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ANNEX to Deliverable 3.1

National contexts and innovative practices in Science Education. A Comparative Report.

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National contexts and innovative practices in Science Education.
A Comparative Report
ANNEX t D.3.1
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Table of Contents

Index of Figures

Introduction

The kidsINNscience project is a collaborative SICA action funded by FP7 and has among its main objectives to compare the various educational systems and policies within the different countries being partners of the Consortium as far as science education is concerned. The rationale of the project is that innovation in science education cannot be simply transferred from one country to another and that the challenge consists in adapting the innovations collected to the contexts and conditions that are specific to each country. This process of adaptation should therefore be accompanied by a clear vision of what are the main differences and analogies between science education policies and practices in the different countries, in order to understand the adaptation's needs and design adequately the implementation of the innovative practices.

By consequence, the aim of this deliverable is to complete and enrich the reflections proposed in Deliverable 3.1, where 80 innovative practices have been collected and analyzed by means of general 'quality criteria', and in Deliverable 4.1 where the process of choice and adaptation has been summarized.

This deliverable – the Annex to Deliverable 3.1 - aims to describe national contexts taking into account

- International Educational Data bases, such as the OECD and the UNESCO Educational Indicators ,
- the results of International Surveys on Science Education and Science Teaching, such as PISA 2009 and 2006, TALIS 2008, TIMSS 2007,
- the National Reports produced by the participating countries of the Consortium.

Differences and similarities will be examined following the guideline proposed to partners and reported in Annex I of this Deliverable, using whenever possible and adequate the data available from international data bases. The National Reports, collected in Annex 2, aim to present the 'personal point of view' of the Consortium members on some of the main issues related to Science Education Development, and to offer an internal, in some case critical, partner institution based, interpretation of the state of Science Education in the country.

1. National differences and similarities in Educational Trends within the countries participating in the Consortium

Nowadays educational aims and benchmarks are very similar and diffused internationally: the United Nations Millenium Goals as well as the Educational Benchmarks proposed by Europe for 2010 and the new 2020 European framework, consider that 'quality education for all' is one of the main goals to be achieved for Human Development.

The International and European interest have greatly contributed to the improvement of the various indicators and indexes concerning education in the last 20 years, in Europe[1] and in other countries; one of the effects of these common goals is the achievement of a common understanding of the main factors influencing education and of the main characteristics of a 'quality education'. Education in general, and science education as a specific case, give more attention every subsequent year to 'key competences' and to 'citizenship literacy', considered as some of the main factors for the success of a democratic country. In this vision science literacy, as well as reading and math literacy, should become a shared characteristic of all populations[2] and has become an international aim, monitored by international surveys as TIMSS or PISA.

In order to understand and to compare the differences concerning Science Education in the ten countries that are members of the kidsINNscience Consortium it is important to describe first the general educational contexts where the concrete Science Teaching and Learning take place, and where the innovative practices collected by the Consortium partners have been produced and will be adapted.

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[1] „*EU education and training policies have gained impetus since the adoption of the Lisbon Strategy in 2000, the EU's overarching programme focusing on growth and jobs. The strategy recognised that knowledge, and the innovation it sparks, are the EU's most valuable assets, particularly in light of increasing global competition.*" (http://ec.europa.eu/education/lifelong-learning-policy/doc28_en.htm)

[2] One of the new benchmarks EU member states set for 2020 is that the "*share of 15-years olds with insufficient abilities in reading, mathematics and science should be less than 15%*".

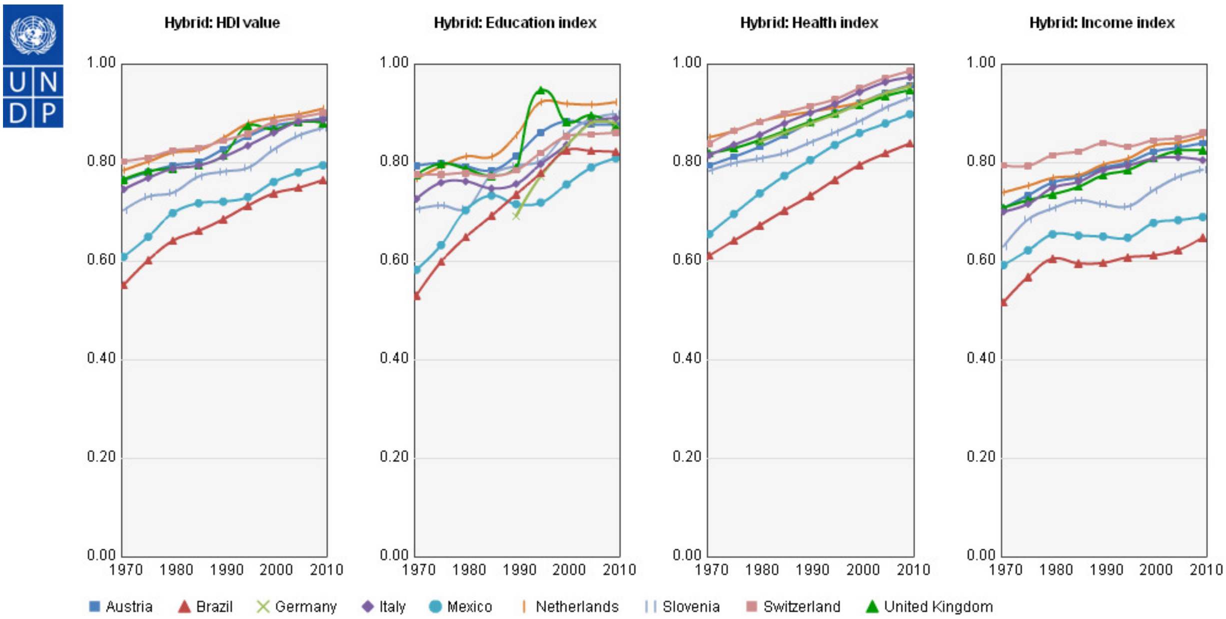
Countries in the consortium are quite different, not only because they are from Europe and Latin-America and have different languages and traditions, but also because they are very different in size and in GDP, and these differences are partially reflected in the education policies and investments.
As shown in Figure 1, the Latin American countries have a larger population, and students population, than other countries in the consortium, whereas some of the European countries, such as Switzerland and the Netherlands, are very small and very rich.

Figure 1. Basic reference statistics
(Source: OECD - Education at glance 2010, www.oecd.org/edu/eag2010, reference period: calendar year 2007)

	Total population in thousand (mid-year estimates)	Gross domestic product (in millions of local currency)	Total public expenditure (in millions of local currency)	Purchasing power parity for GDP (PPP) (euro zone = 1)
Austria	8,301	270,782	132,185	1.0352
Brazil	189,847	2,597,611	840,501	1.5194
Germany	82,263	2,428,200	1,060,650	0.9949
Italy	59,375	1,546,177	739,945	0.9815
Mexico	105,677	11,175,985	2,498,978	8.7512
The Netherlands	16,378	568,664	258,829	1.0252
Slovenia	2,019	34,568	14,665	0.7538
Spain	44,874	1,052,730	412,751	0.8715
Switzerland	7,619	521,068	221,689	1.9128
United Kingdom	60,975	1,398,882	621,725	0.7672

Within these basic differences, an idea of the importance given to the improvement of 'education' in the different countries can be derived from the comparison of the different indicators composing the Human Development Index (Figure 2). It can be observed how all countries have improved their indices in the last 40 years, and how this improvement is largely due, particularly for Latin American countries, to the improvement achieved in education and health.
As far as the European countries are concerned the level of the Education index is on average very high, while the improvement is less significant, and many countries seem to have achieved, or are achieving, their maximum of development as far as education is concerned, and they face difficulties in maintaining their level or further improving their results, at least in the last five years.

Figure 2. Human Development Index
The HDI values are reported together with the Education, Health and Income index, for the 10 partner countries of kidsINNscience. (UNDP data, 2010)



The differences between different countries as far as the average level of education in the country is concerned can be better appreciated from Figure 3. The table reports the population with at least upper secondary education by age group.
The 10 countries in the Consortium look very different in relation to this parameter: countries such as Germany and Switzerland - but also Austria and Slovenia - appear to have a long tradition of secondary education for all, since the percentage of older population (55-64 year old) with upper secondary education reaches 70/80 %. Moreover, the percentage of younger population with upper secondary education is near 90%, while countries as Spain and Italy had to overcome a heritage of limited educational possibilities and only recently have succeeded in extending upper secondary education over the 60% of the population. Brazil and Mexico are still struggling for equality, only recently having achieved the access to compulsory education for the large majority of children (in Brazil 99%, from 5 to 14 years old) and are slowly increasing the percentage of the population with secondary school education.

Figure 3. Percentage of population attaining at least upper secondary education in the ten kidsINNscience countries
(Data 2008, Source: OECD - Education at glance 2010, www.oecd.org/edu/eag2010, table A1.2a)

	Percentage, by age group				
	25-64	25-34	35-44	45-54	55-64
Austria	81	88	85	79	71
Brazil	39	50	40	33	23
Germany	85	86	87	86	82
Italy	53	69	57	49	35
Mexico	34	40	36	30	19
The Netherlands	73	82	77	71	62
Slovenia	82	92	85	78	71
Spain	51	65	57	45	29
Switzerland	87	90	88	85	**83**
United Kingdom	70	77	70	67	63

Furthermore, the organization of studies is different in each country and the duration of primary and secondary studies range from a minimum of 11 years in the Netherlands to a maximum of 13 for Germany and Italy.
As shown in Figure 4, the cumulative expenditure for students is higher in the European countries, especially in Switzerland, and lower in Latin American countries, as would be expected due to the larger number of students. Figure 5 shows instead how the proportion of the GDP dedicated to education is high in Austria and in UK as well as in Latin-American countries and has been increasing in the last 12 years, while many European countries, with the exception of the Netherlands and UK, are decreasing their investment in education.

Figure 4. Average duration of studies in the ten kidsINNscience countries and expenditure for student during primary and secondary studies
(Source: OECD - Education at glance 2010, *www.oecd.org/edu/eag2010*, table B1.3a)

	Notes	Average theoretical duration of primary and secondary studies (in years)				Cumulative expenditure per student over the theoretical duration of primary and secondary studies (in USD)		
		Primary education	Lower secondary education	Upper secondary education	Total primary and secondary education	Primary education	All secondary education	Total primary and secondary education
		(1)	(2)	(3)	(4)	(5)	(8)	(9)
Austria		4.0	4.0	4.0	**12.0**	34,655	85,270	**119,925**
Brazil	1	4.0	4.0	3.0	**11.0**	7,447	12,069	**19,516**
Germany		4.0	6.0	3.0	**13.0**	22,193	69,774	**91,966**
Italy	1	5.0	3.0	5.0	**13.0**	36,915	63,988	**100,903**
Mexico		6.0	3.0	3.0	**12.0**	12,663	14,651	**27,314**
The Netherlands		6.0	2.0	3.0	**11.0**	39,313	51,651	**90,964**
Slovenia	1	6.0	3.0	3.0	**12.0**	x(6)	90,042	**90,042**
Spain		6.0	4.0	2.0	**12.0**	39,199	52,380	**91,579**
Switzerland	1	6.0	3.0	3.5	**12.5**	55,269	92,488	**147,756**
U. K.		6.0	3.0	3.5	**12.5**	49,333	57,796	**107,129**

1. Public institutions only

Figure 5. Expenditure on educational institutions as a percentage of GDP from public and private sources by year
(Source: OECD - Education at glance 2010, *www.oecd.org/edu/eag2010*, Table B2.1)

	Expenditure on educational institutions as a percentage of GDP, by level of education (1995, 2000, 2007) Primary, secondary and post-secondary non-tertiary education		
	2007	**2002**	**1995**
Austria	3,6	3,9	4,3
Brazil	4,0	2,6	2,6
Germany	3,0	3,3	3,4
Italy	3,1	3,2	3,5
Mexico	3,8	3,5	3,7
The Netherlands	3,7	3,4	3,4
Slovenia	3,6	m	m
Spain	2,9	3,2	3,8
Switzerland	4,0	4,2	4,6
United Kingdom	4,2	3,5	3,6

2. National image of science and science teaching

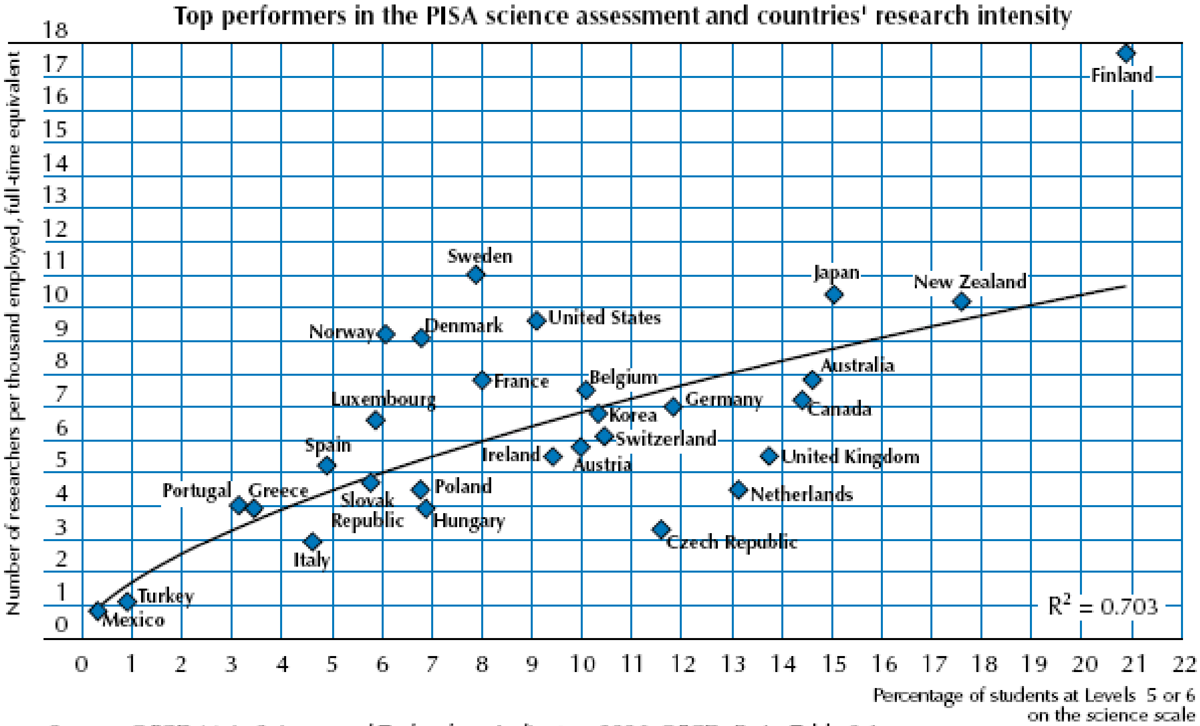
What importance is given to science, and to science education, in each of the countries in the kidsINNscience Consortium? The answer is not easy, because international indicators and partners' personal opinions sometimes differ and the common image of science shared by the citizens is often in itself contradictory.

What emerges from both statistical data and personal feelings is that great importance is attached to science by many European countries – mainly the same that have a long tradition in extended secondary education - while Latin countries that have only recently extended education to all the population share an 'under-evaluation of science and science education'. Brazil seems to be an exception, but partners in Italy, Mexico and Spain, share the impression that science '*is not considered as an essential part of their culture*'.

This feeling is confirmed by different kinds of data, for instance the ones related to the funds assigned to research: only 0.4% of GDP is granted in Mexico, and in Europe in 2008, only 1. 2% was granted in Italy and 1.3% in Spain, (1.6% in Slovenia, 1.8% in the UK and the Netherlands), while Switzerland (3%), Austria (2.7%) and Germany (2.5%), invest considerably more on Science Research and Development (European Data by Eurostat 2010).

PISA data in 2006 had partially confirmed this scarce interest of some countries for investments into science and showed a relation between investment and PISA performances. Figure 6 presents the relationship between the proportion of 15-year-olds who score at the higher levels in science (PISA 2006) and the number of researchers per thousand employed (full time equivalent). Looking at the figure, and focussing on the countries participating in the Consortium, it is evident that on average the presence of high performing students could be correlated with the country investment in R&D: some countries such as the Netherlands and the UK get better results at comparable investments while another country – Spain – invests more and get poorer results. On average more investments in research, which can be a consequence of a more popular interest for science, usually give better performance results.

Figure 6. Top performers in the PISA science assessment and countries' research intensity



Source: *OECD Main Science and Technology Indicators 2006*, OECD, Paris. Table 2.1a.

Despite this relation, other data show that the question cannot be reduced only to investments but need to be carefully explored.
The statistical data, reported in

Figure 7, related to graduates in different fields of Education in the ten countries, show that the major percentage of science graduates come from Germany and UK, but Mexico comes just after them together with Austria. Italy presents the higher percentage of females who graduated in science - 54% of the total science graduates. Although the percentage of science graduates in Italy and in Spain is not very high, they are more than in the Netherlands and Slovenia, where the investment of governments in science related professions seems to be higher.
As far as Education is concerned, in all countries the large majority of graduates in Education are females, with Slovenia, Italy, the Netherlands and Spain exceeding the 80%.

