total body counters	Nr. 225	to specify	OG	(1)	X		
measuring methods for activity calculation of soil, water, air	Nr. 246	to describe	OG	(2)	X		
measuring devices for surface contamination	Nr. 241	to choose	OG	(2)	X	X	
measuring devices for dose rate	Nr. 205	to choose	GH	(2)	X	X	
	Nr. 207	to describe	GH, OG	(2)			
	Nr. 209	to choose	GH, OG	(2)			
	Nr. 267	to explain	GH	(2)			
personal control devices (both active and passive)	Nr. 217	to describe	GH	(2)	X	X	
	Nr. 210	to mention	GH	(1)			
	Nr. 229	to present	GH	(2)			
	Nr. 103	to explain	GH	(2)			
Dosimetry					**K**	**S**	**C**
absorbed dose	*Nr. 173*	to specify	GH	(2)	X	X	
weighting factors	Nr. 164	to mention	GH	(2)	X		
equivalent dose	Nr. 174	to explain	GH	(2)	X		
effective (committed) dose	Nr. 177	to explain	GH	(2)	X		
	Nr. 193	to explain	GH, OG	(2)			
	Nr. 179	to explain	OG	(2)			
	Nr. 87	to mention	GH	(2)			
	Nr. 230	to calculate	GH	(2)			
	Nr. 229	to present	GH	(2)			
	Nr. 231	to calculate	GH	(2)			
Exposure*					X		
ambient dose equivalent	Nr. 343	to explain	GH, OG	(1)	X		
	Nr. 178	to explain	GH	(2)			
	Nr. 212	to describe	GH	(2)			
	Nr. 214	to describe	GH	(2)			
personal dose equivalent	Nr. 178	to explain	GH	(2)	X		
	Nr. 216	to explain	GH	(2)			

neutron dosimetry	Nr. 218	to describe	GH	(2)			
rules of thumb average energy bèta-emitters*					X	X	
rules of thumb penetration bèta-emitters	Nr. 188	to estimate	OG	(2)	X	X	
rules of thumb regarding β-dosimetry*					X	X	
rules of thumb regarding γ-dosimetry *					X	X	
principle protection regulations (time, distance, shielding)*	Nr. 282	to explain	GH	(3)	X	X	X
*The protection regulations are practiced in the experiments							
Source constant	Nr. 182	to calculate	GH	(2)	X		
interpretation of measurements	Nr. 251	to evaluate	OG	(2)	X	X	
	Nr. 176	to clarify	GH	(3)			
	Nr. 274	to evaluate	GH, OG	(2)			
calculate the ambient dose rate depending on the radiation type, activity, source geometry and the distance to the source	Nr. 154	to calculate	GH	(2)	X	X	

Biological consequences of radiation					K	S	C
stochastic/deterministic effects	Nr. 165	to differentiate	GH	(2)	X		
factors that influence the biological effect: - radiation conditions, tissue properties and environmental factors	Nr. 164	to mention	GH	(2)	X		
irradiation of the entire body and partial irradiation	Nr. 235	to term	GH	(2)	X		
	Nr. 230	to calculate	GH	(2)			
	Nr. 231	to calculate	GH	(2)			
	Nr. 91	to mention	GH	(2)			
	Nr. 87	to mention	GH	(2)			
direct/indirect effects, free radicals, DNA-damage, repair mechanisms	Nr. 166	to differentiate	GH	(2)	X		
genetic effects	Nr. 166	to differentiate	GH	(2)	X		
teratogenic effects*					X		
dose-effect relationships	Nr. 169	to correlate	GH	(2)	X		
	Nr. 167	to mention	GH	(2)			
risk estimates	Nr. 170	to evaluate	GH	(2)	X		
	Nr. 232	to estimate	GH	(2)			
risk numbers	Nr. 167	to mention	GH	(2)	X		

Organization and legislation					K	S	C
norms and legal regulations, (inter)national organizations	Nr. 3	to explain	GH	(1)	X		
	Nr. 1	to explain	GH	(1)			
	Nr. 20	to mention	GH	(1)			
	Nr. 27	to explain	GH	(1)			
	Nr. 10	to explain	GH	(1)			
	Nr. 7	to explain	GH	(1)			
	Nr. 12	to describe	GH	(1)			
	Nr. 13	to explain	GH	(2)			
(inter)national organizations with regards to radiation safety, consistency	*Nr. 5*	to explain	GH	(1)	X		
historical developments*					X		
legislation:							
- Directives European Union	Nr. 3	to explain	GH	(1)	X		
- Nuclear Energy Act (Kew)	*Nr. 6*	to explain	GH	(1)	X		
- Decision Radiation Protection (Bs)	*Nr. 11*	to explain	GH	(1)	X		
- Decision Transport Fissionable Materials, Ores, and Radioactive materials	Nr. 22	to mention, judge	GH, OG	(1)	X		
	Nr. 23	to mention	GH, OG	(1)			
- Environmental Management Act	*Nr. 25*	to mention	GH	(1)	X		
- Dutch Occupational Health and Safety Act*					X		
ministerial regulations:							
- Implementation regulation SB EZ	*Nr. 32*	to mention	OG	(1)	X		
- MR for the provision of radiation protection workers	Nr. 38	to explain	GH	(2)	X		
	Nr. 44	to describe	GH	(2)			