Figure 7. Graduates by fields of education (2008). The percentage of female graduates (F%) is compared with the total number (MF).
(Source: UNESCO Institute for Statistics, 2010)

Country	Total number of graduates		Graduates by field of education as a % of total									
			Science and technology fields						Other fields			
			Total		Science		Engineering, manufacturing and construction		Total		Education	
	MF	% F	MF	% F	MF	% F	MF	% F	MF	% F	MF	% F
Austria	44	52	28	24	11	33	18	19	71	63	11	78
Brazil	917	60	12	34	7	37	5	29	83	65	23	78
Germany	467	57	26	31	13	44	13	19	73	66	9	76
Italy	400	60	20	38	7	54	14	31	79	66	12	83
Mexico	420	54	26	34	11	43	15	28	73	62	13	72
The Netherlands	124	57	14	19	6	20	8	18	86	63	15	81
Slovenia	17	63	18	27	4	39	14	23	82	71	8	86
Spain	291	58	36	30	9	36	16	27	74	68	13	82
Switzerland	79	49	21	19	9	28	12	13	79	56	10	71
U. K.	651	58	22	31	13	38	8	21	77	66	11	75

So, also where, as reported by the Netherlands partner, '*science maths and technology are seen as the corner stones of knowledge-based economy*' this governmental vision does not necessarily corresponds to the students vision of science, often considered '*difficult, boring, and not necessary for a future career*'. Also the Austrian partner pointed out that '*Austrian young people are interested in science but do not realize that physics, chemistry or biology, are applicable for their daily life*'. All these feelings seem to be very important for the enrolling of girls in science.
In order to counter this diffused image of science all countries in the Consortium have developed several initiatives: some are mainly addressed to the popularization of science (as scientific weeks, open campus for families, long night of science, science international shows, science museums activities,...) others are more specifically addressed to schools and to the connection with the research world, with the aim of starting and improving collaboration initiatives between education and research (as described in the Form-it project: www.form-it.eu), and of enhancing the appeal of the science curriculum, and the motivation toward future science careers. Some initiatives are specifically addressed to the gender issue and aim '*to improve the image of the female scientist*' (Austria).
In some of the countries in the Consortium science education seems to enjoy a better status than other subjects: for example, in Brazil in recent years '*there has been a greater investment in public policies and funding for science popularization*' and '*unlike what happens in other subject areas, there have been specific policies and programmes funding Science Education activities*'. In the UK '*the STEM (Science, technology, Engineering and Maths) subjects are expected to be less severely cut than other areas*'.

3. The relevance of science in the core curriculum

Time spent on the subject could be considered as a good indicator of the relevance of science in the core curriculum. In Figure 8 the data related to the 4th grade collected by TIMSS are shown. The importance given by the curricula and by the teachers to science at an early age in Austria, Germany and Slovenia is evident. From the National Reports it results that also Brazil and Mexico give more importance to science (approximately 15% of the total number of hours in Brazil and 12%, 3 hours per week, in Mexico). Switzerland dedicates about 20% of hours to natural and social science, without a possibility to distinguish between the two.
On average, the time effectively spent in class for science is less than that prescribed: in almost every country subject such as reading, writing and math are considered more important than science and the hours are used according to this focus.

Figure 8. Weekly Intended and Implemented Instructional Time for Science in 4th grade
(Source: TIMSS 2007, International Science Report, p. 202)

Country	Intended Time for Science Prescribed in the Curriculum		Time for Science Implemented in Schools (in parentheses the standard error, SE)	
	Total Hours of Instructional time per week	Time as a percent of total instructional time	Total Hours of Instructional time per week	Time as a percent of total instructional time
Austria	21	15	21 (0.1)	12 (0.1)
England	24	10	25 (0.2)	7 (0.2)
Germany	21	18	22 (0.2)	13 (0.2)
Italy	30	15	30 (0.4)	6 (0.1)
The Netherlands	np	np	27 (0.1)	3 (0.1)
Scotland	25	5	25 (0.1)	5 (0.3)
Slovenia	18	13	19 (0.1)	12 (0.1)

Although it is relatively difficult to compare the data related to lower secondary school, due to the different duration of the courses in different countries (as shown in Figure 4), data available from PISA allow us to compare the time spent on science, as declared by students. In Figure 9 results for all the countries of the consortium for 15-year-old students are shown.

Figure 9. Percentage of students, by time spent on learning science. Results based on students' self-reports
(Source: PISA 2006, table 5.17)

	Science							
	Regular lessons in school[1]				**Self-study or homework**[1]			
	Less than two hours a week		**Four hours a week or more**		**Less than two hours a week**		**Four hours a week or more**	
	Percentage	S.E.	Percentage	S.E.	Percentage	S.E.	Percentage	S.E.
Austria	44,6	(1,3)	20,4	(1,3)	78,6	(0,9)	6,5	(0,4)
Brazil	**49,9**	(0,8)	11,3	(0,6)	68,3	(0,8)	8,5	(0,4)
Germany	34,6	(1,1)	32,3	(1,0)	68,5	(0,8)	8,2	(0,4)
Italy	34,3	(1,2)	24,9	(1,0)	56,0	(1,0)	14,9	(0,6)
Mexico	41,0	(0,7)	**36,7**	(0,7)	58,3	(0,7)	**15,3**	(0,5)
The Netherlands	**51,5**	(1,0)	16,4	(0,6)	79,4	(0,7)	4,2	(0,4)
Slovenia	42,9	(0,7)	27,3	(0,7)	71,9	(0,6)	6,2	(0,4)
Spain	27,7	(0,8)	26,9	(0,9)	65,2	(0,8)	9,7	(0,4)
Switzerland	48,6	(1,0)	18,7	(0,8)	**84,8**	(0,6)	3,2	(0,2)
United Kingdom	10,1	(0,6)	**61,9**	(1,0)	75,0	(0,8)	3,7	(0,3)

1. Percentages for the middle category can be obtained by subtracting the sum of the other two categories from 100%.

The country devoting more time to science, and the consequent recognition of its relevance, at this age level is U.K., while the other countries offer an average of 2-3 hours per week and ask for a limited amount of study time at home. In Austria the trend is to augment the number of science hours '*to awake pupil's interest in science profession*', while in Italy the recent reform of secondary schools reduced the science hours in technical and vocational schools. In Germany there is a notable difference between states and the ones where science is compulsory obtain the higher PISA results. Brazil is one of the countries where students declared one of the minimum number of regular lessons in science in 2006, while the consortium Brazilian partner declared that the total amount of hours for scientific subjects has risen during the last years, and '*count for around 40% of the total number of hours*' in upper secondary school (15-17 year old).

The performance of the students in science is not only correlated with the time spent: the quality of teaching and the amount of content taught are indeed very important. In some countries – especially in Latin countries - the approach to science in lower and upper secondary school is almost 'encyclopedic', covering a large quantity of science content and disciplines, with neither space left for Inquiry Based Learning nor references with every day life.
In Figure 10 the performance at 4th grade of the six kidsINNscience countries participating in TIMSS is shown: all countries achieve good results, over the TIMSS average of 500, very good in England and Italy. Some of them present significant gender differences at this age already.

Figure 10. TIMSS 2007 distribution of Science achievement in the countries of the Consortium at 4th grade
(Source: TIMSS 2007, International Science Report, p.34)

Countries	Average scale score All students	Gender Difference Boys - Girls	Years of Formal schooling	Average age at time of testing
Austria	526 (2.5)	**13**	4	10.3
England	542 (2.9)	3	5	10.2
Germany	528 (2.4)	**15**	4	10.4
Italy	535 (3.2)	**13**	4	9.8
The Netherlands	523 (2.6)	11	4	10.2
Scotland	500 (2.3)	2	5	9.8
Slovenia	518 (1.9)	0	4	9.8

TIMSS data allow also to compare the performances in different cognitive domains: knowing, applying and reasoning. The kidsINNscience countries with stronger results on reasoning in 2007 have been: England (537), Slovenia (527) and Italy (526) (TIMSS 2007, p. 116).

In lower secondary schools most of the countries of the Consortium propose an integrated approach to science while the differentiation between science subjects is proposed between the 8th and 9th grade.

Performances obtained in PISA 2006 allow a comparison of the results of science curriculum for a different age level: in
Figure **11** the performances of 15-year-old students in all the countries of the Consortium are compared, together with the related gender differences (significant differences in bold).
The PISA performances look very different: the Netherlands, Slovenia, Germany and UK perform significantly over the OECD average; Austria and Switzerland over the average; Italy and Spain under the average and Mexico and Brazil significantly under the average.
Gender difference is not very high but significant for six of the countries with Slovenia in favour of girls, and no (apparent) difference in Austria. The higher difference in favour of boys is recorded in the United Kingdom (while it was one of the lowest in the TIMSS, 4th grade comparison).
Other studies indicate that the lack of a significant difference between boys and girls in science – and the decrease of the gender difference with age - is largely apparent and due to the girls preference for more

academic studies: if the comparison is between students of the same schools the difference is significantly in favour of boys also in science, and not only in math. (Martini, 2009)

Figure 11. PISA Science performances 2006
(Source: PISA 2006. Science Competences for tomorrows world, Volume 2: Data)

	All students		Gender differences		
	Mean score	Standard Deviation	Boys	Girls	Difference (B-G)
Austria	511	100	527	527	0
Brazil	390	89	395	386	**9**
Germany	516	100	519	512	7
Italy	475	96	477	474	3
Mexico	410	81	413	406	**7**
The Netherlands	525	96	528	521	**7**
Slovenia	519	98	515	523	**-8**
Spain	488	91	491	486	4
Switzerland	512	99	514	509	**6**
United Kingdom	515	107	520	510	**10**

In Figure 12 the PISA performances of the countries in the Consortium are compared taking into account the different science scales. The results that are ten or more points higher than the value of the combined science scale are marked in bold while those lower are in italics.
It can be noticed that only Germany maintains approximately the same average for all competencies and all knowledge domains, while the other countries present higher or lower scores in some of the scales. Especially the 'Earth and space' scale seems to indicate a point of weaknesses for many countries (except Slovenia) while the 'Living system' scale marks a point of strength for many (except the Netherlands).

Figure 12. Comparison of performances on different PISA scales in science
(Source: OECD, PISA 2006. Science Competences for tomorrows world, Volume 2: Data)

	Competencies			Knowledge of science			Knowledge about science	Combined Science score
	Identifying scientific issues	Explaining phenomena scientifically	Using scientific evidence	Earth and space	Living systems	Physical Systems		
Austria	505	516	505	503	**522**	518	504	511
Brazil	398	390	*378*	*375*	**403**	385	394	390
Germany	510	519	515	510	524	516	512	516
Italy	474	480	467	474	**488**	472	472	475
Mexico	**421**	406	402	412	402	414	413	410
The Netherlands	533	522	526	518	*509*	533	530	525
Slovenia	517	523	516	**534**	517	531	510	519
Spain	489	490	485	493	**498**	*477*	489	488
Switzerland	515	508	519	*502*	512	506	514	512
U.K.	514	517	514	*505*	**525**	508	517	515

The PISA results in 2009 allow a comparison with the results of 2006.

Figure **13**, where results in science performance are displayed, shows significant differences (in bold) and trends in science performances for some of the countries in the Consortium: Brazil and Italy are still below the OECD average but have significantly improved their performance. The Austrian results in 2009 are not reliable because of an internal dispute, and have not been used by OECD for the comparison of trends.

Figure 13. Trends 2006-2009 in PISA Science performances
(Source: OECD, PISA 2009 results. Volume V: Learning trends).

	2006		2009		2009-2006
	Science Mean score	Standard Deviation	Science Mean score	Standard Deviation	
Austria	511	102	494	100	**-17** *
Brazil	390	84	405	89	**+ 15**
Germany	516	101	520	100	+4
Italy	475	97	489	96	**+14**
Mexico	410	77	416	81	+6
The Netherlands	525	96	522	96	-3
Slovenia	519	94	512	98	-5
Spain	488	87	488	91	0
Switzerland	512	96	517	99	+5
U.K.	515	99	514	107	-1

**Austria has participated in PISA 2009 but data has not been considered in the OECD trends comparison because, due to a dispute between the teachers' union and the education minister, the comparability of data could not be ensured.*

Better results in some of the Consortium's countries could have different explanations. The more immediate, is that teachers and students not accustomed to this kind of testing start to understand the procedure and put more engagement in answering. In Italy, where the improvement is mainly due to the better results of the regions in the South, one of the factors of change could have been the teachers training on PISA testing made in the last 4 years.
In PISA 2006 the socio economic background of the families, strongly related to the Human Development index of the countries shown in Figure 2, has been the larger factor influencing the performance. Another factor taken into account was the '*immigrant status of the students*': this factor has been studied only for the countries where the presence of first-generation or second-generation immigrant students is relevant, and in the Consortium countries could be a significant factor influencing the performance. In Figura 14 the percentage of immigrant students for the European Countries that are members of the Consortium is shown: the situation is more relevant for 'smaller' countries, such as Switzerland or Austria, than for the ones with a the larger population, with the exception of Germany.

Figura 14 Percentage of immigrant students in 2006in the European kidsINNscience partner countries
(Source: OECD 2006 data base, Table 4.3d)

Country	Percentage of immigrant students in the country in 2006
Austria	13
Germany	14
Italy	4
The Netherlands	11
Slovenia	10
Spain	7
Switzerland	22
U. K.	9

Other factors influencing students' performance are the general 'school system' and the 'teaching styles'. One of the school factors taken into account in PISA 2006 was the 'index of school activities to promote the learning of science'. This index collects the principals' responses about questions investigating the school provision of percentage of different activities (excursions, science competitions, extracurricular science projects, science fairs or science clubs) that can provide '*motivation for students and help to place science in a real-life context*'. The index is calculated taking into account the percentage of students in the schools where science is promoted. The OECD average assumes the 0 value, so that a negative value of this index means that relatively few students are enrolled in schools promoting these activities.

In Figure 15, the index of school activities is reported for the different kidsINNscience countries. The most active schools, as defined by this index, are in Slovenia, UK, and Brazil, but the positive correlation with performance - given by the proportion of variance explained – is found only for countries with a negative index! A possible interpretation is that, despite the fact that few schools are 'active' in Austria, Germany, the Netherlands, Mexico and Switzerland, these are the same schools where students have performed better in PISA science. In other countries, such as the UK, the activities are more diffused, and the correlation with performance is very low (the activities are not a distinguishing feature of a 'school' with 'good' PISA students).

Figure 15. School activities to promote the learning of science and the explained variance in students performance
Source: PISA 2006,VOL.2: DATA. Table 5.18.

Country	Index of school activities to promote the learning of science	Explained variance in student performance R-squared x 100
Austria	-0.38	12.7
Brazil	0.24	2.0
Germany	-0.11	14.7
Italy	0.01	1.7
Mexico	-0.02	8.3
The Netherlands	-0.51	9.7
Slovenia	1.15	n
Spain	0.19	0.3
Switzerland	-0.25	6.0
U. K.	0.42	0.1

Other important factors for science learning are teaching styles and the use of active methodologies, such as inquiry based learning, hands-on experiments, design or plan an investigation, and so on. TIMSS data for 4th grade give an idea of the teaching style for some of the kidsINNscience Countries. In Figure **16**, for each activity described, the percentages of the students who directly reported that they have done the activity during half the classes or more are shown in the left column, while in the right column features the percentages of students **whose teachers** reported to have done the same activities. In this way the perception of students and that of teachers can be compared. Only for one activity the question has been addressed only to teachers because the meaning has been proved unclear for students of this age: the relation of what they are doing in science with their daily life.
This table is very rich in information:

- first of all its headings give an outline of what TIMSS consider Inquiry Based Learning: to observe, give an explanation, watch, design and do experiments and investigations, alone or in small groups;
- the table also gives a clear idea of the difference in perception between students and teachers: teachers generally report smaller percentages than their students in scientific inquiry activities. This probably means that Inquiry Based activities last longer in students' memory, but this could be also due to a different meaning given to the same term. For instance, 'to watch' for a teacher could mean that students are not merely looking at but are taking part in what they are seeing, while for a student 'to watch' could mean just to be there;
- the only activity where the percentages are very similar, is the one of 'giving explanation'. The fact that students and teachers agree could also be because explanation can be seen as a theoretical exercise (to repeat an explanation studied or given) not necessarily with a focus on inquiry;
- the Consortium countries show some similar general patterns: the most frequent teacher-reported activity is the one relating what students are learning in science to their daily lives (in Slovenia the teachers of 90% of students report this activity), while the next most frequent activity was

asking for explanations about something students are studying (in Italy the teachers of 91% of students report this activity whereas in Slovenia 86% of the students report this activity);

- the Consortium countries show different teaching styles already from primary school: while England and Slovenia gave high priority to students hands-on activities - the percentages of students declaring to design and do experiments, often in small groups, are over 70% and also the teachers reports show high percentages - other countries' practices – especially Austria, Germany and the Netherlands – seems to be more theoretical and mainly stressing the connection between science concepts and daily life.

Figure 16. Activities in science reported by students and by teachers in 4th grade
(*Source: TIMSS 2007, International Science Report, pp. 298-302)*
The table report for each described activity the percentage of students declaring to have done the activity for half the lessons or more, and the percentage of students ***whose teachers*** *reported to have done the activity for half the lessons or more.*

Percentage of Students who reported (or Whose Teachers Reported) Doing the Activity About Half of the Lessons or More (Standard error in parentheses)														
Country	Observe Natural Phenomena such as the Weather or a Plant Growing and Describe What They See		Give an Explanations about something they are studying		Watch the teacher doing a Science Experiment		Design or Plan Experiments or Investigations		Do Experiments or Investigations		Work together in Small Groups on Experiments or Investigations		Relate What Students Are Learning in Science to Their Daily Lives
	% stud.	% stud. Teach.	% stud.	% stud. Teach.	% stud.	% stud. Teach.	% stud.	% stud. Teach.	% stud.	% stud. Teach.	% stud.	% stud. Teach.	% stud. Teach.
Austria	34 (0.8)	9 (1.9)	58 (1.2)	58 (3.1)	62 (1.1)	3 (1.0)	32 (0.9)	2 (0.9)	33 (1.0)	6 (1.6)	37 (1.0)	12 (2.3)	71 (2.9)
England	45 (1.3)	25 (3.6)	77 (1.0)	72 (3.5)	73 (1.4)	10 (2.5)	**71** (1.7)	**53** (4.0)	**76 (1.4)**	**58** (3.9)	**80 (1.1)**	**61 (4.0)**	70 (3.5)
Germany	40 (1.0)	12 (2.2)	69 (0.8)	64 (3.1)	56 (1.1)	3 (1.1)	27 (0.9)	7 (1.7)	25 (0.9)	14 (2.4)	38 (1.2)	19 (2.6)	70 (2.7)
Italy	52 (1.2)	29 (3.1)	72 (0.8)	**91 (1.9)**	69 (1.5)	**23** (2.5)	45 (1.2)	25 (2.7)	47 (1.3)	31 (3.1)	41 (1.3)	22 (2.7)	72 (3.0)
The Netherlands	12 (0.7)	8 (2.5)	25 (1.2)	39 (4.0)	43 (1.6)	4 (1.9)	11 (0.7)	3 (1.5)	13 (0.9)	11 (3.2)	27 (1.8)	16 (3.5)	54 (4.7)
Scotland [1]	33 (1.4)	18 (3.0)	58 (1.6)	62 (4.3)	57 (2.2)	16 (3.1)	38 (1.7)	24 (3.6)	46 (1.9)	46 (4.2)	64 (1.7)	54 (4.8)	66 (3.8)
Slovenia	**61** (1.2)	**34** (2.9)	**86** (0.7)	82 (2.5)	**86 (0.8)**	21 (2.4)	70 (1.1)	17 (2.3)	71 (1.0)	39 (3.2)	78 (0.9)	31 (2.8)	**90** (1.9)
[1] In Scotland data are available for at least 70 but less than 85% of the students.													