	Nr. 41	to clarify	GH	(3)		
	Nr. 42	to mention	GH	(2)		
- MR publication justification of use of ionizing radiation	Nr. 71	to describe	GH	(2)	X	
	Nr. 103	to mention	GH, OG	(2)		
	Nr. 101	to mention	GH, OG	(2)		
	Nr. 102	to list	GH	(1)		
justification, optimization (ALARA) and dose limits	Nr. 282	to explain	GH	(3)	X	
permit application (document ANVS)	Nr. 53	to explain	OG	(2)	X	
	Nr. 55	to explain	GH, OG	(2)		
	Nr. 54	to explain	GH	(2)		
	Nr. 16	to mention	GH	(1)		
procedures / work activities	Nr. 298	to explain	OG	(2)	X	
	Nr. 119	to explain	GH, OG	(2)		
	Nr. 296	to explain	GH, OG	(2)		
	Nr. 89	to classify	GH	(2)		
calibration of detectors and function check	Nr. 129	to clarify	GH	(2)	X	X
	Nr. 261	to describe	GH	(2)		
	Nr. 260	to clarify	GH	(2)		
	Nr. 262	to execute	GH	(2)		
	Nr. 263	to execute	OG	(2)		
source-oriented approach	Nr. 363	to explain	OG	(2)	X	X
	Nr. 338	to explain	OG	(1)		
exclusion / exemption	Nr. 118	to mention	GH, OG	(2)	X	
	Nr. 315	to practice	OG	(2)		
	Nr. 385	to mention	GH	(2)		
	Nr. 109	to practice	GH, OG	(2)		
	Nr. 108	to explain	GH, OG	(2)		
	Nr. 346	to determine	OG	(2)		
	Nr. 347	to mention	OG	(2)		
radiotoxicity equivalent, Re	Nr. 233	to calculate	OG	(2)	X	
supervised and controlled zones	Nr. 327	to explain	GH	(2)	X	
	Nr. 121	to mention	GH, OG	(2)		
	Nr. 76	to mention	GH	(2)		
	Nr. 328	to explain	OG	(2)		
determination of yearly dose for rooms, workers and others	Nr. 284	to determine	GH, OG	(2)	X	
	Nr. 90	to mention	GH	(3)		
	Nr. 332	to determine	GH	(2)		
	Nr. 86	to estimate	GH	(2)		
	Nr. 93	to mention	GH	(2)		
A and B workers	Nr. 331	to clarify	GH, OG	(2)	X	
	Nr. 106	to explain	GH	(2)		
	Nr. 105	to mention	GH	(2)		
outfitting requirement for nuclide laboratories	Nr. 380	to describe	GH, OG	(1)	X	X
	Nr. 336	to describe	OG	(2)		
	Nr. 335	to describe	OG	(2)		
	Nr. 337	to explain	OG	(2)		
	Nr. 346	to determine	OG	(2)		
	Nr. 208	to term	GH	(2)		
	Nr. 75	to clarify	GH	(2)		
	Nr. 389	to create	GH	(2)		
Maintenance of the equipment	Nr. 99	to explain	GH	(2)		
	Nr. 208	to execute	GH	(2)		
definition closed source*					X	
ISO 2919 for requirements on closed sources	*Nr. 96*	to list	GH	(2)	X	
Practical implementation for transport of radioactive materials	Nr. 114	to mention	GH, OG	(2)	X	
	Nr. 71	to describe	GH	(2)		

Organizational aspects radiation protection					K	S	C
responsibilities within the radiation protection unit	Nr. 47	to mention	GH	(1)	X	X	
	Nr. 38	to explain	GH	(2)			
	Nr. 59	to explain	GH	(2)			
	Nr. 58	to mention	GH	(2)			
	Nr. 57	to explain	GH	(3)			
	Nr. 61	to mention	GH, OG	(2)			
Nuclear Energy Act file (i.e. from the Directive on radionuclides or analogs)	*Nr. 6*	to explain	GH	(1)	X	X	
	Nr. 5	to explain	GH	(1)			
	Nr. 7	to explain	GH	(1)			
disposal routes	Nr. 115	to mention	GH, OG	(2)	X	X	
	Nr. 116	to mention	GH, OG	(2)			
	Nr. 292	to plan	OG	(2)			
	Nr. 291	to respect	GH, OG	(2)			
	Nr. 71	to describe	GH	(2)			
dose calculations for simple cases	Nr. 182	to calculate	GH	(2)	X		

External irradiation					K	S	C
small beam and broad beam geometries for photon radiation	*Nr. 339*	to mention	GH	(2)	X		
	Nr. 186	to explain	GH	(2)			
build-up factor for non-composite materials	Nr. 145	to explain	GH	(2)	X		
choice of material for shielding as a function of photon energy	Nr. 190	to describe	GH	(2)	X		
	Nr. 339	to mention	GH	(2)			
(calculation)* of radiation scattering by objects	Nr. 190	to describe	GH	(2)	X		
use of graphs and tables with regards to attenuation and transmission for sources	Nr. 184	to determine	GH	(2)	X		
	Nr. 183	to practice	GH	(2)			
	Nr. 341	to calculate	GH	(2)			
shielding of neutron radiation (qualitative)	Nr. 186	to explain	GH	(2)	X		
	Nr. 339	to mention	GH	(2)			
Submergence and immersion	Nr. 191	to explain	OG	(2)			

Internal contamination					K	S	C
incorporation routes; retention and excretion	Nr. 226	to mention	OG	(1)	X		
general transport model of the ICRP*					X		
inhalation and ingestion	Nr. 194	to explain	GH, OG	(1)	X		
wound contamination with respect to the skin	Nr. 269	to evaluate	GH	(2)	X		
selection e(50) from the Handbook of Radionuclides or analogs	Nr. 195	to explain	OG	(2)	X		