A comparison to higher age levels is only partially possible because just a few Consortium countries participated in the TIMSS 2007 survey for the 8th grade. It could be interesting to notice – also because it is related to a decline in performance – that Italy at grade 4th shows an 'average' use of Inquiry Based methods and school time in science, while Italy at grade 8th presents not only one of the lowest time spent on science but also the minimum percentage of students and teachers reporting hands-on and Inquiry Based activities, are largely below the international average (TIMSS 2007, pp. 299-303).
As far as 15 year old students are concerned, PISA official reports do not offer too much information about the teaching styles, since no questionnaires have so far been proposed to teachers. However in PISA 2006 many questions concerning the science learning contexts and practices have been proposed to students, searching for indexes related not only to the learning resources (Figure 15) but also to the general teaching style (interactive versus transmissive), to the inquiry based learning activities and to the way teaching is addressing real-life applications. As Seidel and Prenzel pointed out (Seidel & Prenzel, 2006), in the literature, science education researchers differentiate between "inquiry learning" as a systematic approach to understanding scientific investigations and "student work and experiments" which are limited to the phase of hands-on activities, and they should be investigated separately.
Consequently, in PISA 2006, four indexes have been constructed:

1. SCHANDS, related to hands-on lab activities and the ability to use them to answer scientific questions,
2. SCAPLLY, investigating the connections made during science classes to the daily life use of science and technology,
3. SCINTACT, concerning the choice of an interactive teaching style, with large freedom for students to debate and ask questions,
4. SCINVEST, related to the students freedom of experimenting and investigating.

As for the school activity index reported in **Figure 15**, the four indexes have been constructed taking into account the students answers to four different sets of questions (asking to indicate on a Likert scale the frequency of some activity or behaviour). The OECD average has been assumed as 0, and the countries indexes, positive or negative, depend on the percentage of students 'positive' answers.
The PISA indexes and the correlations with students' performances have not been published by OECD, because of the difficulties to explain the data collected. An attempt to interpret the results obtained has been made in Italy (Di Chiacchio & Mayer, 2010) and a specific data analysis made by Carlo Di Chiacchio allows a discussion of the correlations between the indexes and performances for the ten countries participating in the kidsINNscience Consortium.
In
Figure **17**, the results of a multiple regression model connecting the four indexes with the performances of the ten countries participating in the consortium are shown.

Figure 17. Variance in students performance and indexes related to teaching styles
(Data sources: OECD, PISA2006. Original elaboration by Carlo Di Chiacchio.)

Country	Explained variance in students performance R-squared x 100	SCHANDS	SCAPPLY	SCINTACT	SCINVEST
Austria	17	11.5	24.8	-5.6	-45.4
Brazil	8	-3.1	14.3	6.5	-29.3
Germany	14	26.8	12.8	-9.6	-41.5
Italy	14	4.9	12.6	-6.7	-38.4
Mexico	5	3.8	10.8	2.9	-26.9
The Netherlands	15	8.8	31.9	-26.9	-28.9
Slovenia	10	22.4	8.3	-7.1	-41.5
Spain	11	3.0	22.9	-7.3	-33.1
Switzerland	20	25.5	29.0	-12.4	-45.2
U. K.	7	15.9	18.7	-2.8	-33.3

The variance in the students' performance explained by the differences in teaching style is larger than the one explained by the differences in school learning resources, but the results are very difficult to interpret, especially when the higher correlations are negative, as for the SCINVEST index. A negative correlation means that in schools where the index goes up by one unit, the average performance of the students goes down according to the value reported in the table. An interpretation of these data requires the knowledge of the country's school system and also of the students understanding of the meaning of the questions. The analysis made in the Italian contexts allow us to make the hypothesis that nowadays, as far as the SCINTACT and the SCINVEST indexes are concerned, students understand the questions related to the possibility to interact with each other and with the teachers, and to be free to investigate what they want, as related to a 'laissez faire' context, where there are no rules to follow. As a result of this mis-interpretation these two indexes are for almost all the Consortium countries negatively correlated with performance, and probably the situation of the schools where the index is higher correspond to 'remedial' teaching styles, where teachers try to raise the interest of students with low cognitive skills giving them more possibilities to interact and to act autonomously.
Also the other two indexes, SCHANDS and SCAPPLY, strictly related to a laboratory based and to a daily life connected teaching style, are difficult to interpret: in fact a larger correlation does not mean that the country index is high and that the related practice are very diffused in the country, but only that the teaching style is 'characteristic' of the 'best performing students'. One example is given by the UK: the index SCHANDS is relatively high (0.45, data source: Di Chiacchio & Mayer, 2010)) but the correlation is lower than that of other countries, and this probably because the use of experiments is so diffused in UK that the difference in students performance is due to other factors. On the contrary, the Netherlands has a low SCAPPLY index (-0.27) but it also has a very high correlation with it, and this is maybe because only few teachers, probably in the best schools, use this methodology.
The meaning of the table has therefore to be found in 'what makes the difference' in different countries, and consequently it could be argued that:

- the use of labs and hands-on experiments is part of 'good school' innovations in Germany, Slovenia and Switzerland, while in Brazil[3], Italy, Spain, and Mexico, are reserved to more vocational or technical schools, where students have lower performances;
- to put science contents in relation with the application indaily life is an innovative characteristic of 'good schools' and 'good teachers' mainly in the Netherlands, but also in Switzerland, Austria, and Spain.

4. Science Teachers education

'The available evidence suggests that the main driver of the variation of student learning at school is the quality of the teachers' stressed the McKinsey report in 2007, and the OECD PISA 2009 report adds "the quality of an education system cannot exceed the quality of its teachers and principals, since student learning is ultimately the product of what goes on in classrooms." (OECD 2010, PISA 2009 results, Vol. V, p.4).

As many official documents and reports pointed out, the quality of teachers – and this means also the quality of teacher education – could make the difference, especially in science education. In November 2007 the European Council Conclusions on improving the Quality of Teacher Education stressed the need for today's teachers to '*develop new knowledge and be innovative through engagement in reflective practice and research".* What is really going on in different countries is difficult to say because it is very difficult to collect comparable information on the contents and aims of initial and in-service teacher education programs. This is due to the high level of institutional autonomy not only in Europe but also in many federal countries, such as Brazil, Germany or Spain.[4]

[3] The Brazil Consortium partner stress that in Brazil ' the existence of labs and experiments as part of curriculum activities in schools are indicators of quality teaching' and that 'the use of labs and hands-on experiments is part of 'good schools' innovations', especially in private schools.

[4] At present the European Union is launching through Eurydice an European Survey concerning initial teacher education programs for specialist science and mathematics teachers: SITEP 2011

A first look at the distribution of teachers in terms of gender and age in the countries participating in the Consortium shows that the teaching profession is becoming every year more, and especially in Europe, a woman profession and an 'old age profession'.
Women account for the large majority of teachers in primary and lower secondary education for all the Consortium's countries, as shown in Figure 18. Even if the proportion varies according to the level of education: - the younger the children, the higher the number of female teachers. For some of the Consortium countries, namely for Brazil, Italy, Slovenia and UK , women are the majority at any level. This contrasts sharply with the relative absence of women in management positions at schools (Eurydice 2010).
As far as age is concerned, Figure 19 shows as the large majority of the teachers employed in the European countries are over 40, in Germany and in Italy over 50, while in Brazil the majority is under 40. This is of course due to the stability, or diminution, in the birth rate in many European countries and implies that both in-service training and initial training are becoming crucial. In some of the Consortium countries a lack of qualified teachers – in all subjects but especially science and math – is forecast.

Figure 18. Gender distribution of teachers (2008). Percentage of females among teaching staff in public and private institutions by level of education.
(Source: Education at a Glance 2010: OECD Indicators - © OECD 2010, Indicator D7)

	Notes	Pre-primary education	Primary education	Lower secondary education	Upper secondary education		
					General programmes	Prevocational /vocational programmes	All programmes
		(1)	(2)	(3)	(4)	(5)	(6)
OECD countries							
Austria		99.0	89.2	69.2	60.9	48.1	51.9
Brazil		96.9	91.1	**72.6**	**63.9**	54.1	62.4
Germany		97.8	85.2	61.6	51.3	46.0	49.0
Italy	1	99.2	**95.3**	**71.4**	**70.4**	53.4	59.7
Mexico		95.5	66.4	50.3	43.9	46.3	44.2
The Netherlands		na	83.8	na	46.9	48.4	47.4
Slovenia		98.3	**97.5**	**78.9**	**70.7**	61.3	64.8
Spain		90.6	75.2	57.9	na	na	49.1
Switzerland	1	98.2	79.8	50.0	42.5	na	42.5
United Kingdom		94.5	81.4	62.5	62.5	64.8	63.3

1. Public institutions only (for Italy, from pre-primary to secondary level).
na: comparable data are not available

Figure 19. Age distribution of teachers (2008) Percentage of teachers in public and private institutions by level of education and age group

(Source: OECD, www.oecd.org/edu/eag2010)

	Notes	Primary education					Lower secondary education					Upper secondary education				
		< 30 years	*30-39 years*	*40-49 years*	*50-59 years*	*>= 60 years*	*< 30 years*	*30-39 years*	*40-49 years*	*50-59 years*	*>= 60 years*	*< 30 years*	*30-39 years*	*40-49 years*	*50-59 years*	*>= 60 years*
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Austria		8.3	21.4	35.6	33.4	1.3	6.1	16.7	37.9	37.8	1.5	5.7	21.5	37.1	32.8	2.9
Brazil		19.6	**35.4**	31.9	11.5	1.6	19.4	33.6	31.4	13.5	2.1	17.9	33.3	31.7	14.7	2.4
Germany		6.1	22.3	21.3	**41.8**	8.5	3.6	20.7	23.5	**43.6**	8.6	2.4	22.4	28.8	38.4	8.1
Italy	3	1.4	19.1	37.5	37.5	4.5	0.5	12.1	27.7	**52.2**	7.5	0.5	9.0	37.1	**46.5**	7.0
The Netherlands	4	20.3	21.3	24.6	29.2	4.6	na	na	na	na	na	11.5	18.1	25.7	37.3	7.3
Slovenia		11.1	32.4	40.6	15.6	0.3	10.9	28.8	34.6	23.7	2.1	6.8	33.0	33.1	23.5	3.6
Spain		14.2	25.3	29.1	27.4	4.0	7.4	30.2	34.6	23.5	4.3	6.8	29.6	35.1	24.4	4.2
Switzerland	3, 5	18.1	23.0	26.4	28.8	3.8	12.6	26.0	26.5	29.6	5.3	7.2	25.5	30.4	29.4	7.4
U. K.		24.6	26.7	21.3	25.8	1.6	20.3	27.0	23.6	26.0	3.2	16.9	25.2	26.0	26.6	5.3

3. Public institutions only.
4. Primary education includes pre-primary education.
5. Upper secondary education includes general programmes only.
na: comparable data are not available

As far as the quality and contents of Science Teachers Education in Europe is concerned, one of the achievements of the last ten years is that all teacher education programs, also for primary school, has been upgraded to University status. The European Trade Union Committee for Education, recently wrote: '*the demands that teachers face today in terms of in-depth subject knowledge, advanced pedagogical skills, reflective practice and ability to adapt teaching to the needs of each individual as well as to the needs of the group of learners as a whole, require that teachers are highly educated and equipped with the ability to integrate knowledge and handle complexity at the level which characterises studies at the Master's level*."

The Master level is effectively required for primary school teachers only in very few cases (Slovenia and some Germany states) but it is necessary for Science teachers in lower and upper secondary schools in all Europe and is increasingly diffused in Mexico and in Brazil (in Brazil in these latter years 40 new graduate courses in science and mathematics have been approved, including professional Masters and Doctoral programmes).

The organization of the Science Education courses varies greatly from country to country, and depend on the national choices concerning the main focus of the science teacher education curriculum. As pointed out by the Mexican partners, two different cultures co-exist in science teacher education: "*on one side the discipline specialist and, by the other side, the teaching specialist*." This is presented by Eurydice and the European Agency (Key Data on Education in Europe 2009) as a contrast between the 'general education' in the subjects and the 'professional component' including practical skills and the in class-placement. As stressed by this European report two main models can be distinguished '*on the basis in which these two components are combined.*': the **concurrent model**, where the general and the professional components are provided at the same time, and the **consecutive model** where they are in a sequence.

These general choices are often strictly correlated: the countries where the importance of the discipline is stressed often propose a 'consecutive model' where the professional courses and practicum follow a subject based degree, while the countries that prefer the concurrent model in general emphasize the importance of professional teaching skills. The choices are also dependent on the level of schooling: all the countries participating in the consortium adopt a concurrent model for primary school teachers, while the consecutive model is the more often adopted – in some countries it is the only option– for science teachers in lower and upper secondary schools.

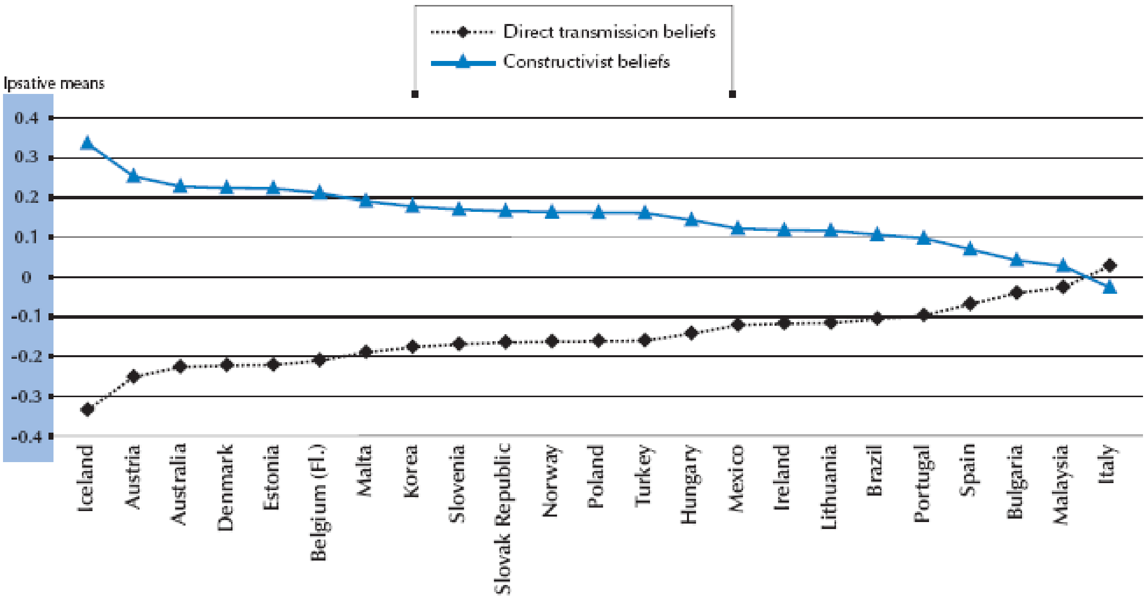
This means that the specific preparation for or in the science subjects could be very different from country to country, some countries ask, for a subject based master degree before the science education course. It can also vary from teacher to teacher - depending on the regulations and examinations existing in the countries. It can happen that some teachers have a University degree only in one part of the subjects s/he is supposed to teach (as for instance a biologist teaching chemistry or a mathematician teaching physics) while others have a specific preparation in the subject -. In many countries teachers, especially in lower and upper secondary schools, have a relatively deep subject preparation but have not received an adequate preparation in educational research for becoming a 'reflective practitioner', able to plan innovation and to reflect on its own planning. In other countries the lack of subject specialists seems more important.

As far as professional development is concerned , according to the TALIS survey (OECD, 2009) "teachers have few incentives to improve their teaching and most common types of professional development activity available to them are not the most effective. The majority of teachers would like more professional development (particularly on special learning needs, ICT skills, and student behaviour)".

The TALIS survey focused on the working conditions of teachers, and especially on the professional development of lower secondary school teachers. Twenty four countries participated in the first round of TALIS and six of them are partners of the kidsINNscience consortium. The TALIS data confirmed previous data about the age and gender of teachers: Italy and Austria are the countries that have, for this school level, older teachers, and Slovenia and Italy the ones that have more female teachers, the younger teachers being in Brazil. As far as professional development is concerned Spain has the higher percentage of teachers (100%) who undertook some professional development in the previous 18 months, while Italy and Brazil are between the lower ones with 85% and 83% respectively. A considerable amount of teachers declared they would participate in more professional development, mainly in Mexico and Brazil (more than 80%) while Slovenia's unsatisfied requests are less than 35%. In Slovenia the in service training is offered through the Ministry of Education and Sports and is evaluated with marks offering an advancement of the teachers position (also on the salary).

Chapter 4 of the TALIS survey is dedicated to teaching practices and general teachers' beliefs about 'direct transmission' versus 'constructive' views have been investigated. The general conclusions are very interesting for the kidsINNscience project and for Science teaching: in Figure 18 the country profiles of beliefs about the nature of teaching and learning are reported. In all countries but Italy the average endorsement of constructivist beliefs is stronger than that of direct transmission. The difference is higher in countries such as Austria and Slovenia and lower in Mexico, Brazil and Spain. The TALIS survey suggests that teachers beliefs are very strongly influenced by the 'culture' and pedagogical traditions of the national systems, especially as far as the transmissive beliefs are concerned. Transmissive beliefs seem to be formed relatively early in education and remain stable a long time.
The two approaches are often integrated, in the same school, and also co-exist in the same teachers.