Practical aspects					K	S	C
maximal permissable surface contamination	Nr. 240	to practice	OG	(2)	X	X	
	Nr. 287	to explain	GH	(2)			
	Nr. 306	to practice	OG	(3)			
	Nr. 288	to check	OG	(2)			
personal protection measures	Nr. 237	to estimate	OG	(1)	X	X	
	Nr. 283	to explain	OG	(3)			
	Nr. 363	to explain	OG	(2)			
	Nr. 390	to explain	OG	(1)			
	Nr. 364	to explain	GH	(2*)			
	Nr. 366	Erläutern	GH	(2*)			
	Nr. 361	to mention	GH	(2*)			
	Nr. 362	to explain, estimate	GH	(2*)			
control methods:							
- surface contamination	Nr. 239	to mention	OG	(2)	X	X	
	Nr. 277	to explain	OG	(2)			
- discharges	Nr. 301	to practice	OG	(1)	X		
retrospective inventory and evaluation of incidents	Nr. 380	to describe	GH, OG	(1)	X		
	Nr. 111	to explain	GH	(2)			
	Nr. 291	to respect	GH, OG	(2)			

	Nr. 378	to classify	GH	(2)			
	Nr. 379	to explain	GH	(2)			
	Nr. 97	to mention	GH	(2)			
	Nr. 309	to explain	OG	(2)			
	Nr. 94	to describe	GH	(2)			
Practical skills in contamination measuring	Nr. 242	to execute	OG	(2)	X	X	
	Nr. 270	to evaluate	OG	(2)			
	Nr. 244	to evaluate	OG	(2)			
	Nr. 289	to decide	OG	(2)			
	Nr. 241	to choose	OG	(2)			
	Nr. 185	to calculate	OG	(2)			
practical skills in release of contaminated work areas	Nr. 307	to explain	OG	(2)	X	X	
	Nr. 309	to explain	OG	(2)			
	Nr. 308	to differentiate	OG	(2)			
	Nr. 310	to know	OG	(2)			
practical skills in release of contaminated people	Nr. 368	to mention	OG	(2)	X		
	Nr. 371	to execute	OG	(2)			
	Nr. 372	to estimate	OG	(2)			
	Nr. 369	to evaluate	OG	(2)			
	Nr. 370	to mention	OG	(2)			
knowledge and practical skills of different cordoning off levels	Nr. 342	to explain	GH, OG	(1)	X	X	
(map, tape, barricade)	Nr. 14	to explain	GH	(2)			
	Nr. 85	to practice	GH	(2)			
	Nr. 77	to clarify	GH	(2)			
	Nr. 78	to clarify	GH	(2)			
	Nr. 80	to realize	GH	(2)			
	Nr. 88	to mention	GH	(3)			
	Nr. 329	to execute	GH	(2)			
	Nr. 330	to describe	GH	(2)			
	Nr. 327	to explain	GH	(2)			
	Nr. 334	to mention	GH	(2)			
waste handling	Nr. 348	to mention, execute	OG	(2)	X		
	Nr. 313	to know	GH, OG	(2)			
	Nr. 312	to explain	OG	(2)			
	Nr. 71	to describe	GH	(2)			
	Nr. 314	to assign, mention	OG	(2)			
discharge standards according to regulations and permits	Nr. 301	to practice	OG	(1)	X		
	Nr. 302	to practice	OG	(1)			
	Nr. 303	to practice	OG	(1)			
position COVRA	Nr. 304	to mention	OG	(1)	X		
	Nr. 316	to create	OG	(2)			
	Nr. 317	to report	OG	(2)			

Risk-inventory and evaluation					K	S	C
- open sources	Nr. 233	to calculate	OG	(2)	X	X	
	Nr. 30	to explain	GH, OG	(1)			
	Nr. 236	to estimate	OG	(2)			
	Nr. 221	to explain	OG	(2)			
	Nr. 232	to estimate	GH	(2)			
- p,q,r-formula*	Nr. 299	to explain	OG	(1)	X		
	Nr. 346	to determine	OG	(2)			
	Nr. 171	to mention	GH	(2)			
- RI&E-description	Nr. 223	to mention	OG	(2)	X	X	
- control of risks during procedures with open sources in	Nr. 284	to determine	GH, OG	(2)	X	X	
laboratories	Nr. 220	to explain	OG	(2)			
	Nr. 344	to Explain	OG	(1)			
	Nr. 222	to explain	OG	(2)			

	Nr. 363	to explain	OG	(2)			
	Nr. 354	to clarify	OG	(1)			
	Nr. 355	to mention	OG	(1)			
generate an alarm plan for fighting a burning, where radioactive material is involved	Nr. 388	to create	GH	(1)			
Organizational					**K**	**S**	**C**
give short, succinct and target-group oriented knowledge transfer	Nr. 67	to explain	GH, OG	(3)	X	X	
	Nr. 43	to explain	GH, OG	(1)			
	Nr. 65	to create	GH, OG	(2)			
	Nr. 93	to mention	GH	(2)			
	Nr. 66	to term	GH	(2)			
write work protocols/internal protocols	Nr. 69	to mention	GH	(2)	X	X	
	Nr. 35	to mention	GH	(1)			
	Nr. 73	to mention	GH	(2)			
	Nr. 264	to mention	GH	(2)			
	Nr. 71	to describe	GH	(2)			
	Nr. 103	to mention	GH, OG	(2)			
determination of risk perception	Nr. 82	to determine	GH	(2)	X		
	Nr. 39	to mention	GH	(1)			
organizational behavior (formal/informal organization; organization structure, role of the expert, role of the CE)	Nr. 47	to mention	GH	(1)	X		
	Nr. 51	to explain	GH, OG	(3)			
	Nr. 45	to clarify	GH	(2)			
	Nr. 60	to clarify	OG	(2)			
	Nr. 62	to clarify	GH	(1)			
	Nr. 63	to clarify	GH	(1)			
	Nr. 101	to mention	GH, OG	(2)			
	Nr. 16	to mention	GH	(1)			
	Nr. 384	to mention	GH	(2)			
	Nr. 382	to report	GH	(2)			
	Nr. 15	to describe	GH	(2)			
organization structure of employment in external installations	Nr. 40	to explain	OG	(1)			
requisite qualification	Nr. 17	to explain	GH	(2)			
support and inform the CE	Nr. 46	to mention	GH	(2)	X	X	
	Nr. 36	to explain	GH	(2)			
	Nr. 83	to explain	GH	(2)			
practical skills in sampling	Nr. 249	to explain	OG	(2)			
importance of representative samples	Nr. 250	to explain	OG	(2)			
Delimitation agreement and radiation passport					**K**	**S**	**C**
treaty between the user and the outside company that regulates radiation protection tasks	Nr. 123	to mention	GH,OG	(1)			
purpose and content of the registrated radiation passport	*Nr. 124*	to explain	GH,OG	(3)			
resource of radiation passports	Nr. 126	to mention	GH,OG	(1)			
necessity of passing a radiation passport regarding § 15 StrlSchV	Nr. 125	to explain	GH	(2)			
managing a radiation passport	*Nr. 127*	to manage	GH,OG	(3)			

Note that Dutch legislation will change considerably in February, 2018. The decision/directive on Radiation Protection (Bs) and the ministerial regulations on implementation of radiation protection (Sb EZ) and on justification of radiation will be replaced by a directive, a regulation and an ordinance regarding basic safety standards for Radiation Protection.

4 Analysis

4.1 Summary

In summary, a comprehensive conformity between the Dutch and German learning outcomes can be observed if only key words are compared. The analysis of content wise identical subjects respecting the extent and depth of teaching reveals no noticeable gaps. Therefore, the compared learning outcomes are more or less equivalent. However, it is necessary to comment on the correlation between the lecture times and the extent of teaching. Approximately one-third of all German learning outcomes refer directly to the German RP ordinance or to further regulations as presented in table 6. Most German learning outcomes affected by the legislative text do have a Dutch counterpart with respect to the topic. Though the topics are identical, the content might vary. Additionally, the implementation of experiments in the various RP courses is examined. At a first glance, the University of Groningen includes more experiments than the Institute for Radioecology and Radiation Protection in Hannover.

4.2 Differences in keywords

The German learning objectives catalogue, compiled and published by the Swiss-German Association for Radiation Protection, contains subjects that are not covered by the Dutch catalogue: "maintenance of equipment", "neutron dosimetry", "radiochemistry", "sampling", "radiation passport and nuclide chart". Exclusively the topics "maintenance of equipment", "neutron dosimetry" and "radiation passport" are essential parts of the education to meet the supervising tasks of an RPO or RPE. The RPO-DRM D is created with respect to open sources giving rise to limited risk for lab assistants. If the supervision of an appropriate Dutch laboratory is performed by these RPOs, the lab assistants will therefore virtually never be categorized as A-workers. Radiation passports are necessary only if an A-worker is employed abroad. Consequently, most of the Dutch RPOs get never in touch with radiation passports. Radiochemistry can be considered as a German voluntary excursus. The discrepancies in the required expertise concerning the skills in sampling of material and handling of the nuclide chart are insignificant.

The German subject "maintenance of the equipment" is officially not included in the Dutch draft of learning outcomes. In The Netherlands, this safety measure is handled by radiation protection experts and is performed by an annual check. Nevertheless, the course participants, who reach the qualification of a radiation protection officer get trained cursorily in the maintenance of their equipment to check some basic functions.

The Dutch draft learning outcomes for RPO-DRM D provide information on the relevant subjects: "teratogenic effects", "calculation of radiation scattering by objects", "p,q,r-formula" (see below), "general ICRP transport model for internal contamination" and "rules of thumb for both β- and γ-dosimetry" as well as the "average energy of β-emitters". Those Dutch learning objectives are either not or only partially covered by the German objectives catalogue. Especially the "rules of thumb", the "calculation of radiation scattering by objects" and the "p,q,r-formula" are vital for the notice of supervising tasks in The Netherlands. The variation in the RP expertise concerning the teratogenic effects and the transport model are insignificant. The training of the S4.1 Module respects teratogenic effects in the context of special threshold values and staff instructions.

The Dutch learning outcome "calculation of radiation scattering by objects" is included in the S4.1 Module, but with the focus on the qualitative interpretation exclusively. The "p,q,r-formula" is used to perform a specific Dutch risk estimate. The calculation determines the maximum manageable activity of radioactive material inside a laboratory. The formula includes the available ventilation, the laboratory classification, the type of practice and the dose coefficient [7]. In Germany, these factors have to be taken into account without using a standardized formula. Therefore, a significant difference has to be stated for the mentioned calculations.

4.3 Differences concerning the teaching extent

Firstly, the number of significance ($1<2<3$) determines only whether a subject is included in the S4.1 Module either obligatorily or voluntarily. Secondly, the used didactic operator specifies the German qualification level. If both descriptors are taken into account, the German teaching extent can be verified.

As mentioned before, most learning outcomes with an identical content are also similar regarding the teaching extent and are therefore equivalent. A German course provider covers an insignificant subject (1) only, if both enough time and interest by the participants are available, for instance: The functional principle of accelerators and plasma equipment. The course participants are expected at most to reflect the learning outcome cursorily. As higher numbers implying a higher degree of significance, a most significant learning objective (3) is included obligatorily in the RP course and the course participant has to understand the content in depth. The determination of knowledge, skills or competences depends on the used didactic operators, for instance “to list” and “to estimate”. The German didactic operators provide information on the profundity of the learning process. Therefore, the German number of significance is not equal to a Dutch teaching category.