Figure 18. Country profile of beliefs about the nature of teaching and learning (2007-2008) *(Source: OECD, TALIS Database).*



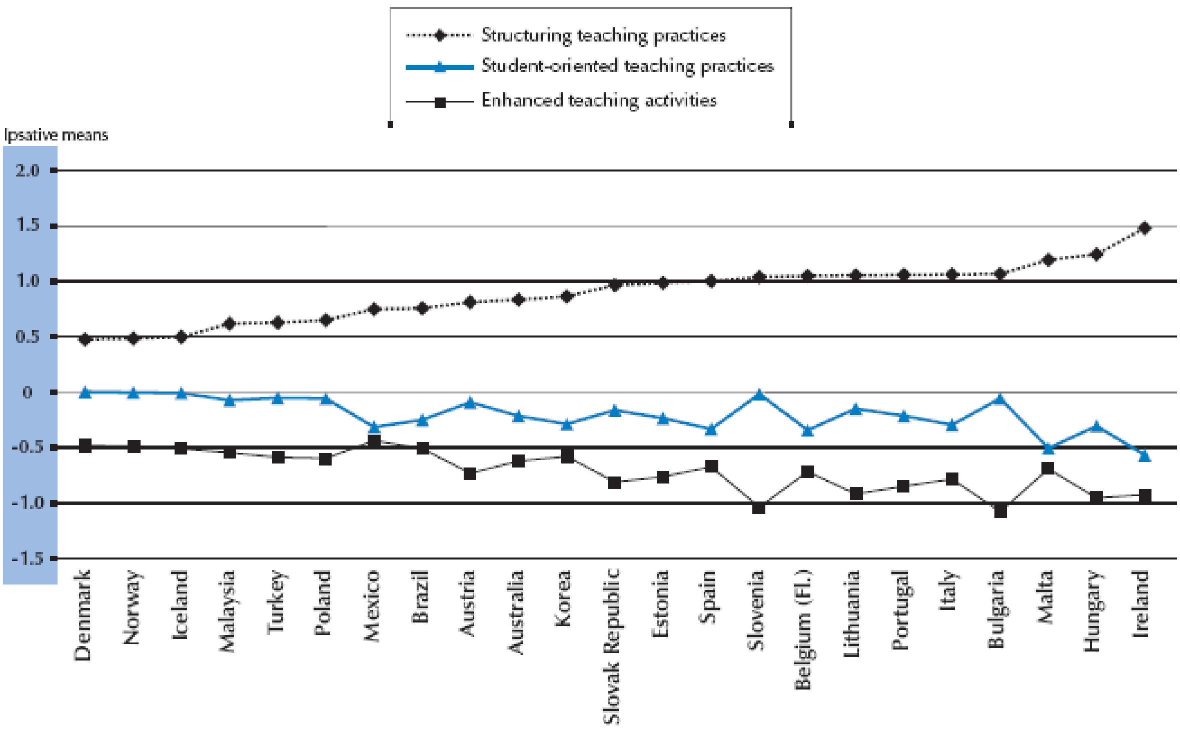
Countries are ranked by the strength of preference among teachers in each country between direct transmission beliefs about teaching and constructivist beliefs about teaching. So, teachers in Iceland show the strongest preference for constructivist beliefs, over direct transmission beliefs.
Source: OECD, *TALIS Database*.

Other interesting TALIS results concern the classroom teaching practice. The teaching practices examined by TALIS have been:
'***structuring practices'*** including summary of earlier lessons, homework review, checking the exercise book, checking students' understanding by questioning students;

'***student oriented practices'***, including students' work in small groups, ability grouping, student self-evaluation, students participation in classroom planning. Lab and hands-on science work are part of these practices;
'***enhanced activities'***, including projects work, writing an essay, debating arguments. Science project work, debates and argumentation are part of these practices.

In Figure 19 the country profile of classroom teaching practice is reported. The structured teaching practices are the most frequently employed in all countries, with special emphasis in Italy, Slovenia and Spain among the kidsINNscience Consortium's countries, while less frequent, in all participating countries with a special emphasis for Slovenia, are the enhanced activities. Slovenia presents a relatively high frequency of students' oriented activities, more than Mexico, Italy, Spain, Brazil, and even Austria. These data are in accordance with the TIMSS and PISA data examined in the previous chapter, and with a larger use of hands on activities in Slovenia and Austria, compared to the Latin countries.

Figure 19. Country profile of classroom teaching practices (2007-2008)
(Source: OECD, TALIS Database)

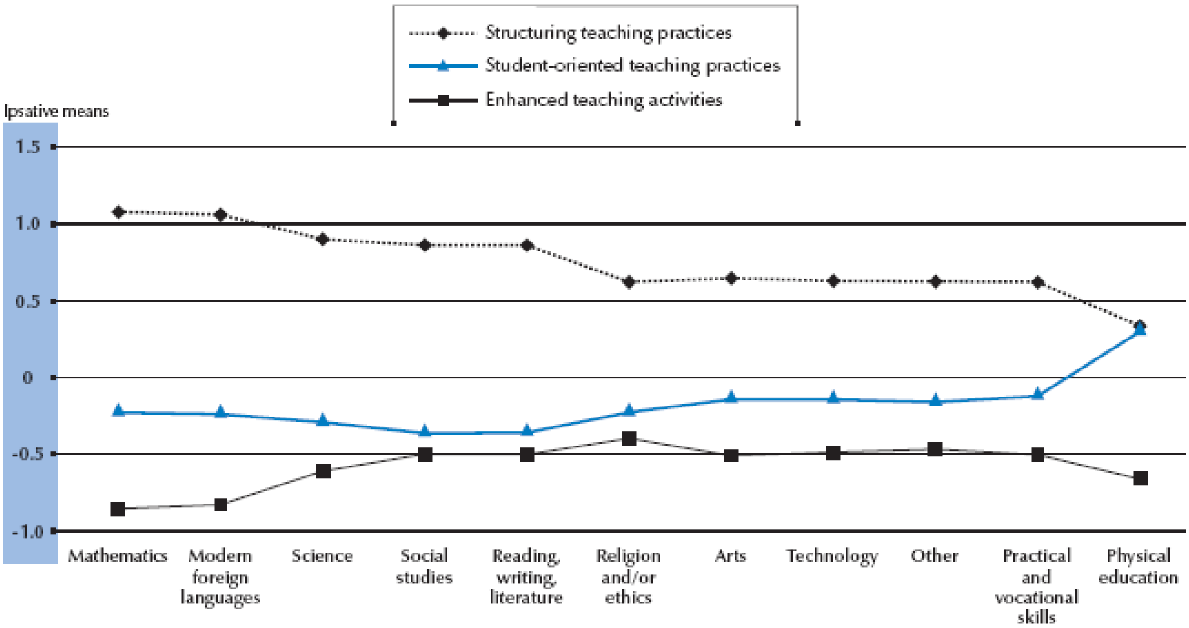


Countries are ranked by the relative frequency with which they engage in structuring teaching practices, student-oriented teaching practices and enhanced activities. So, teachers in Denmark adopt the different practices to a fairly similar degree, while teachers in Ireland use structuring teaching practices much more than they do either student-oriented practices and enhanced activities.
Source: OECD, *TALIS Database*.

Another interesting piece of information coming from TALIS is the 'domain specificity' of instructional practices, exploring how the three dimensions of instructional practices apply for the different school subjects.

In **Figure 20,** the subject profiles of classroom teaching practices are reported. As expected the profile of the teaching practices proved to be domain specific: math and science are among the subjects where structured practices are used more often, while physical education or arts are using more students oriented practices. Teachers of mathematics and science are more likely to share a 'constructivist view' of teaching (TALIS, Table 4.3) but at the same time they strongly believe in the need to structure teaching practices and provide a good classroom disciplinary climate.
The focus on structured practices could be seen as one of the reasons for the scarce interest in science. The main challenge for many of the Innovative Practices collected by kidsINNscience (see Deliverable 3.1.a), and for many of the National Programs trying to improve science teaching described by the national reports, is in fact to increase the number and quality of students oriented practices and enhanced teaching activities maintaining a clear structure and work organisation.

Figure 20. Subject profiles of classroom teaching practices (2007-2008)
(Source: OECD, TALIS Data base.)



Subjects are ranked in descending order of the degree to which the use of different practices differs. Across countries, for example, mathematics teachers use structuring teaching practices much more than they do either student-oriented practices or enhanced activities.
Source: OECD, *TALIS Database.*

As far as specific Science Education initial and in service trainings are concerned, some countries, such as Austria and Italy, stressed the difficulty of teacher training institutes (but also of the University science regular courses) to adopt for themselves an Inquiry Based style of teaching, and to stress the relationship between science and daily life. This results in a difficulty for the young teachers to escape from the transmissive, content based, habits inherited from their own personal education.
Some countries, such as Brazil and mainly the UK, support the science teacher 's professional development offering '*more exciting, intellectually stimulating and relevant science education'* experiences through multidisciplinary activities or the activities of Science Learning Centres.
Another important contribution to the teachers' continuing professional development is given, in many of the Consortium's countries, by the science teacher associations, with their activities , journals and magazines they produce and issue.

5. Main national programs or projects concerning science education in the Consortium's Countries

Every country in the Consortium, also the ones that complained about the national image of science and science teaching, had launched in the past 5-10 years several programmes focused on science education, or on science teachers' training.
The improvement of Science Education in some countries is seen as a consequence of general indirect measures:
in Germany, by the rising the number of full-time schools, on the basis of data proving that *'extra-curricular learning contribute significantly to the achievements in science'*;
in Slovenia, through new strategies for cross-curricular integration, included the planning of '*lessons with blurred boundaries between subjects'*, and the training of 'projects team'

- in Switzerland, a great aim is the harmonisation of the different Cantons' educational systems, and the formulation of national standards, also for maths and science;
- in Germany and Switzerland, the integration of Education for Sustainable Development in the national curricula is seen as a possible gate to improve and update science subjects;
- in the Netherlands and Switzerland, networks of schools supporting each other are another proposed strategy.

Also the new European 2020 benchmarks (the proportion of 15-years olds with insufficient abilities in reading, math and science should be less than 15%) could be seen, if taken seriously and transformed in national programs, as a way to improve Science Education in the European Countries.

The countries' initiatives specific toward sciences described by the Consortium's Partners are planned to face four of the main perceived problems:

1. the improvement of the popular image of science and science learning, through science centres, museums or special days/events or, in Austria, through initiatives oriented to encourage young peoples' innovative ideas;

the revision and updating in terms of competencies of the present science curricula, proposing the implementation of science education program with 'clear identity'(as 21st Century Science in the UK or the programs of Technasium or Universum in the Netherlands), or developing strategies and approaches especially outstanding for the development of 'science competences' (Slovenia and Spain);

2. the need to raise the student interest toward scientific careers and more generally to improve the collaboration between school and research. In this field countries offer programmes that provide visits and stages in universities and research labs (as in Austria, Italy and Spain) and programmes that seek for a deeper and durable collaboration between schools and research institutes (like in Germany and Austria). The large presence of enterprises , companies, private foundations in these programs is a characteristic of some of the countries, such as Austria, Germany and the Netherlands;

to improve teachers professional development through various forms of networking, training courses, peers' development and exchanges, teachers centres. Teachers are recognized in many of the Consortium's countries as the key factor influencing education and several initiatives of teachers' education are proposed in order to involve them not only as 'students' but also as 'innovators and producers' of new educational materials mainly focusing on the IBLT (Brazil, UK, Italy), taking also into account the educational research component needed in educational innovations. A very interesting Brazilian initiative has increased the '*funding for scholarship, classroom projects, research and development*' and provided that '*some research agencies have special lines of funding for project which involves school teachers in their teams'*. This kind of initiatives aimed to fill the gap between school practice and educational research are still very rare and needs to be extended to other countries.

6. Perceived state of Science Educational Research

Science Educational Research was slowly growing in quality and in extension in the past 20 years, but with different pace and characteristics. In general, the large scale surveys as PISA or TIMSS, are carried out by national institutions with special competence in educational statistics, while the educational research institutes within the Universities take care of the research on educational innovation development and implementation.

In the partners' countries several organizations or networks are active in science educational research: in Austria the 'Austrian Educational Competence Centres ', in Brazil the 'Brazilian Association for Research in Science Education' , promoting a biannual meeting with more than 1000 papers presented; in Germany and the Netherlands international well known Centres as the IPN at the Kiel University or the Utrecht University; in Spain twenty Science Education teams are based at the Universities and offer Doctoral programmes; in Switzerland '*master programmes in discipline based educational research*' have recently started, while the UK has several universally well known associations (as ASE) and University teams devoted to science education research. Compared to other fields, however, science education research is still a young discipline, although it is growing in many of the Consortium's countries, in others it has already declined or is beginning to decline. In Italy, science educational researchers are few and not properly academically recognised: few teaching places were given mainly in the '90s, funds were reduced, no master or doctoral programmes and only few scientific journals. The Netherlands announce a diminution of interest 'in spite of their rich tradition'. The scarcity of funding for this line of research starts to affect other countries such as Austria and UK.

The scarcity of recognised journals in the different national languages could also be considered a problem: among the journals considered in the 'social science citation index' (Thomson Reuters, http://science.thomsonreuters.com/) more than ten journals in English are specifically related to Science Education while only one, 'Ensenanza de las ciencias,' is in Spanish and collects articles on science educational research all over Latin Countries. The index does not include Science Education journals in German, Italian or Portuguese, even though in Brazil there are at least 20 science education journals. In effect many Science Education Researchers publish in the English journals – Spanish scholars are the first producers of papers in English, after the English speaking countries – but this does not necessarily improve the image of Science Education Research within their own country.

In general the science education research community presents strong international connections – also thanks to the European associations (as ESERA), and the national, European and International funding programmes. The recognition of the educational research role is, on the contrary, not very good within each country: the role of the science education researchers and of educational research in general is often not duly considered by the national educational authorities and important changes in the curriculum or in the examinations are often made without any involvement of the research community.

7. Main difficulties and challenges for developing and disseminating science educational innovations

Many of the difficulties identified by the national reports are very general and are common to all countries: economic difficulties in the past years had serious effects on school development, teacher training, teachers' salary and working time, but also on the availability of science related jobs, so much so that in some countries many of the young graduate scientists are unemployed.

Other difficulties, with different emphasis from country to country, are general difficulties in the educational world: federal states ask for more harmonization, central states ask for more locally adapted educational systems, schools differentiation – mainly in the upper secondary level –is revealed to be, in many countries, a differentiation based on social background and doesn't guarantee citizenship literacy for all. Equity with respect to the socio-economic status is a well known problem but with few attempts to find a solution, as well as the presence of small or large migrant population. All these factors affect education in general and also science education.

Gender disparities are nowadays another well known challenge, not receiving real recognition and interest by the teachers, not even from female science teachers as far as girls' lack of interest is concerned. Austria reported within the main national projects one project aimed to spark girls' interest for science and technology, and few others exist in different countries, but the issue does not receive adequate attention by the policy makers and by teachers yet (as well as the problem of boys difficulties in reading and writing)

Other common difficulties are more directly related to the present challenges to science education:

one of the more relevant seems to be the difficulty to change deep-rooted **teaching methods**. As the Spanish national report pointed out teachers need to shift "*from traditional lecturing to students' participation ... from non-dialogic approaches to dialogic and interactive approaches'*. Inquiry Based Teaching has not yet become in many countries a shared methodology to teach science, neither at the University nor in the Science Teachers Initial Education. Teaching is still considered a '*stand alone'* profession, and the exchange of experiences and good practices is very limited not only nation wide but often within the same school. To involve teachers in the adaptation and implementation of innovations, and in an international exchange of good practice, as proposed by the kidsINNscience Project seems a good way to face this difficulty;

another common difficulty is the related **teachers initial and continuous education**. Many of the present teachers courses focus more on the individual development than on team work, innovative networks, or research aimed groups within the school (as proposed by the Sinus project quoted in the Rocard Report, European Commission, 2007). Teachers in service courses need to deal with the scarcity of time that teachers have. All countries complain that teachers are 'overloaded': in Europe because the teaching hours correspond to about 50%-60% of their effective working hours, in Latin America because they need to teach for a large amount of hours to obtain a decent salary. Teachers' participation in the development and in the implementation of innovations is to great part a voluntary work;

the science curricula are still 'content based', and in some countries, such as Italy and Spain this lead to an encyclopaedic approach where there is no time for Inquiry Based Learning. The transition to a **competencies based curriculum** is still very slow, and the European and National guidelines have not yet been transformed into good practices. Also '**teachers competencies'** need to be re-defined, and for all grades of schools: better scientific competencies are needed by primary school teachers and better communicative and pedagogical competencies are needed by specialist teachers in secondary schools;

the **gaps between educational research, curriculum policy, and science teachers** implicit theories and practices are still very large: the science educational research is not very strong, either academically or politically, and various policy decisions were only generically following the research results and indications. Projects, such as kidsINNscience, that try to connect the research world with the national educational authorities and the teachers' practice are very important;

the relationship between **curriculum and assessment**, especially for the final examinations is another difficulty, implicit into the national reports: if changes in contents and methodologies are not reflected in the assessment, and if there are no clear national standards defining scientific competencies and the methodologies that can be used for their assessment, it is difficult, if not impossible, to have a real change in science education practices. Vice versa, well oriented assessment guidelines could make a large contribution to deep changes: PISA's and TIMSS's results have in some countries contributed to teachers' methodological changes more than many teachers courses. Of course new standards and assessment methodologies need to be accompanied by a large reflection on the 'quality criteria' inspiring the new evaluation lines, by concrete examples of innovations and by the adequate teacher training. The project kidsINNscience aims to contribute to this line of change.