Comparing the Dutch teaching categories with the German didactic operators, some general conclusions can be drawn. The Dutch learning objective “Practical skills in release of contaminated people” is rated by the Dutch teaching category: knowledge. The comparable German subjects rated by the number of significance 2 include the didactic operators “to execute”, “to evaluate” and “to estimate”. These operators describe skills. For this reason, the general teaching extent is more comprehensive in Germany than in The Netherlands. In contrast, the Dutch learning outcome “Write work/internal protocols” is classified by the teaching category “skills”. Although the number of significance 2 was chosen for the German counterparts, the didactic operators lead to a minor classification, because the didactic operator used mostly is: to mention. As indicated, an extensive comprehension of the learning outcome is not demanded and a reflection or application of the knowledge is unnecessary. In that case, the Dutch learning outcome is more comprehensive.

Generally, the analysis reveals no significant gaps concerning the way that learning outcomes with an identical content are taught. The fundamental aspects are present in both courses and only minor differences are observed.

4.4 Lecture times

It seems that the lecture times influence the extent of teaching more than the Dutch teaching categories or the German didactic operators. In Germany, the lecture times are determined for each superior course topic [5]. In contrast, in The Netherlands only the course providers are responsible for lecture times. The RPO-DRM D document however, provides some indicative lecture times [2]. Nevertheless, the durations of the lectures vary enormously between different Dutch RP course providers as they focus on different topics and include the preliminary education and training of the participants [1]. This variation is also caused by the option to take a self-study course, in which the lecture times depend on the course participants only. Nevertheless, the purpose is to achieve the learning outcomes in terms of knowledge, skills and competences. These categories adhere to the definition of competencies as given by the IAEA [8]. By passing the exam, the various course participants prove a comparable qualification, whereby the reported topic discrepancies and the influence of the German legislation references have to be taken into account exclusively.

4.5 Legislation references

4.5.1 Total distribution of German legislation references

As illustrated in figure 1, a considerable amount of German learning outcomes refer directly to the radiation protection ordinance or to other German regulations like the Waste Water Ordinance as is listed in table 6. Furthermore, eight learning outcomes show indeed no direct legislation reference, but the content examines the national legal system as shown in table 7 in the Appendix of this report. Most of those subjects implicitly do have a Dutch counterpart. For instance, it is necessary to communicate the guidelines concerning the transport requirements of radioactive material. This topic is taught in The Netherlands as well as in Germany, but the content differs slightly.

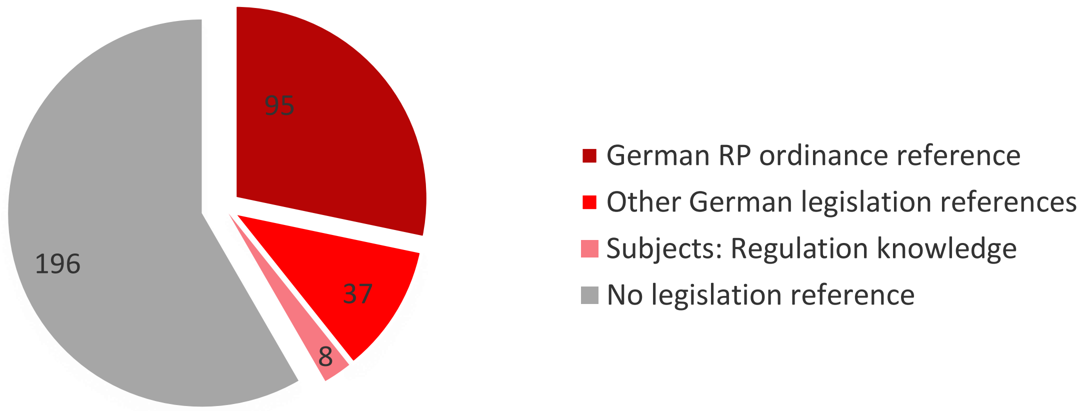

Figure 1: Total distribution of German legislation references respecting all subjects of the modules GH and OG.

The greyish fraction covers German learning outcomes that include no legislation reference. Very few German learning outcomes deal with European regulations. These few learning outcomes are presented identically in the S4.1 Module and the RPO-DRM D. The detailed analysis shows that the German legislative text determines the topics “legislation”, “organization” and “practical aspects” significantly.

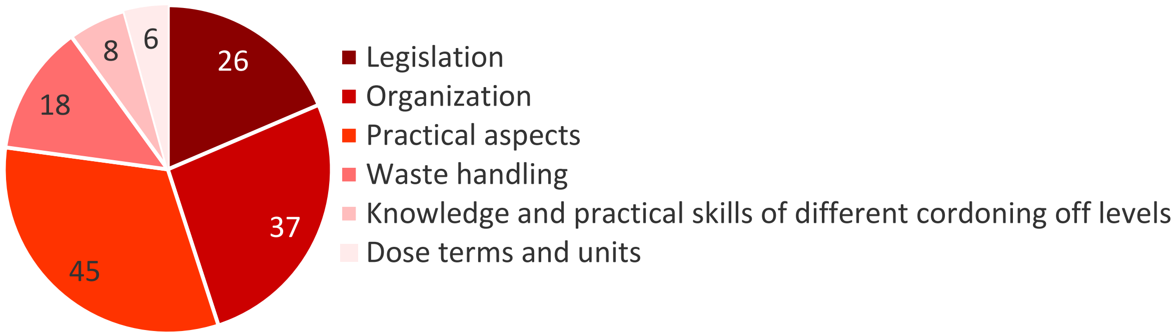

Figure 2: Sectioning of German legislation references respecting specific topics (see also table 8 in the Appendix)

4.5.2 Legislation

The part “legislation” includes learning objectives that focus only on the content of specific national regulations. Furthermore, it is the intention that the course participants become familiar with the legal framework of their operations. Therefore, the subjects that clarify the legal position of RPOs and RPEs are covered by this fraction too. Most German subjects do have a Dutch counterpart. In contrast, the variation of the detailed content is enormous, what inducing discrepancies in the required expertise. Often the national specific legislative text is almost repeated directly in the corresponding learning outcomes.

4.5.3 Organization

Learning outcomes that cover structural or administrative aspects of RP are summarized in the category “organization”. The subjects deal with the hierarchy of RPOs and RPEs and focus especially on the authority of an RPO including the legal prerequisites to appoint an RPO. Furthermore, administrative aspects like licensing-procedures and retention periods are clarified. The learning objectives include also the collaboration between RPOs and authorities. The content of most subjects concerning organization are influenced directly by the legislation references. Official obligations of an RPO like the supervision of category A-workers are communicated in both courses almost identically.

4.5.4 Practical aspects

The part “practical aspects” covers learning outcomes that include any practical issues concerning radiation protection. Most learning objectives focus on laboratory practice. Frequent aspects are the tasks of an RPO to ensure that the operation of a laboratory complies with regulative needs. Furthermore the learning outcomes deal of course with protective measures. Therefore, the topics “calibration”, “dosimetry”, the “usage of protective equipment” and “dose calculations” are approached practically, too. Learning outcomes concerning these topics are almost identical in both courses, although references to legislation were taken into account. Nevertheless, individual learning outcomes vary significantly with respect to their content. Therefore, the specific subjects are listed in table 8. Some laboratory procedures are exercised literally in agreement with regulations, for instance the transfer of radioactive material, the official documentation and the fire protection. An additional training concerning the individual subjects is considered as unnecessary. The subject waste handling is analyzed separately.

4.5.5 Waste handling

The compared subjects of the section “waste handling” are taught differently. Most significant is that in The Netherlands usually a RPE establishes, within national regulations, procedures and requirements for the disposal of radioactive waste at an institute. Therefore, the waste management differs from one Dutch institute to another [7]. Furthermore, the Radiation Protection Ordinance [4] determines in detail the official documentation, the waste classification and the legal conditions.

4.5.6 Knowledge and practical skills in different cordoning off levels (RP-areas like supervising area, controlled area and exclusion area)

Mostly, the labeling standards of the RP zones are listed by the German learning outcomes that are included in the part “knowledge and practical skills of different cordoning off levels”. The contrasted subjects focus also on the methods used to delimitate different RP areas. Indirectly the learning outcomes refer to the RP zones classification. The national legislation specifies requirements concerning labeling and marking considerably. Subjects included in the section “practical aspects” clarify specifications that deal with the marking requirements of laboratory equipment. The Globally Harmonized System mostly harmonizes chemical warning signs [9]. Of course, different laboratory classification systems determine different requirements concerning the equipment including the appropriate labeling. Neither the Dutch nor the German course participants become familiar with the different specifications how to label RP-areas in different countries. Language problems intensify this effect.

4.5.7 Dose terms and units

The part "dose terms and units" includes learning outcomes that are defined and used in the legislative text (see table 6). Thereby, the subjects focus on the comprehensive understanding of absorbed dose, equivalent dose, effective dose, committed effective dose, ambient dose equivalent and on the personnel dose equivalent including the statutory units. The comparison of the German and Dutch subjects signalizes that the compared courses use identical dose definitions.

4.6 Practical experience

The University of Groningen offers more experiments than the Institute for Radioecology and Radiation Protection in Hannover. In Germany, seven hours must be spent on experiments [5]. In The Netherlands, there is no specific definition on the extent of the experiments, although roughly 12 hours are spent on experiments at the University of Groningen. Because of the implementation of the EU-BSS [10], [11] the Dutch course arrangement is likely to be extended with a few hours of lecturing or experiments focusing on supervising skills.

It is necessary to take into account that, additional to the RP-course, the requisite qualification in radiation protection shall be acquired through an education suited for the respective area of application and sufficient practical experience. For the Knowledge Group S4.1 the correlation between the sufficient practical experience and the sufficient professional education is determined by [5] and is illustrated in table 5. In The Netherlands, there are no comparable requirements for the expertise level RPO-DRM D. Nevertheless, the included experiments of the Dutch RP course are considered as a first practical experience.

Table 5: Minimum required practice time to achieve the sufficient practical experience in Germany respecting the S4.1 Module

Graduation in the natural scientific sector	Practice time in months
University/Polytechnic degree	3
Technician/Foreman	6
Apprenticeship degree	9
No Graduation in the natural scientific sector	24

5 Conclusion

As analyzed, the German subjects "maintenance of equipment", "neutron dosimetry and radiation passport" are not included in the RPO-DRM D. An additional training that clarifies the fundamental German RP legislation is necessary, too. The implementation of a detailed excursus that focuses on the German legal framework of RPO operations is advisable. Further, the lessons should comment on the German RP hierarchical structures of RPOs and RPEs. The authority of an RPO and the administrative aspects like the specific licensing-procedures need to be exercised too. The general German waste handling principles are not comparable with the Dutch arrangements. The official documentation and marking requirements differ considerably, too, what is intensified by the language differences. An additional instruction program should also compensate these discrepancies.

The official recognition as a German RPO depends not only on the acceptation of the Dutch certificate by the German competent authority. If the Dutch certificate is accepted to be equivalent to the S4.1 Module, the requirements for sufficient professional education and the sufficient practical experience are necessary to be verified independently [5]. Most of the Dutch RPOs reach the required sufficient practical experience as well as the sufficient professional education in the same way as German course participants.