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ANNEX 1 Guidelines for reporting on National Contexts

Two, three pages of general information about the situation of science teaching and learning in your country.
Possible elements to take into accounts:
National image of science and science teaching, as inferred from national documents
The relevance of science in the core curriculum (average number of hours in different grades; diffusion of science labs at different grades; relevance of Science in final examinations, ...)
Science Teachers education (initial and in service) in different grades, evaluation of teachers work for personnel advancement
Main national (state for federal organisation) **projects** concerning science education and/or science teachers training
Main difficulties for developing and disseminating educational innovations (structural difficulties, social difficulties,...)
Perceived state of **Science Educational Research** (we will ask you after to collect some data on it, but for the moment is enough to present your feelings, or ask to some prominent expert)

ANNEX 2 Countries National Reports

1. **Austria, Nadia Prauhart and Johanna Berzler**
2. **Brazil, Isabel Martins and Luiz Rezende**
3. **Germany, Robert Lorenz**
4. **Italy, Michela Mayer and Eugenio Torracca**
5. **Mexico, Alma Adrianna Gómez Galindo and Mariana Avila Montero**
6. **The Netherlands, Wout Ottevanger**
7. **Slovenia, Tomaz Ogrin**
8. **Spain, Fins Eirexas and María Pilar Jiménez Aleixandre**
9. **Switzerland, Christine Gerloff**
10. **United Kingdom, John Meadows and Chris Horner**

Austria Science Education National Context

National image of science and science teaching

Science and technology play an important role in Austria and are actively promoted and supported by initiatives of the Austrian government. Austria´s investment in research, technology and innovation (RTI) has increased significantly in the last 10 years which can be attributed to an increase in research and development (R&D). Austria´s R&D intensity is at the front of the European Member states (Austrian Research Report, 2010; Austrian Council for Research and Technology Development, 2010). However, the number of students in science and technology must urgently be increased as described below. Therefore a dialogue with the broad population has been started by several science communication initiatives. Activities and initiatives such as the Viennese Science Festival (more than 20.000 visitors in 2010) or open days for families at universities and research centres (open campus) form only a part of a long list of communication projects that receive special governmental financial support to improve the image of science and technology on a national level and to reach people of all ranks. The variety of target group oriented methods reaches from the "science cabaret" Science Busters (www.sciencebusters.at)[5] which fascinates members of all generations or the science slam, a format for scientists to compete in presenting their research to a broad public (http://www.scienceslam.at), to the communication activities of the Austrian Programme of Genome Research, GEN-AU which additionally offers a summer school for young people (http://www.gen-au.at). Despite of the large number of initiatives addressing children, students and the broad public, the Austrian Council for Research and Technology Development identifies structural deficits amongst others in the dialogue between science and society and asks to deal with the challenges in the recruitment of high qualified human resources (Austrian Council for R&T Development, p.5). Between 2002 and 2007, Austria also had to report a decrease of 2,3 % of the annual average growth rate of the number of students in the science and engineering sector in tertiary education, (Eurostat, Table 4.1, p. 54). A change of this trend is also clearly demanded by the Austrian Council for R&T Development, emphasizing that the interest and fun in mathematics and natural sciences has to be sparked in nursery school and primary school (Austrian Council, p. 5).
The Federal Ministry of Science and Research tries to change this trend, e.g. with initiatives such as MINT (http://mint.bmwf.gv.at/content/about.php) aiming to improve the image of science, technology and engineering studies and arguing that between 40 and 50% of the industry face problems in recruiting experts in the fields of technique and production and high qualified persons in R&D. Another initiative, FEM tech (www.femtech.at) focuses on promoting equal opportunities in research and technology for men and women. The programme of the Federal Ministry for Transport, Innovation and Technology (BMVIT) also offers various activities for improving the image of female scientists in S&T. The lack of high qualified persons and the low number of students of S&T studies might be rooted in the low instrumental motivation in science obtained by students aged 15/16 (Schreiner, 2009, p. 52; Schwantner in Specht, 2009, p. 139).

Image of science and science teaching - by students (primary and secondary level)

Instrumental motivation poses an important determinant of later choices in studies and occupation. According to PISA 2006, especially Austrian girls do not ascribe any significance to natural sciences for their later professional lives. *"Apparently, Austria is not managing, whether in coursework or in the home environment, to inform young people of the high importance and opportunities within natural scientific and technological careers"* (Schreiner 2007b, p. 69; in Austrian Research Report, 2010, p. 130). The PISA and TIMSS results show that, Austrian youth interested in science but do not realize that physics, chemistry or biology is applicable for their daily life, nor do they give them any importance for their futures or their job plans (Specht, 2009, p. 139). Looking at Austrian results of TIMSS 2007 and of PISA one realizes that the interest of students in natural sciences gets lost when entering or in lower secondary school. 75 % of primary school students take much pleasure in natural sciences and 79% are self-confident in their competences in sciences (Schreiner, TIMSS 2007).
Nursery school: Since 2009, a frame-curriculum which includes a paragraph for science, maths and technic has to be considered in nursery school.

[5] Two physicians (theoretical and experimental physics), one cabaret artist and one visual artist perform science cabaret.

Elementary school: In the international survey TIMSS 2007, Austrian's 4th grade students results are placed in the average (mathematics 17th place and science 15th place of 36 participating countries). Compared to the survey 1995, the results in both subjects decreased significantly. There was a wide range of achievement and performance differing between schools and gender (Schreiner, TIMSS 2007).
Secondary school: The international survey PISA 2006 shows that Austria with mean scores of 511 points belongs to the high-scoring countries. In most categories and competences e.g. "Identifying scientific issues", "physical systems" or "knowledge of science", Austrian students´ results are at the average. A relative weakness was measured in "using scientific competences", "knowledge about science" and "earth and space systems". Gender-differences occurred in some fields: males performed substantially better than females when answering questions on "physical systems". Furthermore, the student's performance varied between schools and within schools on the science scale (OECD, 2007; Schreiner, 2009). PISA 2009 results show that Austria is located in science and mathematics, statistically significantly below the average of OECDhttp:///. Regarding science performance, there is still a gap between girls and boys, being boys the better, but with 8 points, not significantly better performing group. Each 5th student at the end of compulsory education is allocated to the risk group in natural sciences. (Schwantner, 2010, p. 35 – p. 39). From the trend comparisons, data for Austria have been excluded for the fact that the negative atmosphere in regard to the assessment – caused by a dispute between teachers´ union and the education minister and a teachers´ and students' strike - had affected the conditions and could have had adversely affected student motivation to respond to the PISA tasks. Therefore comparability of the Austrian data of 2009 with data from earlier years cannot be ensured (OECD 2010a, p. 26).

The relevance of science in the core curriculum

Numbers of hours (h) taught in science-education-subjects (there are big differences depending on each school and school-types) per educational phase (school grades 1-4, 5-8/9, 9-12/13[6]).
Primary school: General science education (9h), Mathematics (16h), Technical work (6h)
Regular secondary school: Biology (7 - 12h), Chemistry (1,5 - 4h), Nourishment and Budget (2 – 6h), Geography and Economics (7 - 12h), Geometric drawing (2 – 6h), Mathematics (14 – 20h), Physics (5 – 10h), Technical work (7 – 12h)
Secondary academic school (lower and upper level): Biology (7 - 12h), Chemistry (1,5 - 4h), Nourishment and Budget (2 - 6h), Geography and Economics (7 - 12h), Descriptive geometry (2 - 6h), Mathematics (14 - 20h), Physic (5 - 10h), Technical work (7 - 12h), Informatics (7 - 12h)
VET colleges, VET schools, Pre-vocational and Vocational schools for apprentices: A listing is not possible because the subjects vary depending on the special focus of the school.
Duration of elementary schooling: to the 9th school-grade;
From the 1st to the 9th school grade, a minimum of science hours taught in science subjects is obligatory. For secondary academic school – higher level / school-leaving examinations the compulsory hours in science subjects depend on the school-type. A minimum and maximum of cumulative hours taught per week per educational phase in science subjects are predetermined by the ministry. They are often reduced in non-science-focused-schools in favour of other subjects. By trend the number of science hours taught increases to spark pupils' interest in science professions.

Science Teachers education

Teachers' education is offered in two different institutions at tertiary level. Compulsory general school teachers (primary, secondary general, special and pre-vocational school) are educated at University Colleges of Teacher Education (public and private) which, since 2006 (in the course of the Bologna process), end with a Bachelor of Education (Eurydice, 2010, p. 9). In each of the nine Austrian states, there is at least one University College of Teacher Education. Universities educate teachers for one type of secondary school lower level (Gymnasium) and for all kind of secondary school higher level - the graduation is Magister. A graduation from a university (Magister or Diplom Engineer) is a precondition for being allowed to teach at secondary school upper level. Qualifying examination or teacher examination is not a prerequisite for becoming a teacher. The salaries of S&T teachers differ depending on the school type. Teachers of "Hauptschulen" earn less than teachers of "Gymnasien",

[6] See also Eurydice (2010), p. 2-6.

lower level is less paid than upper level (www.cct-austria.at). The number of S&T teachers especially in technical subjects, maths, physics and chemistry is lower than the demand. In the future, there will be a high demand on S&T teachers to replace e.g. retired teachers. A big lack of qualified teachers is forecasted - according to TALIS, 40% are over 50 years (OECD, 2009).
As mentioned above, Austrian science teachers seem to face difficulties in communicating the importance of scientific literacy and the relevance of knowledge in and about sciences for the students´ individual lives. According to didactic experts this is rooted in the fact that in teacher training the relationship between natural sciences and daily life is not communicated (Stadler et al. in Schreiner, 2009, p. 52). Teachers´ work is not evaluated or monitored by any authority, self evaluation does exist. The next teacher generation is expected to be more open for regular evaluation and monitoring. For almost all science subjects (except technology), didactic centres are founded, which are involved in teacher-students training.

Main national projects – structural programmes (top-down)

Comprehensive schools: In Austria, political parties have been discussing for few years to pool together the two different kinds of secondary school lower level (Hauptschule and Gymnasium) in one type of school (comprehensive school). This discussion emerged because the better results of northern countries like Finland or Norway were attributed to comprehensive schools among other things.
Education standards: Education standards for maths are already implemented and start in 2011/12. For biology education standards are in the developing-process.

Main national project – instructional improvement and in-service training

IMST – Innovations in Mathematics, Science and Technology Teaching aims at improving instruction in mathematics, science, IT and related subjects. The Institute of Instructional and School Development (IUS) of the Alpen-Adria-University Klagenfurt conducts this national large-scale project. The focus is on students' and teachers' learning. Teachers put innovative instructional projects into practice and get support in terms of content, organisation and finances. In order to investigate the impacts of IMST, evaluation and research is integrated on all levels: http://imst3plus.uni-klu.ac.at/english.php

Main national projects – cooperation projects between research and education

Sparkling Science: programme of the Federal Ministry of Science and Research to promote projects in which scientists and young people work side by side in current scientific research projects: www.sparklingscience.at
Generation Innovation: The initiative of the Federal Ministry for Transport, Innovation and Technology (BMVIT) and the Federal Ministry of Education, Arts and Culture developed various activities (of all age groups, from nursery school to the end of upper secondary) to provide the opportunity for children and youngsters to get to know about science, technology, development and innovation. Its aim is to spark interest and to get to know its own potentials in these fields. Enterprises and research institutions benefit by getting into contact with interested young persons.
www.generationinnovation.at
FIT: (Frauen in die Technik) - woman turn to technique: an info-campaign, which informs girls up to the 9th school-level about studies in the field of technology at universities, polytechnic universities and colleges in order to spark their interest: www.fitwien.at
Jugend Innovativ: (Creative youth) is a national competition for students at the age from 15 to 20 aiming to encourage the development of innovative ideas and the development of concrete solutions in the fields of business, design, engineering and science. The programme exists since 1986 and is commissioned and supported by the Federal Ministry of Education, Arts and Culture and the Federal Ministry of Economy, Family and Youth: www.jugendinnovativ.at

Main difficulties

1) In the structure of the educational system in general because of early separation of secondary school types

- gap of quality level and achievements between the two different types of secondary school lower level (Hauptschule, Gymnasium);

- Lower Secondary schools (Hauptschulen) geographically far away from Gymnasien (e.g. on the country side) tend to have a higher educational level than Gymnasien. Close together, a lower level at Hauptschulen is measured (e.g. in town) (Thonhauser, 2007).
- Taking into account the results of PATS in TIMSS 2007 (Martin, 2009) and PISA (OECD, 2009), a gap between primary school and secondary school concerning the "sparking and keeping alive" of the interest in science must be localized.

2) Teacher training and teaching

Coordination of **teacher training** courses between various University Colleges of Teacher Training in the Austrian states and coordination plus cooperation between Universities and University Colleges of Teacher Training in general should be optimized. There is no competence allocation.
In addition, TIMSS (Martin, 2007, p. 263) results show that Austria was amongst the countries where 80% or more of the fourth grade students had teachers who studied primary/elementary education **without a major specialization in mathematics or science**.

- Teachers do not experience the relationship between natural sciences and daily life in their teacher training and therefore they are not able to communicate this most of the time (Stadler, et al. in Schreiner, 2009, p. 52).

Slow **information-transfer** of science research and didactic research to teachers; little use of teacher training to achieve an efficient transfer;

- The University Colleges of Teacher Training decide upon including or cooperating with universities, e.g. with departments or studies of S&T, within the teacher training, or not. They are subordinated to the ministries (Fuchs, 2010).

There **is no money** at universities **for young researchers** at the didactic institutions. Interest would be given, but no salaried posts can be offered. University professors often are overworked and overloaded as the ratio between professors and students is indirect proportional. Many didactic researchers will retire the next years without any replacements. The education will suffer under these circumstances (Fuchs, 2010).

- During the past few months, didactic researchers are more and more represented at experts-commissions at the Federal Ministry of Education, Arts and Culture (Fuchs, 2010).

lack of evaluation and **monitoring** for teachers of all subjects
high workload for teachers

3) Equity is not a main principle of the educational system

<u>Equity</u> - according to the National Education Report (Specht, 2009, p. 33) – is not defined as an explicite aim of policy of education. The results of PISA 2009 show that the relation between the International Socioeconomic Index (ISEI) and the achievements of students has grown (Schwantner, 2010, p. 41).
<u>Migration</u> – the percentage of students with migration background has increased continuously: in total (in the PISA 2009 population) it is around 15%, whereof 10,5% are 2nd- generation migrants (Schwantner, 2010, p. 45).

- Missing initiatives by teachers (and missing support for teachers) to respond to language problems, to realize and to take advantage of cultural diversity as a potential for teaching (Stalder in Schreiner 2009, p. 53).
- There existed initiatives and programmes to support migrant-students in sciences and technics, such as MINA (MigrantInnen in Naturwissenschaften) or PROMISE (Promotion of Migrants in Science Education, FP6) – actually no specific programme or initiative could be localized in Austria.
- <u>Gender differences</u>

Male students´ performances tend to more knowledge and higher competences in science and technic questions; little interest of girls in science and technics is the consequence (Schreiner, 2009, p. 52).

- In terms of instrumental motivation they do not realize a relation between the contents of natural sciences taught in school and their daily life, nor do they see any importance of sciences for their future and job plans, girls even less than boys (Specht, p. 136).

PISA 2009, does not show any significant differences between girls and boys on a general level[7].

[7] As the number of questions is lower than in PISA 2006, it is not possible to do such detailed analysis (Schwantner, 2010, p.39)

Science Educational Research

In Austria, didactic research institutes exist for every science subject (except technics) and are represented at nearly every university in the capitals of the nine Austrian states. Most of the didactic research institutions - except for some subjects - are united attributed to subjects in six different institutions (Biology, Chemistry, Physics, Mathematics, German, Education- and School development) which are called Austrian Educational Competence Centres (AECC). The Austrian didactic-centres do research, develop and inform in the field of teaching and learning and offer further training and further education for teachers. The results contribute to education, teacher training, school development, science associations, education administration and education politics (www.bmukk.gv.at/schulen/schubf/se/aecc.xml). In general, didactic research is still a young and growing discipline in Austria. The AECC for education- and school development in Klagenfurt (IUS) is leading the internationally known programme IMST (http://ius.uni-klu.ac.at/).
At BIFIE (education research, innovation and development of the Austrian school system), another important education research institution, scientists and pedagogues work on several topics such as education-monitoring, quality-development, applied education-science, national education report etc. BIFIE is also responsible for the implementation, interpretation and evaluation of international programmes like PISA, TIMSS, PIRLS etc.
In Austria education is still an input-oriented discipline. According to the international trend, Austria changes towards process- and output-oriented approaches (www.bmukk.gv.at/schulen/schubf/se/Weissbuch_Qualitaetssic10091.xml).
As mentioned in point 2 of "Main difficulties", a main problem is the lack of money to contract young researchers in didactic institutes of universities.

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Brazil Science Education National Context

National image of science and science teaching

Natural scientists have been instrumental in the creation and consolidation of the public structure for R&D in Brazil. Science is considered as important for nation development and scientists are highly regarded by the general public. Surveys carried out by the Ministry of Science and Technology (BRASIL 1987; BRASIL, 2006) reveal that the majority of respondents declare an interest in science, especially in matters related to health, environmental technology. The level of interest is correlated with respondents' years of schooling. Most respondents support an increase in governmental (financial) support to R&D in science and technology. However, very few respondents were able to mention specific scientific discoveries of the name of a Brazilian scientist. The curiosity about science discoveries is proportional to increasing numbers of science sections in daily papers, specialized magazines and TV shows which feature science related topics. In recent years there has been a greater investment in public policies and funding for science popularization, which is conceived under the governmental social inclusion policy. Examples of sponsored activities are itinerant exhibitions and the creation of science centres and museums. Unlike what happens in other subject areas (e.g. History Education), there have been specific policies and programmes for funding Science Education activities and science teacher education courses for about 30 years.

The relevance of science in the core curriculum

Science has featured in school curricula for the last 50 years. Before the 1960, science classes were exclusively offered only at the two last years of education. After the Educational Acts of 1961 and 1971 science was made compulsory for all years of basic education. There was an increase in the number of hours for science and, nowadays, General Science represents approximately 15% of the total number of hours in Primary Education (7-14 YO) whereas the disciplines of Physics, Chemistry and Biology count for around 40% of the total number of hours in Secondary Education (15 to 17 YO). Not all schools have science labs and, in some of those which have one, they are not either fully equipped or properly used. According to National Curriculum Guidelines, alternative conceptions, beliefs and values, and relationships between science and technology should be considered in the development of curricula. Interdisciplinarity and contextualisation should also be principles to guide school work. References to alternative conceptions, STS, inquiry based learning are present in the text which suggests strategies for classroom work. Ethics, consumption, sexuality and sexual orientation, environment and health are cross-curriculum topics.