The RPO-DRM D deals with the p,q,r-formula, the calculation of radiation scattering by objects and various rules of thumb. These contents are not included in the S4.1 Module. The German RPOs are adept at the German legislation, the German RP administration and hierarchical structures and the German marking specifications as well as the documentation requirements exclusively. An additional training is necessary to clarify the differences. Furthermore, a German RPO needs to be instructed by the local Dutch RPE to become familiar with the local established procedures and requirements for the disposal of radioactive waste. The lack of German experiments is roughly compensated by the sufficient practical experience.

Currently the Dutch competent authorities recognize the RPO training programs only. In contrast, the Dutch training providers are recognized from February 2018 onwards. Thereby, the renewed recognition depends on an audit that evaluates the assessment of the learning outcomes every five years. The course provider notifies the competent authority about the performed training programs and is responsible for recording the course participants, who passed the exam. Therefore, the S4.1 Module needs to be considered as equivalent to the RPO-DRM D either by the competent authority or by a course provider from February 2018 onwards. Occasionally, the Dutch employer overviews the preliminary practical experience. A sufficient professional education is not required.

6 Appendix

Table 6: German legislation references

German subject	Legislation reference
Nr. 96	Richtlinie über Dichtheitsprüfungen an umschlossenen radioaktiven Stoffen vom 04. Februar 2004
Nr. 5,6,7,13	Atomgesetz
Nr. 16	Zuständigkeitsverordnung der Länder
Nr. 30	Verwaltungsverfahrensgesetz des Bundes und der Länder
Nr. 173, 176,179	Fachverband für Strahlenschutz
Nr. 385	RdSchr des BMU 2003
Nr. 389, 390	Feuerwehrdienstvorschrift
Nr. 378, 382	AtSMV
Nr. 102	§ 40 Abs. 4
Nr. 335, 336, 337, 339, 346, 347, 361	DIN-Normen
Nr. 124, 127	Allgemeine Verwaltungsvorschriften
Nr. 355	Berufsgenossenschaftliche Grundsätze für Arbeitsmedizinische Vorsorgeuntersuchungen
Nr. 312	Empfehlungen der Strahlenschutzkommission
Nr. 25	Kreislaufwirtschafts-und Abfallgesetz vom 27. August 1994 (BGBl.I 1994, Nr.66); Verordnung zur Umsetzung des Europäischen Abfallverzeichnisses vom 10. Dezember 2001 (BGBl.I 2001, Nr. 65); Bestimmungsverordnung über überwachungsbedürftige Abfälle zur Verwertung vom 10.September 1996 (BGBl.I 1996, S. 1377);__Gesetz zur Ordnung des Wasserhaushalts (Wasserhaushaltsgesetz - WHG) vom 27.Juli 1957, letzte Neufassung vom 19. August 2002 (BGBl.I 2002, Nr. 59); Abwasserverordnung vom 9. Februar 1999 (BGBl.I 1999, S. 86), Neufassung vom 20. September 2001,Neufassung vom 15. Oktober 2002 (BGBl.I 2002, Nr. 74),Berichtigung vom 16. Dezember 2002 (BGBl.I 2002, Nr. 85);Verordnung über Trinkwasser und über Wasser für Lebensmittelbetriebe (Trinkwasserverordnung - TrinkwV) vom 5.Dezember 1990 (BGBl.I 1990, S. 2612, BGBl.I 1991, S. 227)
Nr. 22	Europäisches Übereinkommen über die internationale Beförderung gefährlicher Güter auf der Straße (ADR); Neufassung der Anlagen A und B zum ADR; ADR Rahmenrichtlinie 94/55/EG; 26. Ausnahmeverordnung zum ADR vom 15. Dezember 2004 (BGBl.II 2004, Nr. 40); Verordnung über die innerstaatliche und grenzüberschreitende Beförderung gefährlicher Güter auf der Straße und mit der Eisenbahn (Gefahrgutverordnung Straße und Eisenbahn - GGVSE) vom 11. Dezember 2001 (BGBl.I 2001, Nr. 67), Neufassung vom 10. September 2003 (BGBl.I 2003, Nr.49), Neufassung vom 3. Januar 2005 (BGBl.I 2005, Nr. 2); Richtlinien zur Durchführung der GGVSE (GGVSE-Durchführungsrichtlinien) vom 20. Juni 2003, Berichtigung vom 17. November 2003 (VkBl. 2003, S. 776); Verordnung über die Kontrolle von Gefahrguttransporten auf der Straße und in den Unternehmen (GGKontrolV) vom 27. Mai 1997 (BGBl.I 1997, Nr. 35), zuletzt geändert durch VO vom 11. Dezember 2001 (BGBl. 2001, S. 3529)

Table 7: German subjects: Regulation knowledge

Dutch subject	German subject	Figure 2: Parts	Content of the German subject
permit application (document ANVS)	*Nr. 54*	Organization	Die Notwendigkeit zur Beachtung der Bestimmungen des Genehmigungsbescheides, der erlassenen Anordnungen und Auflagen erläutern können.
responsibilities within the radiation protection unit	*Nr. 58*	Organization	Beispiele für die eindeutige Abgrenzung von Entscheidungsbereichen nennen können.
norms and legal regulations, (inter)national organizations	*Nr. 1*	Legislation	Die hierarchische Struktur des Regelwerkes zum Strahlenschutz erläutern können (Gesetze, Verordnungen, Richtlinien, Normen, KTA-Regelungen, BG-Vorschriften).
norms and legal regulations, (inter)national organizations	*Nr. 10*	Legislation	Die rechtliche Bedeutung von Verordnungen erläutern können.
Implementation regulation SB EZ	*Nr. 32*	Legislation	Die für das vorliegende Modul wichtigen amtlichen Richtlinien nennen können (z.B. Richtlinien des BMU zur Fachkunde, zur Dichtheitsprüfung, zu Sicherungsmaßnahmen, Empfehlungen der SSK).
Decision Radiation Protection (Bs)	*Nr. 11*	Legislation	Den räumlichen und sachlichen Geltungsbereich der Strahlenschutzverordnung erläutern können.
determination of risk perception	*Nr. 39*	Legislation	Die Pflicht, zur Auslegung der StrlSchV nennen können.
norms and legal regulations, (inter)national organizations	*Nr. 20*	Legislation	Für den Strahlenschutz wichtige andere Gesetze und Verordnungen des Atomrechtes nennen und den Geltungsbereich angeben können.

Table 8: Specific assignment of German learning outcomes in Figure 2 separated according to the legislation reference

Section	Radiation Protection Ordinance	Other	Regulation knowledge
Legislation	Nr. 51, 2x 47, 17, 83, 12, 23, 3x 49	*Nr. 13*, 2x *5*, 2x *6*, 2x *7*, *25*, *96*, *30*	*Nr. 1, 10, 20, 11, 32, 39*
Organization	Nr. 111, 2x 38, 2x 101, 55, 53, 42, 41, 105, 59, 57, 61, 45, 60, 62, 44, 73, 63, 384, 15, 46, 36, 67, 43, 69, 125, 3x 103, 123, 35	*Nr. 102*, *385*, *382*	*Nr. 54, 58*
Practical Aspects	Nr. 119, 112, 121, 129, 331, 106, 75, 82, 40, 89, 109, 108, 2x 93, 114, 97, 94, 235, 388, 2x 87, 65, 78, 99	*Nr. 176, 336*, 2x *16*, *337*, *389*, *124*, *127*, *355*, 3x *346*, *347*, 4x *339,390*, *361*, *378, 335*	
Waste handling	Nr. 313, 5x 71, 314, 2x 301, 302, 303, 304, 316, 317, 115, 116, 118	*Nr. 312*	
Knowledge and practical skills of different cordoning off levels	Nr. 77, 76, 80, 88, 330, 334, 85, 14		
Dose terms and units	Nr. 174, 177, 2x 178	*Nr. 173*, *179*	

7 References

[1] Haagen, J.; Greuter, M. et al: Comparison of the lowest level radiation protection courses in Germany and The Netherlands – a bilateral pilot; EUTERP; 2012

[2] Zandvoort, A.; Boersma, H.F. et al: Qualification Descriptors for the training of Supervisory Experts in Dispersible Radioactive Materials Level D (SE-DRM D); University of Groningen: 2016; Available at: http://www.rug.nl/education/other-study-opportunities/radiation-protection/strcursusinformatie/strcureindtermen/pdf_documenten/english-concept_eindtermen_td-vrs_d_final.pdf; Accessed: 23.07.2017

[3] Lernzielkatalog zu den Fachkunde-Richtlinien Technik nach RöV und StrlSchV; FS-2011-166-AKA-NETZ; ISSN 1013-4506; Available at: http://www.fs-ev.org/fileadmin/dummy/lernzielkatalog_fs_aka_april_2007_1.pdf; Accessed: 05.04.2017

[4] Strahlenschutzverordnung (StrlSchV), Ordinance on the Protection against Damage and Injuries Caused by Ionizing Radiation (Radiation Protection Ordinance): Strahlenschutzverordnung vom 20. Juli 2001 (BGBl. I S. 1714; 2002 I S. 1459), die zuletzt durch Artikel 5 der Verordnung vom 27. April 2016 (BGBl. I S. 980) geändert worden ist

[5] Richtlinie über die im Strahlenschutz erforderliche Fachkunde (Fachkunde-Richtlinie Technik nach Strahlenschutzverordnung) vom 18.06.2004 (GMBI. 2004, Nr. 40/41, S. 799), die zuletzt am 19.04.2006 geändert (GMBl. 2006, Nr. 38, S. 735) worden ist

[6] THE EUROPEAN QUALIFICATIONS FRAMEWORK FOR LIFELONG LEARNING (EQF); Luxembourg: Office for Official Publications of the European Communities, 2008; DOI 10.2766/14352; ISBN 978-92-79-08474-4; Available at: http://www.ecompetences.eu/site/objects/download/4550_EQFbroch2008en.pdf; Accessed: 21. Jul. 2017.

[7] Eijnde, J.; Schouwenburg, M.: Practical Radiation Protection. Utrecht: Syntax Media, 2013

[8] Andrei Kossilov: Requirements and Generic Guidance for Management System; IAEA/ICTP/WNU Workshop on Managing Nuclear Knowledge: 22-26.08.2005; Available at: https://www.iaea.org/km/documents/05_W_Kossilov_2226Aug05.pdf; Accessed: 21. Jul. 2017

[9] Globally Harmonized System of Classification and Labelling of Chemicals (GHS); Annex 1: Classification and Labelling Summary Tables; United Nations: 2015; Available at: http://www.unece.org/fileadmin/DAM/trans/danger/publi/ghs/ghs_rev06/English/ST-SG-AC10-30-Rev6e.pdf; Accessed 21. Jul. 2017

[10] COUNCIL DIRECTIVE 96/29/Euratom of 13 May 1996; laying down basic safety standards for the health protection of the general public and workers against the danger of ionizing radiation; EUR-Lex: Official Journal of the European Union on 29.06.1996; L-159;

[11] COUNCIL DIRECTIVE 2013/59/EURATOM of 5 December 2013; laying down basic safety standards for protection against the dangers arising from exposure to ionising radiation, and repealing Directives 89/618/Euratom, 90/641/Euratom, 96/29/Euratom, 97/43/Euratom and 2003/122/Euratom; EUR-Lex: Official Journal of the European Union on 17.01.2014; L 13/1;