Science Teacher education

Science teachers are trained at undergraduate level, in universities. Traditionally initial teacher training consisted of three years of disciplines related to the content area (Physics, Chemistry or Biology) followed at one year of disciples related to Education and Teaching Practice. This model was substituted by a more integrated one, where the contact with Education related disciplines stars earlier and there was an increase in teaching practice hours (which count for 300 hours). In all states of the federation, both public and private universities offer initial training courses. There are also graduate studies (diplomas/360 hour and professional masters/540 hour) specifically addressed to science teachers. Both graduate and undergraduate degrees are authorised and systematically evaluated by the Ministry of Education. Over the last 10 years more than 40 new graduate courses in the area of science and mathematics education were approved by the Ministry of Education (CAPES 2010), including academic and Professional Masters and Doctoral programmes. In one decade 2,000 masters and 300 doctors in Science Education were graduated. On the one hand, the increased demand for specialisation by high school and university science teachers was a consequence of the Basic Educational Guidelines Act of 1996, which introduced new requirements for pre-service teacher training. Universities increased the number of teachers with Master and Doctoral degrees and greater emphasis was given to the practice-teaching aspect of training. The content of training courses was also changed by introducing multidisciplinary activities, an aspect with which teachers were not yet familiar.

Main national projects in Science Education

A number of Teacher Education Projects have been sponsored by the Ministry of Education and by the Ministry of Science and Technology. An important development in the 1980 decade was the National Programme for the Advancement of Science (PADCT), which has a specific subprogram for Science Education (SPEC). This initiative was responsible for the qualification (both in Brazil and abroad) of a generation of science educators and research in science education which still active. From 1990 there were several calls for proposals on in service teacher education courses and programmes, which qualified thousands of science teachers in different knowledge areas all over the country (PRO-CIÊNCIAS). Many of them involved teachers in the development of educational materials, informed teachers about and encouraged the integration of contemporary science in school curricula, discussed implications of research results for classroom practice (e.g. use of ICT in teaching, alternative conceptions, STS approaches etc.). In the 2000 decade was an increase in funding for scholarships, classroom projects, research and development which resulted in a number of actions such as: in-service teacher education programmes, scholarships for pre-service teachers, distribution of lap-tops to both teachers and children in state schools (PROUCA), amongst others. Some research agencies have special lines of funding for project which involves school teachers in their teams. An educational object public databases (Portal do Professor) is kept by the Ministry of Education. Similarly, the Brazilian Societies of Physics, Chemistry and Biology keep open access websites containing online educational resources for teachers and students. Other recent initiatives by the Ministry of Education, which have impact on teachers' education and practice, are: (i) the evaluation of textbooks of textbooks (PNLD)by a specialist panel and the involvement of teachers in the choice of textbooks to be bought and distributed in schools and (ii) the scholarships for beginning teachers and for the practising teachers who act as their mentors during teaching practice to develop activities in partnership with university based teacher educators (PIBID)and (iii) research projects which analyse data from national exams and educational censuses and, based on that, design interventions to improve education (Observatório da Educação).

Main difficulties for developing and disseminating educational innovations

The country has faced the historical social debt concerning the eradication of illiteracy. Around 99% of children have now access to Primary Education (which in Brazil goes from 5 to 14 years old). The continental dimensions of the country, and its diversity in both physical and economical geographies, poses great challenges to both planning and implementation of public policies. The number of qualified teachers is still insufficient considering the system's needs and the target to universalize secondary education (15 to 17 years old). Full time education is not a reality for most schools in the country which take students in two, sometimes, three shifts. Teachers' salaries are very low and it is very common for teachers to work in more than on school. Only recently has a minimum wage for teachers been enforced. Besides these problems, other situations also influence teaching in both public and private schools, such as increased violence and overcrowded classrooms. The access to university education is still highly correlated with socio-economic status and, recently, affirmative action policies have been discussed and implemented aimed at increasing numbers of students who are afro-descendents, first nations or who studied in state schools (usually attended by children from low-income families) in universities (e.g. BRASIL 2004).

Perceived state of Science Education Research

In the specific case of Brazil, research in science education first appeared systematically 40 years ago, as a consequence of an overall renovation in the field of science education. This evolution was also related to the political events taking place in the country. The growth of this area of research can be divided into three phases: The first was related to its beginning and early configurations; the second consisted of a process of consolidation of this institution; and the third consists of more recent developments, characterised by a multiplicity of research lines and corresponding challenges to be faced. We see the area as having been characterised initially by the development of research based on alternative conceptions and conceptual changes and, later, by the emergence of different lines of research. Science education research was first developed systematically in Brazil during the late 1960s, and expanded rapidly, especially at universities. However, it was actually an extension of a broader movement of *renovation* in science education that had begun at least a decade earlier, on all levels of education. In the late nineties the Brazilian Association for Research in Science Education was created and since then it has promoted seven biennial meetings. The growth of the science education community in Brazil can be inferred from statistical data concerning attendance to those meetings. For example, there were almost 150 participants at the first meeting (1997), and approximately the same number of papers was presented. In contrast, more than 1,000 papers were submitted to the seventh and most recent meeting (2009). 'Teacher education' and 'teaching/learning processes' are the strands in which most contributions are concentrated. Other strands are 'Science Technology Society', 'Language and Cognition'. History and Philosophy of Science'. The expansion of the area, not only in the number of researchers but also, above all, in the variety of their lines of research, along with the corresponding theoretical and methodological references, has allowed for considerable openness to and cooperation with other educational areas (Villani et al., 2010). There are at least 20 Brazilian science education journals, most of which are open access internet based. The Ministries of Education and of Science and Technology (through CAPES and CNPq) have permanent funding programmes of scholarships and of research programmes, which include international cooperation. There has been regular calls for funded research on topics such as General Science Education, Science Teaching Materials, as well as for Human Sciences and Gender issues. The research community has strong international connections with teachers and schools. Leading Brazilian science education researchers are in editorial and referee boards of journals such as the International Journal of Science Education, Cultural Studies of Science Education, Enseñanza de las Ciencias and Journal of Research in Science Teaching. It has also strong connections with the researchers in Latin American countries.

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Germany Science Education National Context

National image of science and science teaching

Science education and all linked relevant skills are regarded as important. All different state curricula highlight the importance of science teaching although there are considerable differences among the federal states of Germany. There are very general aims regarding science education that are supported by all states, the ways and methods to achieve these aims show significant differences. The general image of science is still very good on a national level and contributes to a positive image of science education/science teaching.

The relevance of science in the core curriculum

Sometimes huge differences between federal states of Germany: from less than 2 hours per week of science education to more than 4 hours per week. Results of education achievement comparisons (national and international, e.g. PISA) show clear interrelations between the number of SE hours and students' performance. Additionally, in some states a "voting out" of some science subjects (an established system in Germany during upper secondary level) is not possible – students from these states then show considerably higher results in achievement tests.

Science Teachers education

Initial teacher training is basically divided into two stages, a course of higher education and practical pedagogic training. A pass in the First Staatsprüfung (first state examination) is the requirement for admission to the preparatory service.
Training for primary school teachers takes 3.5 years at university. For lower secondary teachers, university training lasts 3.5–4.5 years with two further years practical training in school settings. For upper secondary school teachers, training takes 4.5 years at university, then a further 2.5 years practical training in a school setting. Responsibility for teacher training rests with the ministries of education and cultural affairs of the federal states which regulate training through study regulations and examination regulations. Examinations (first and second state examination) are conducted by the state examination authorities or boards of the federal states.
Reform of initial teacher training has been demanded after PISA 2010, especially clear initial criteria and tests for enrolling students in science education.

Main national projects

- In service teacher training – like initial training – is again under the responsibility of the federal states and all ministries of education. The in service teacher training serves to maintain and extend the professional skills of teachers as well as helping teachers to adapt from one federal state to another.
- On national level a project for full-time schools has been initialised that also influences science education. Experiences have shown that extra-curricular learning after regular school lessons contribute significantly to achievements in science learning. Still the number of full-time schools is very low in Germany, the same accounts for the readiness of parents to have their children stay at school for full days.
- Educational report for Germany 2010 (Bildung in Deutschland 2010) from the 16 educational ministries, current developments within the German educational system (with special focus on science education), perspectives for the educational system regarding demographic change
- Education for sustainable development: subject is being intergrated into curriculum and teacher education during the UNESCO decade of ESD (2005-2014)

Main difficulties for developing and disseminating educational innovations

- Federal system: 16 federal states with their own ministries of education and curricula mean a very difficult obstacle for national education innovations, there are no present serious harmonization plans, "education sovereignty" of federal states is unlikely to be given up.
- Large migrant population (only in city states and big cities): general language problems with effects on SE, participation of migrant population in extra-curricular activities (e.g. science

circles) is very low, significant disparity in numbers of students and teachers with migration background (ca. 25% vs. 7%).
- High workload of teachers: high number of pupils/students per teacher in general education, especially in science education.
- Over-aging of teachers: more than 50% of all teachers in Germany are older than 50 years, lack of readiness for change in science education, retiring teachers lead to a present and future lack of qualified science teachers.
- Lower expenses for education: percentage of GDP spent for education is decreasing, although absolute number is rising slightly, compared to international average Germany is spending less for education.

Perceived state of Science Educational Research

- Increased attention on science education since PISA 2000, so called "PISA shock" has lead to more awareness and media coverage of science education and science in general.
- Increased support for research projects regarding education/science education
- Lots of international collaborations among research institutions, strong participation in international projects.

Italy Science Education National Context

National image of science and science teaching

In Italy, science education has never reached the same 'status' recognized in many other countries: as an heritage of the 'idealistic' structure of the Italian educational system, science "*is not considered as an essential part of our culture, not a true form of knowledge but a partial and limited approach to reality*" .

With these words the 'National group for the relevance of Scientific Culture' , set up under the guidance of the former Minister of Education prof. Luigi Berlinguer, and with the support of 4 Ministries (Education, Research, Cultural Heritage, Public Administration), denounced the situation in 2007 and added: '*In Italy the situation of science education is very serious, and its seriousness is not perceived as such by the Country as a whole*".

Some efforts have been done in the last 20 years for achieving a better image of science in the Italian society, with the support of the Italian Ministry of Education and thanks to the involvement of scientific institutions and/or science teachers associations. Some examples are in the following :

- a week for the diffusion of scientific culture is organized every year since 20 years, giving raise to many initiatives carried out by schools, universities, and science research Institutes with the funding of the Ministry of Education,
- science museums have increased in number and quality of their educational offers ,
- since 2003 an International Science Festival is being organized in Genoa by local and scientific authorities and receives a large national and international success,
- various TV programs present scientific issues, although mainly with a naturalistic focus.

Science is slowly becoming more popular, even if is still considered as a subject far away of the every day life and reserved to 'experts'; as a consequence a reduced educational time is devoted to science education and science subjects are considered less relevant than other subjects as Math or Italian Language both by parents and the school management. The social image of science has not improved enough to obtain consistent investments for the enhancement of science teaching. Some attention has been directed to science teaching by the bad results gained in the international surveys (TIMSS and PISA), but efforts are more focused on Math than on Science.

The relevance of science in the core curriculum

In the Italian educational system, there is a large gap between the official recommendations, guidelines and curricula and the concrete everyday practice. Principles such as centrality of the learner, laboratorial/ inquiry based approach, link to everyday life, interdisciplinarity, social aspect of learning , are all taken into account in the official documents but few measures actually have been undertaken to provide the necessary conditions to be enacted.

The general characteristics of the Italian Science curriculum are the following:

Time dedicated to science teaching **is less** than in other countries: **8% of total time in primary school** (73 hours/year on average); **7% of total time in lower secondary school** (69 hours/year, less than 2 periods per week, which is the international minimum in the TIMSS 2007 survey); from **5 to 25 % of total time in upper secondary schools** depending of the school orientation chosen, and where the maximum amount of time, and of compulsory laboratory work, corresponds to basic science courses for vocational or technical orientations.

Science contents as they result from programmes **are more extended** than in other countries**;** even when the programme leaves the teachers the freedom to make choices, they prefer to use the textbooks, that are often adopting an 'encyclopaedic approach', with few references to everyday facts and problems.

The **instructional focus** is traditionally more on contents than on competences, and the teaching style is consequently **mainly transmissive**, as shown by the TALIS survey results (OECD, 2009), with a very limited use (also because there is not enough time) of laboratory work. An exception to this habit are the Italian primary schools where, in general, the teaching style is involving the active participation of pupils and where science could be easily integrated with other subjects.

The **final examinations** (13 grade, 19 years old) seldom involve science and often only as repetition of part of the theoretical subjects, with no evaluation of labs or problem solving competences. The

National Evaluation System has proposed in the last 5 years only written texts on Italian language and Math, so that the only national comparison for science performance are the International ones, as TIMSS and PISA.

This situation, connected with the general lack of interest for science in the Italian society largely justify the results Italy obtained in International comparisons:

- Italian science performance is above the international average at the primary school level (TIMSS 2007 average score in 4th grade: 535);
- the results become worse in lower secondary school, and Italian students are among the worst performers within industrialised countries (TIMSS 2007 average score in 8th grade: 495);
- in the upper secondary schools, the fifteen year old students perform very badly in the PISA survey on natural sciences (PISA 2006 average score: 475; PISA 2009 average score: 486).

Analysing the Italian situation more in detail, one of the main issues to consider is the geographical distribution: the average performance in the regions in the north of Italy are comparable with the upper level countries in TIMSS and PISA while the regions in the south perform very low (INVALSI, 2008 and 2010). The other meaningful difference for the 15 years old students is related to the different type of schools: the Lyceums perform better than technical or vocational schools, scoring around 530 on average, even if they have less science hours for week and often no or few laboratory classes. As a matter of fact, the more important correlation of the performance is with the socio-economic-cultural background that is strongly connected – mainly in the centre and in the south of Italy – with the choice of the Lyceum as upper secondary school.
As far as 'gender differences' are concerned, the international survey shows that in Italy differences seems to be very small and not relevant, as in many other countries (OECD PISA, 2007 and 2010). Deeper investigations (Martini, 2009) show that, as for other countries, this lack of gender difference is more an effect of different criteria in choosing a secondary school orientation: if the difference is calculated between students in the same school a significant gender difference, in favour of males, is found also in the Italian schools.

Science Teachers education

The great majority of Italian teachers are women - from 99% in pre-school, to 96% in primary, 77% in first grade secondary school and 62% in second grade secondary school – the average age of teachers being 50 years old. These figures apply also to science teaching, while in more technological subjects the males percentage increases.
The initial education of **Italian science teachers** depend on the subject and on the school level: **primary school teachers** should, at present**, obtain a 4 years university qualification**, in a course named Primary Education Sciences. The courses cover both contents and methodologies, include science subjects, and provide a large amount of practical training at school. Because up to the year 1990 the only qualification required was an high-school diploma, the large majority of the present teachers have neither a university degree nor any specific science course in their initial preparation.
secondary schools teachers, both in lower secondary and in upper secondary school, are requested of a discipline oriented second level academic degree, where no educational theories or practices are included. In various cases, because of the compulsory composition of the teachers duties – the 'cathedra' - it can occur that **teachers have not even received a complete initial education** in all the subjects they should teach: e.g. at Lyceum physics is taught together with math, and often the teachers who have obtained an advanced degree in math have only an abstract knowledge of physics (2 years course) with no experience in lab work. Natural science teachers at Lyceum should teach Biology, Chemistry and Geologyoften having followed only one or none of these courses in their university education. In lower secondary school a science teacher can be a pharmacist with few courses in math and in science, etc..
Till 2 years ago Italian universities were proposing a **2 years Specialization School for Secondary Education** (SISS) that gave to future teachers a specific training concerning not only all the subjects they could be requested to teach but also the methodological and pedagogical background. In 2009 the last teachers trained by SISS have got their degree and the present law for secondary school

teachers recruitment - expected to start in 2012-13 - provide for a two years second level academic degree, within the disciplinary faculty, with the presence of up to 15% of credits related to teaching and learning theories and practices, plus a year of supervisioned school practice.

As a consequence of this situation, and of the lack of habit to make use of group work and laboratory work, a large majority of science teachers is not prepared to use an inquiry based approach to science teaching: a small percentage (less than 15% in lower secondary, TIMSS data) ask students to work in groups and to perform their own experiments. The use of ICT is often more a 'showcase' than a science oriented functional use. Also in upper secondary school, science teachers could have little or none laboratory background.

In-service training is not compulsory any more (it was like that 10 years ago), the participation in training courses is not acknowledged by advancement of career and often is hindered by the school management because it can interfere with other schools' meeting or initiatives. Italian teachers could ask for 5 days each year for training purposes but principals can deny the permission.
Having in service training and science innovations a very small recognition in the school daily life only very committed teachers and principals will accept to work for scientific educational innovation.

Main national projects

In this difficult context, under the pressure of the 'National group for the relevance of Scientific Culture' on one side, of Science teachers Associations on the other side, and also as a reaction to the Italian low average performances in International Surveys and to the decline of enrolments in science faculties, various national projects for improving science teaching has been launched in the last 10 years. The more important have been:

1. The SET project, proposed and financed by the Ministry of Education between 2000 and 2002 which ended in 2004. About 500 schools have been asked to design science innovative unities (10-20 hours of educational activity)and implement them in the highest possible number of classes; a financial support was assigned to each selected school both for the training and the necessary materials. The subject of the activities had to be chosen from a list of 15 interdisciplinary thematic areas, and the project main requests were: a) an unitarian vision of science and technology; b) a broad view of what an experimental work and a lab work could be; c) the use of ICT tools; d)an interdisciplinary and integrated approach to science teaching.

The ISS plan (Teaching Experimental Science, an action research project aimed at in-service training of teachers and the dissemination of hands-on practices), started in 2006, proposed by the Ministry of Education. Physics, Natural Sciences and Chemistry teachers associations participated in the scientific committee together with the Milan Science Museum and the Naples Science Centre. The unifying concepts and/or points of view for the themes covered were: 'Observation, models and theories', 'Systems and variables, order and organisation', 'Size effects, relation between micro and macro level', 'Interactions, transformations and conservation', 'Evolution and equilibrium', 'Shape and function'. The main topics explored have been 'light and vision', 'transformations', 'earth and universe', 'reading the environment'. The plan is still working with a national coordination – and a national web site – and regional organisations identifying local focal points and coordinating science teachers networks .

2. An important financial resource, coming from the European funding for Objective 1 regions (south Italy regions), have allowed for the launch of a national plan – PON Science – for the improvement of Science Education in southern lower secondary schools, and for the construction of 24 teaching innovative units, mainly based on the products of the ISS plan for science teaching, on the 4 topics nominated above plus 'science history' and 'sustainability' as transversal themes. The units has been experimented in 2009-2010, through an e-learning teachers training course and the material produced will be improved and offered on line to all science teachers in 2011. Ad hoc evaluation texts inspired to PISA and TIMSS surveys have been prepared.

3. The PLS, Scientific Degrees Plan has been launched in 2009 as a follow up of the Scientific Degree Project, active from 2005 to 2009, with the support of the Ministry of Education, University and Research, and in agreement with the Industrial National Federation (Confindustria) and the Conference of Deans of the Science Faculties . The number of schools directly or indirectly concerned by the activities of the project till 2009 was around 3000, with

4000 secondary school teachers and 1800 university researchers or lecturers involved. The PLS project's aims where to enhance the interest of young people for Science and for science careers. The PLS projects involved not only pure sciences – physics, chemistry, biology, astronomy, geology,... - but also mathematic and material science. Within the PLS project, a variety of activities have been offered by universities and research labs: from stages for students in research laboratories to in-service training for teachers, from distance learning to science students competitions. Schools had a small say in the identification of the topics and of the methodologies. The project effects have been correlated with an improvement of inscriptions to the science faculty in the same period (while in the previous years the inscriptions were severely diminishing).

Perceived state of Science Educational Research

Science Educational Research developed in Italy during the late '60-early '70, slowly growing within Science Faculties till the end of the '90 and is at present declining. Research in fact developed in correlation with the broader movement of *renovation* in education that involved all levels of education for 30 years, and this process was interrupted in this new century by educational reforms aimed mainly to financial saving. The slow growing of Science Education Research, and the present decline, are also due to a lack of concern of the broader academic world: many among 'pure' scientists in fact do not consider research in science education serious enough and think that knowing a subject is enough to teach it successfully. On the other side, the recently established Educational Faculties (previously their field of interest was pedagogy and it was unified with philosophy) have not yet developed an interest in science education and experimental research in education. A result of this situation is that in the Italian list of University sectors only one concerns Science Education (namely History and Education of Physics); other sectors, as Mathematics Education, Chemistry Education, or Ecology Education, are included within other more general groups. Only a few Italian universities have a researcher or a professor formally charged to teach science education subjects. No PhD courses are devoted to science education research and the doctorate theses in science education of the last 27 year (the first PhD course started in Italy in 1984) where formally listed as Pedagogical Research or Subject based research, but not as science education research. As a consequence in Italy there are not academic journal devoted to Science Education research, but only journal (very few) for general Education Research, and the journals of the Science Teachers main Associations (Physics, Chemistry, Natural Science, Ecology,...) with a consistent space devoted to science education research. In fact teachers associations continued to be very active, also in the last 10 years, and support and publish research practices: surveys, innovations reports, and action research reports. Italian researchers publish of course on International Journals, and some of them are in international board or group of referees.

Main trends, obstacles and possibilities

The latest PISA data (OECD, 2010) show a small but significant improvement in the performance of Italian students in science: the Italian average score (489) is still under the OECD average (501) as it was in all previous PISA surveys, but with an increase of 14 score points compared to 2003 (fig.1). A larger increase of 17 score points has been obtained in Math. Will these trends continue in the future? The situation at the moment is really ambiguous: the 'educational reforms' approved in the last 8 years had as their main aims to reduce the educational state budget mainly cutting school time both in primary schools – reducing the 'full time classes' – and in secondary schools – diminishing teaching hours, mainly in technical and vocational school, with no correspondent reduction of the contents. At the same time also University and research funds have been significantly reduced. In this situation the better results achieved by Italy in PISA 2009 could become an argument for interrupting the process of reflection and action on science teaching and the update of science teaching styles.

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Mexico Science Education National Context

National image of science

For Mexico the scientific knowledge production is not a priority, in 2006 only 0.4% of Gross Domestic Product was assigned to research. Researchers per residents are about 0.7 out of every thousand economical active residents.

We may say, however, education is considered as a priority in Mexico by the government, who assigned in 1998 the 6.1% of GDP to education, from which the 36.4% was given to elementary school. In 2006 the 5.3% of gross domestic product was assigned to education. From social viewpoint, the education is also observed as a priority for general population, who consider it as the option per excellence to improve life level and socioeconomic status. Now a days in Mexico sons & daughters education is a priority from parents, however, it is considered even more worthy men respect women education; particularly in rural zones, many girls are excluded from junior high school education to have them dedicate to housework.

Curriculum and science education

In Mexico there is a national curriculum based in competences, it points out the achievement levels that are expected to be obtained from students in basic education. The basic education is of compulsory nature, and to a great extent it is assisted in public schools (90%), which are secular and free. Basic education is divided in three levels: Pre-school, from 4 to 6 years old (taken for more than four million boys and girls), elementary from 6 to 12 years old (more than 14 million) and junior high school from 12 to 15 (more than six million). In total, in basic education are assisted more than 23 million of students by one million of professors in 200 thousand schools (Garritz and Chamizo, 2008).

In the pre-school and elementary school levels have three school types: General, native and community, in junior high school there are four categories: General, technique, distance education programs for secondary school and for workers (INEE, 2007) (See annex 1). This gives an idea about the complexity of the Mexican system and the diversity of population it assists on.

In general terms into the pre-school level the science teaching is practically absent, there is an area related with the natural and social environment knowledge, however the pre-school teachers have very few preparation and interest in science education.

Into the elementary school it is found a process of reform, currently two study plans exist together. With the proposal that began in 2009 the Exploration of Nature and Society is worked in the first and second grades (6 to 8 years old) where natural and social sciences are integrated. Since third to sixth grade (8 to 12 years old) the Natural Science subject is introduced, spending 3 hours a week. The natural science teaching is considered as of secondary level giving priority to Spanish and math (6 hours are assigned to Spanish and 5 hours to math weekly) (SEP, 2009).

In secondary level, divided by three years, in the first year, is approached the related to biology knowledge, in the second year, related to Physical and in the third year with Chemistry. There is a series of approved books by the Department of Education which are official books for the students. Some school is provided with labs; however the use of them is limited.

In general terms the experimental science area is considered less important than the language and math areas, which receive more curricula importance and in which the teachers show more interest, particularly in pre-school and elementary school.

By other hand in the results of external evaluation like PISA, Mexico is situated in the "Countries with average performance within expectations". The result of 2009 was better than the result of 2006. Even this improve in the students' performance, the Mexican students are located between levels 1 or 2. This indicates the big challenges for Science education in Mexico.

Science teacher education

Initial training:

Teachers who want to work in basic education have to have a degree in education. The degree is offered by the institutions called "Normal". These institutions are physically and intellectually separate from the universities, which has generated wide controversy over the level of education provided in "Normal" schools. It is generally considered inferior the "Normal" training in comparison to the university training.

Teacher Professional Development:

Regarding the teachers training, since the 2000 there is the called teacher's career whose curricula emphasis into the science subjects, however, different teacher cultures exist on together. On one side, we have the discipline specialist and, by the other side, the teaching specialist (Garritz and Chamizo, 2008).

In Mexico the teaching performance is assessed by questionnaires, with the ones different needs from the teaching system are located: Teachers and students assessments to teaching improvement; authority assessments to take managing decisions, course assignments, promotions, and economic incentives and the governmental assessments to evaluate the teaching quality (Luna and Torquemada, 2008).

Main national projects concerning science education

There are several research groups in science education; some of them work in conceptual change, modeling, teacher training, history of science, gender, and cultural and ethnographic perspectives of science education.

The master and doctoral degrees are not in science education but in educational research or in science. Even there are some consolidates groups of research there are not graduate programs no in science education. Nevertheless there are several programs in innovation.

Main difficulties for developing and disseminating educational innovations

To innovate in science education in Mexico, we affront several problems, the most relevant could be:

- Mexico has a very close and centralized curriculum, especially in primary and secondary school. Even in primary school all students recipe a set of textbooks, one of them of natural science. These books were used for all students and teachers, and also the teachers have equal "Book for teachers". In one side this guarantee to all the school population to have access to books, buy in other side produces a very little space for innovation and very little need to produce innovative materials or practices, the teachers generally "follow the book".
- In Mexico there are not periodic publications for teachers, and were teachers wrote their experiences.
- Fortunately there is a Mexican Association of Science Teachers Education, who celebrates meetings every two years. These meetings provide a place to interchange experience, but there is not a monograph, or proceedings that permit collect the innovations.

Lack of documentation of innovation was a major obstacle in the collection of innovations for the KIS project.

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The Netherlands Science Education National context

National image of science and science teaching

In the Netherlands much importance is attached to science, maths and technology (MST) and the teaching and learning of these as subjects at all levels of education. Science, maths and technology[8] are seen as the cornerstone of knowledge-based economy. The problem is a structural shortage in the MST workforce. This has undoubtedly its origins in the general image of MST subjects as difficult, boring and not necessary for a future career.
The Ministry of Education, Culture and Science has developed several initiatives to counter this image and to address this shortage. One such initiative is the Platform for Science and Technology[9] commissioned by the government, education and business sectors to ensure sufficient availability of people who have a background in scientific or technical education. This approach has been formulated in the Deltaplan[10] Science and Technology, a memorandum on preventing shortages. The aim: to achieve a structural increase of 15 per cent more pupils and students in scientific and technical education and to use existing talent more effectively in businesses and research institutes. The aim is not just to make careers in science more appealing, but also to introduce educational innovations that inspire and challenge young people. The Platform therefore targets schools, universities, businesses, ministries, municipalities, regions and sectors. The objective is to ensure that the future supply of knowledge workers will meet the future demand.

Under the auspices of the Platform a large number of activities are being developed, targeting primary and secondary school education in science and technology. A small numbers of activities are outlined below, the website indicated in the footnote highlights a more extensive array of activities.

Jet-Net, Youth and Technology Network in the Netherlands[11]

Jet-Net is a joint venture between Dutch companies and pre-college schools in the Netherlands. Jet-Net companies help schools enhance the appeal of their science curriculum by using a great variety of activities and also allow students to gain a better understanding of their future career prospects in industry and technology. About 150 schools (30% of the total number of schools) take part in the activities of Jet-Net, as well as 300 MST teachers and 770 employees of science and technology-based companies.

Technasium[12]

Technasium is an education programme with a clear identity. About 60 schools have up to now registered as Technasium. These schools endorse the following five goals:

1. To offer research and design as an examination subject. Pupils in Classes 1 (age 12) and 4 (age 15) can opt for Technasium and take its core subject, Research and Design. The subject is completed by passing a school exam.
2. To collaborate with business communities and higher education institutions. Technasium aims at showing pupils how versatile and interesting science and technology-related studies and professions can be. Co-operation with companies and institutions for higher education is embedded in the Research and Design subject.
3. To educate in a way that is geared towards thinking and doing. Technasium pupils work as a team on tasks that lead to concrete results. This requires an active method of instruction, oriented towards the development of skills and knowledge.
4. To set up a practical workspace. Technasium schools have a special workshop for Research and Design. The workshop is accessible both during and outside class hours.

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[8] Even though it must be said that the technology component in MST is rather limited in terms of focus, at all levels.

[5] http://www.platformbetatechniek.nl/?pid=49&page=About%20Platform%20Beta%20Techniek

[10] Deltaplan is referring to the Deltaworks in the Netherlands erected to keep the Dutch protected from the sea.

[11] Information about Jet-Net - Youth and Technology Network Netherlands. http://www.jet-net.nl/english

[12] http://www.technasium.nl/ORGANISATIE/StichtingTechnasium.aspx

5. To develop a Technasium ethos. A Technasium school develops a clear cultural identity, based upon the modern world of science. Different activities revolving around science and technology can be engineered to make the school a lively environment for the pupils at Technasium.

VTB programme[13]
The VTB programme promotes the development of Science and Technology in Basic Education. Schools are supported (financially, organizationally and content-wise in their attempts to anchor MST into the basic education curriculum. It provides support to teachers in the form of exemplary teaching materials to integrate MST in their lessons. The goal of the VTB programme is to bring children in contact with science and technology and to create a positive attitude among them for science and technology. The ultimate aim of the programme is to help schools develop a learning strand for MST, MST is part of the school curriculum, and the school team actively purchase MST activities.

The Universum Programme
The Universum Programma focuses on integrated school development. Starting point is an increase of 15% in students at secondary schools who opt to enroll in a science-based tertiary education. To that end the programme encouraged schools to develop a strong MST profile. There are currently 183 Universum schools. The programme runs since 2005. The results so far indicate more increase in enrolment in MST subjects in Universum secondary schools than in the regular secondary schools. However, after an initial increase in enrolment in science-based tertiary studies this now seems to be back at the level of the start of the programme.

MST subjects in senior secondary schools
At the end of 2010 a pilot with a small number of schools for the design and implementation for the reform of MST subject in senior secondary has been concluded. The Ministry of Education, Culture and Science are now in the process of deciding on how to proceed with the nation-wide implementation. The pilot concerns new programmes for Physics, Chemistry, and Biology. A new subject called Nature, Life and Technology (NLT) has already been implemented as a optional subject in senior secondary schools. It merges many components of the separate science into a new subject which – evaluation studies show – is appealing to both teachers and students. The common approach in the reformed programmes is that it uses a context-based approach to make both content and didactical approach more appealing. Evaluation shows that this approach makes the lessons more interesting and attractive to students. The aim of the reform that more students would subsequently opt for a science-based study at tertiary level could not be confirmed by the evaluation study.
As part of the curriculum reform at this level there are initiatives to come to more coherence and synergy between the programmes of the separate sciences. Until now this have only been limited successful, with the exception of NLT which is considered to be rather successful in this respect.

Science and technology in the curriculum

Primary education
The Netherlands is not doing very well in terms of emphasis on science and technology in primary education. A mere 30-60 minutes per week for in total 26 weeks per year are devoted to science and technology. These few minutes also include components from social studies, geography and the like. Another problem is that preparation of teachers usually does not have a specific science component. As a result teachers are not very confident in teaching science and technology classes in the primary grades.
Lower secondary education
Science and technology in lower secondary education is offered in a clustered core subject called Man and Nature (Dutch: Mens en Natuur, literally Human and Nature). Schools are free in their

[13] VTB programme: Verbreding Techniek Basisonderwijs (Expanding Technology in Basic Education). http://www.vtbprogramma.nl/?pid=203&page=Over%20Programma%20VTB

organization and allocation of study hours to subjects, total time available being 1040 hours. Schools work towards achieving the science attainment targets.

Senior secondary education

All pupils entering the 4th year (HAVO and VWO) or the 5th year (VWO) have to choose one of the following four subject combinations:

- culture and society;
- economics and society;
- science and health;
- science and technology.

Each group of subjects includes a common component, which occupies 40% to 46% of the curriculum; a specialized component (consisting of subjects relating to the chosen subject combination, e.g. science), occupying 36% to 38% of the curriculum, and an optional component occupying 18% to 21% of the curriculum (pupils are free to choose from the subjects offered by the school, including subjects provided through an arrangement with other schools; the number of optional subjects depends on the study load in the specialized component).

The table below shows the time allocation in the science component in the pre-university stream of senior secondary education. The indicated hours for each subject are the total number of hours available. About half of these hours are contact hours.

VWO subject combinations

Table 5.12 Science and technology (specialised component)

Prior to August 2007		As of 1 August 2007	
mathematics B1&2	760	mathematics B	600
physics 1&2	560	physics	480
chemistry 1&2	520	chemistry	440
project		project	80
TOTAL STUDY LOAD	1840		1600

Table 5.13 Science and health (specialised component)

Prior to August 2007		As of 1 August 2007	
mathematics B1	600	mathematics A or B	520
physics 1	360	biology	480
chemistry 1	400	chemistry	440
biology 1&2	480		
project		project	80
TOTAL STUDY LOAD	1840		1520

Source: Min of Education, Culture and Science (2007). The Education System in the Netherlands.

In the Netherlands the Ministry of Education, Culture and Science prescribed the content of the curriculum in examination programmes for all subjects which are examined centrally. However, the schools determine the pedagogical and didactical approached they wish to employ in the classrooms. Nevertheless, there is a strong push for active and context-based teaching and learning.

Science and technology teacher education

Teachers of science and technology in senior secondary education usually have a subject-based MSc degree supplemented by a one-year post-graduate teacher education programme. Due to the low numbers of students opting for a teaching career in maths, science and technology, a programme has recently been developed for professional staff from the business sector who wish to become a teacher in MST.

Teachers in lower secondary are prepared for teaching at teacher education programmes at higher professional institutions. These have in recent years been upgraded to university status. Teachers at these institutes may opt for a science based teaching qualification.

Primary school teachers are prepared at the same institutes or at a so-called Pedagogical Institute. At this level, teachers are usually prepared as general classroom teachers, although lately science specializations are offered.

Science education research

The Netherlands has a rich tradition of educational research and especially science education research. The Society for Educational Research (VOR), provides among others ethical guidelines for doing research in education, and organizes the annual educational research conference (Educational Research Days). The main institutions for research in education are located at some of the universities in the Netherlands, notably Universities of Utrecht, Leiden en Nijmegen. Results of the studies at these institutions are published in international journals. In spite of the rich tradition of science education research at universities recent trends suggest that universities revert back to what they consider as their core business. Science education in not one of those.

Trends in achievement in science and technology

The recent PISA and TIMSS results show that science students continue to be in the upper positions of the ranking. For science in PISA the Netherlands take position 11 (out of 69 countries). Similar scores exist for the subject of reading skills (position 10) and mathematics (position 11). The trend in ranking in PISA is slightly downwards. The ministry is now developing measures to counteract this somewhat downward trend.

Slovenia Science Education National context

National image of science and science teaching and relevance of science in the core curriculum

Basic education (mainstream) legislation is composed of Pre-school Institutions Act, Basic School Act, Gimnasium Act, Education and training of children, youth and junior adults with special needs, and in a special Act on the Placement of Children With Special Needs.
All acts include regulation for minorities: Italian, Hungarian and Rom. Separately from these acts curriculums regulate a detailed contents of education. The White paper I on education (1995), prepared by experts including teachers, gave orientations in education, adopted by government after public discussion.

As far as useful data for clarifying the National Context are concerned, links to the Structure of the Education System in Slovenia and to Euryidice are added in the bibliography.

Pre-primary education intended for children between the ages of one and five are not compulsory. It is provided by pre-school institutions – kindergartens. The White paper I brought curriculum into pre-school institutions.

Regarding science the contents called Nature is included. In it experimenting is enabled and suggested. Measuring, observing phenomena and living and non-living world are examples of activities. Contents are divided for two gorups: between 1 and 3 years and 4 to 6 years.

Mathematical activities too are included separately, but also used at measuring and such activities. There are some institutionalized and non-institutionalized activities (special workshops organized by some associations and holiday activities) to broaden these contents. At Josef Stefan Institute we are carrying out programmes with science contents for such groups of children.

The length of basic education is nine years and it is compulsory. Pupils must be six years old to enter the first year. The basic school curriculum is divided to three, three-year cycles. Successful completion of basic education enables pupils to proceed to a chosen upper secondary school. Following the completion of basic education, almost all students continue their education at the upper secondary level. At the end of basic education a national tests are carried out, compulsory of national language and math, the third subject each year ordered the Minister of the Ministry of Education and Sport.

The number of pupils in a class is at its maximum of 28 (lower in case of presence of 'Roms' or pupils with special needs). The curriculum is divided into A) Compulsory core curriculum subjects, together with special days, and B) Extended curriculum. During the all 9 years only mathematics has constant 4-5 lessons (45 min.) per week, totally 1318 per 9 years. Other science subjects are only partially included into curriculum.

In the first three-year cycle Environmental education (3 lessons /week, totally 315 lessons per 3 years) could be called the beginning of science teaching. In the second three years period Natural sciences and techniques comes with 3 lessons/week for 4th and 5th class (totally 210 lessons/2 years). Combined with last three years period this subject passes to Natural sciences (6th, 2 lessons and 7th class, 3 lessons/weeek, totally 175 lessons/2 years) and to Techniques and technologies (6th 2 lessons and 7th and 8th 1 lesson per week, totally 140 lessons/3 years). Also geography begins in 6th class and continues up to 9th class with 1 – 2 lessons per week, totally 221,5 lessons/4 years.

Biology, Chemistry and Physics are separately taught in 8th and 9th class, each with 2 lessons/week/class (Biology 1.5 /week in 8th class), reaching each totally 134 lessons/2 years (Biology 116,5). Total number of lessons of all subjects in all 9 years is 7.702. Number of weeks is 35 /school year, in 9th class 32.

There is additional form of activity called Days of learning activities per year in all classes (once per year). Regarding science we have Days for natural sciences with 3 hours/class/year and Days for techniques and technologies (ICT) 3 – 4 hours/class/year.

In Extended curriculum Interest activities (2 hours/week, with parent`s consent) includes also science-like subjects: Experiments in chemistry (70 hours), Chemistry of the Environment (70 hours), Chemistry in life (70 hours), Environmental education I and II., etc. Not every school has all the activities. The activities are defined on the base of the pupils interest. Minimum 10 pupils should be in a group.

Many schools find useful and atractive to visit IJS for a couple of hours to carry out some chemical experimentation not possible in schools. Some also combine it visiting nearby (20 km) IJS Nuclear Training Centre with the school education programme on radioactivity and nuclear technology. Namely, radioactivity was abandoned from curricula. The same as genetics in biology. This were not good decisions in educational policy. Future will show that we should implement both into curricula again.

In compulsory education teachers (and also management staff) are mainly women. Out of total 17.671 professional staff, 15.3356 are women.

Schools are equipped with labs for each of the science subjects. Not all schools have technical lab stuff.

Upper secondary education is provided by vocational, technical and gymnasiums (general education) schools or combined school centres.
For the completion of gymnasium, students must pass the general *matura* examination, which provides general eligibility for higher education. The main objective of gymnasium is the preparation of students for further academic studies.

Matura comprises 5 subjects, 3 compulsory: national and one foreign language and math, and 2 to choose out of science subjects: biology, chemistry, physics or of the other subjects. When science subjects are chosen, 20% of points for that subject is received if the special experimental programme is successfully carried out in the school during the year. Gymnasiums have a lab for each of the science subjects and also technical assistants. Lab lessons are determined as a portion, e.g. 10 /year/ 70 lessons of the subject. At lab work students form groups.

From the school year 2008/2009 on the so called modernized curricula are valid. For the mainstream education schools (gymnasiums) the number of lessons (hours)/ year of each of the biology, chemistry and physics are 210 (compulsory) and additional 105 + 35 when the subject is chosen for matura exams (+ number means time for experimentation).
Mathematics cover 560 hours (together with matura, because math is compulsory on matura)/year and Informatics compulsory 70 hours, if chosen for matura additional 210 hours are allowed.

Science Teachers education

Initial teachers' education is conducted at Universities for all levels (grades) of schools from kindergarten on. Pre-school teachers at the pre-primary level qualify for the traineeship position after obtaining a qualification Bachelor degree for pre-school teachers; Compulsory and upper secondary school teachers qualify for the traineeship position in schools after obtaining the Master degree. The traineeship period of 6-10 months of training in a work placement ends with a Teacher Certification Examination, which finally qualifies them for a permanent position.

Teachers of the first cycle (3 years) of basic education are general teachers (class teachers). Teachers in the second cycle are either general teachers or specialist teachers, while in the third cycle only specialist teachers are allowed to teach. Pre-school and school teachers of general subjects must hold

a relevant diploma (from a faculty of education, faculty of arts, faculty of sports, faculty of mathematics and sciences and others) and the title required by legislation.
In upper secondary education all teachers are specialists in their field. Depending on the institution and subject, vocational and technical school teachers are required to complete either: 1) an appropriate academic or professionally oriented Bachelor or Master degree programme or; 2) the highest possible qualification in their own vocational field and pedagogical course of 60 ECTS. A minimum of 3 years of work experience is often required.

Ministry of Education and Sport each year calls for applications for programmes, workshops, expert meetings and other forms of additional education for professional school stuff of all school levels. The main applicants are the National Institute of Education, the Institute of the Republic of Slovenia for Vocational Education and Training, Universities, Research institutes and other. Courses are evaluated with different number of marks (points) regarding volume and time. Some courses are without marks. Teachers need these points to achieve advancement as an expert (also higher salary). There are four official titles for the teacher; the highest is the teacher-councillor.

Very valuable programme for teachers and with the tight collaboration with teachers is carried out by the National Education Institute in science disciplines known as Study days or workshops several times in a school year at different locations near or at the schools. Teachers prepare the theme out of problems to be solved or for the advancement of the discipline. IJS participated in some of these sessions.

Main national projects

After the White paper on education I (1995) the Ministry of Education and Sport is conducting and coordinating many experts` activities to give the White paper on Education II (2011) in March this year to public discussion. The group of experts (teachers included) will review the current situation and draft the development plan for the future. Their tasks include an overview and analysis of the current situation in education, and identification of trends and policies in the EU, especially in the priority areas. Science education and science teachers training will be included. No draft was available to date for public use.

Current greatest project important for science education is European funded “"Development of Science Competences" carried out by the Faculty of Natural Sciences and Mathematics from the University of Maribor. **The aim of the project**: To develop teaching strategies and approaches particularly in the areas of science behaviour with a significant impact on society of the future. Participants in the project will develop strategies, methods and techniques that will ensure the successful conduction of scientific knowledge into school knowledge and take care of the promotion of science. **Estimated results of the project**: elements of new science didactics, didactic materials / models, ready for a certain scientific discipline and quarterly period specified by the school vertical examination of the materials / models in school workshops for teacher training practitioners' participation of experts at international conferences promotion projects for the popularisation of science among young people.

In 2010, the National Education Institute presented its successful implementation of the new strategies for cross-curricular integration which include planning and amending the time-table and organisation and conduct of lessons with blurred boundaries between subjects. The new strategies facilitate the development of environmental awareness, inter-cultural and civic competencies, linguistic and critical literacy, media literacy, IT competencies, etc. Following pilot projects in a few gymnasiums, project teams were trained in most gymnasiums so that two years later these models became a permanent practice which is now being introduced in basic, technical and vocational schools.

The National Education Institute is working on modernisation of curriculum processes for basic education schools and gymnasiums.

Main difficulties for developing and disseminating educational innovations

A first difficulty is the lack of financing. There are many ideas and programmes among teachers and other experts which could not be realised because the Ministry of Education and Sport and The Government are not enough aware of the importance of investing in young people to achieve the society of knowledge, innovation and better well-being. For example: The Ministry was able to find in this crisis-year big money for sports (stadium, organizing international sports games, etc.), but find no funds for promotion of science activities or for a programme of pupils and students investigation projects in cooperation with University and science research institutions.

The second difficulty is that teachers are constantly overloaded and the whole system works with much of teachers additional, not paid volunteer work. In the near past (2008) strikes were almost at the door.

The third difficulty is that the Ministry of Higher Education, Science and Technology do not collaborate with the Ministry of Education and Sport in the sense to facilitate science research institutions and universities to establish firm long lasting programmes for children, pupils and students. They see only research at the science institutes and universities.

Perceived state of Science Educational Research

University faculties for education in science disciplines constantly carry out research work in science education as their professors are also mentors to students for M.Sc. and Ph.D. degrees. Results are published in national and international expert journals.

Still more is important that each of the science school disciplines has some journal (periodic and popular) monthly or quarterly intended to be read by children, pupils, students and also teachers. There are journals and/or magazines with tradition as Chemistry in School, Physics in School, Proteus (nature, biology, geo, and other science), Presek (maths, physics) and others.

In regular yearly basic research expert meetings of science disciplines there is always education included, for example Chemistry days in September each year. IJS with school activities also several times contributed there.

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http://www.eurydice.si/images/stories/Diagram_Tatjana_Plevnik__1564.pdf Structure of the Education System in Slovenia (in colours)

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http://kompetence.uni-mb.si/index_en.html project "Development of Science Competences"

http://www.zrss.si/default_ang.asp the National Education Institute page

http://www.mvzt.gov.si/en/ Ministry of High Education, Science and Technology where information on some other projects could be found

http://www.mss.gov.si/en/ Ministry of Education and Sport for information of the education system and parts of it

Spain Science Education National Context

Institutional framework:

Spain is organized in 17 Autonomous Communities whit full educational competences. The Ministry of Education has the responsibility for establishing the National Curricula for all educational levels. Autonomous Communities can then develop their own curricula, aligned with these general guidelines and organize primary and secondary education, and teacher training. Five Autonomous Communities (Basque Country, Catalonia, Valencia, Balearic Islands, and Galicia) have a second co-official language alongside Spanish.
Schooling is compulsory for children aged between 6 and 16: Primary Education (6-12); Compulsory Secondary Education (12-16); Baccalaureate or Vocational training (16-18).
The salary of teachers is uniform across all Spain, and is of a medium range compared with other EU countries.

National image of science

The social image of science and the perception of the role of science in Spanish society is not devoid of problems. The authors of this report (together with other scientists and science educators) consider that in Spain science is not valued as a cultural resource. This perception may be connected to a decrease of students' interest and enrolment in scientific subjects.

The relevance of science in the core Curriculum

Primary school: At this stage, all science subjects are taught integrated within one area "*Conocimiento del Medio Natural, Social y Cultural*" (Knowledge about natural, social and cultural environment), covering not only science, but also social science. Its teaching hours are 175 for the first four years and 140 for the last two years of primary.
Compulsory Secondary Education (ESO) or **Lower Secondary:** Science subjects are compulsory for all students in the first three grades and optional in the fourth. In the first two grades science subjects are taught integrated (Natural Sciences) with a timetable of 4 and 3 hours/week. The Natural Sciences subject comprises contents of Physics, Chemistry, Biology and Geology. There is a progressive differentiation of scientific contents: In the third year, science disciplines are integrated in two compulsory subjects: Physics & Chemistry, on the one hand and Biology & Geology on the other, with a timetable of 2 hours/week each. In the fourth year, science subjects are optional and they are taught integrated in two subjects, Physics & Chemistry and Biology & Geology, with 3 hours/week each. Therefore the third year is the last when science is compulsory for all students.

Baccalaureate or **Upper Secondary** (16-18 years): There are three itineraries of specialization: 1) Arts; 2) Science and Technology; 3) Humanities and Social Sciences. There is only one compulsory science subject for all students enrolling in Baccalaureate: Science for the Contemporary World in the 1st year, with 3 hours/week. Other science subjects may be studied or not, depending a) on the students' choice of itinerary, and b) on students choices within the Science and Technology itinerary.

Science Teacher Education

Initial training: The basic guidelines for the Primary School Teaching degree are established by the Ministry of Education. Then, universities can organize their own curricula. Until 2009, Primary Teacher Education was a 3 years degree. Beginning in 2009, new Primary Teachers Certificate is a 4 years degree. Of the 240 ECTS in this new certificate only 15 credits correspond to Science Education and 20 to Mathematics Education. A period practicum in schools is also included in this initial training stage.
Secondary Education Teachers are required to hold a four year degree, in the relevant subject matter (Biology, Physics, etc.) at the university, before entering the Master degree for Secondary Education. From its 60 ECTS, eight are related to science, its nature and methods, and 18 to Science Education.
Teacher Professional Development: The organization of Teacher Professional Development is not centralized, being the responsibility of the Educational Department in each Autonomous Community. There is a wide range of programs and courses in the different Autonomous Communities and nationwide, both targeted to science teachers or to all teachers within particular science strands.

Main national projects concerning science education

There are many strategies, policies and programmes both from the Ministry of Education and the Autonomous Communities to promote science education. Two examples of nationwide strategies are: 1a) Improvement of Science Teaching and 1b) Scientific Culture and Innovation Program. Two instances of programs are: 2a) Scientific Research Council in Schools and 2b) Scientific Routes.

1a. "Improvement of Science Teaching" Strategy

Aims:

- To promote student-centred and inquiry-based approaches.
- To monitor students' development of scientific competences.
- To bridge existing gaps among educational research, policy and science teachers.
- To promote students' enrolment in scientific in scientific careers/options, both for girls and boys.
- To spread science vulgarisation and to improve the social image of science.
- To promote scientific literacy and interest in scientific culture

These aims relate on the one hand to decrease of students' enrolment in science subjects, and on the other hand to problem identified as hindering implementation of innovative practices.

The Ministry of Education and Education departments of the Autonomous Communities are responsible for it; its time frame is 2010-2012 and it addresses both Primary and Secondary Education.

1b. FECYT Scientific Culture and Innovation Program

FECYT (Spanish Foundation for Science and Technology) is a public foundation of the Ministry of Science and Innovation launched to promote social integration of scientific and technological knowledge; to involve Spanish citizenship in science, technology and innovation; and to incorporate science and technology vulgarisation and communication to the regular practices of researchers.

Aims of the program: To support projects oriented to promote and develop scientific vocations among school students

The Ministry of Science and Innovation through FECYT is responsible for it. Its time frame is 2010-2011 and it addresses both Primary and Secondary Education.

2a. Program "El CSIC en la Escuela" (Scientific Research Council in Schools)

CSIC depends from the Ministry of Science and Innovation.

The program constitutes a Partnership among the CSIC, the BBVA Foundation, established by the bank of the same name, and schools all over Spain different Autonomous Communities.

3b. Program "Rutas Científicas" (Scientific Routes Program)

Ministry of Education, in collaboration with Autonomous Communities with the partnership of research centres, laboratories, museums, etc.

Program Description: The students of science subjects from Upper Secondary and Vocational training travel to visit and participate in short internships during one week in laboratories, research centres, natural parks or science museums.

Main difficulties for developing and dissemination educational innovations

The Educational Authorities identify six problem areas for implementing innovative practices in science education, both in Primary and Secondary School and in Teacher Education:

– *Curriculum:* The curriculum is too long and extensive, and the science hours have been reduced a 30 % since 1970, without a corresponding reduction in core content.

– *Teacher education*: There are deficits in teacher education, both in initial and in Teacher Continuing Professional Development. Teachers' Centres offer courses that are sometimes dispersed, rather than according to a plan. There is a need for a shift in emphasis from stand-alone courses, to a focus in schools and groups of teachers. There are difficulties for translating the courses contents to the classroom.

– *Competences-based curricula*: A current challenge is the need for developing both curricula and Teacher Continuing Professional Development based in the competences and to connect scientific competence with communicative competence.

– *Teaching methods*: There is a need for transforming teaching methods, from traditional lecturing to students' participation through activities, learning tasks and projects. This change would entail a shift from non-dialogic approaches to dialogic and interactive approaches. Textbooks should be a resource, but not necessarily the most important or the single one.

– *Gaps*: It is considered that there are not enough connections among educational research, curriculum policy, as reflected in Steering Documents, and science teachers.
– *Science image* (discussed above).

Perceived state of Science Educational Research

Science Education research community was born in Spain around 1983 when the journal *Enseñanza de las Ciencias* was launched. This research journal, now in the Social Sciences Citation Index, since 2009, is widely read in all Latin America, Portugal and some European countries, besides Spain, and has over 3000 subscriptors. It organizes an international conference each four years. There is a second widely read journal, *Alambique*, more targeted to teachers. From the 70 Spanish Universities, around 20 have Science Education research teams of different sizes, and offer Doctoral Programs in Science Education. Spanish scholars are the first producers of papers in English, after the four English-speaking countries, in the four SSCI journals included in the JCR, according to bibliometric studies published in IJSE. About 60 science education Spanish researchers publish in these four Science Education JCR journals (Science Education; JRST; IJSE and RISE). The research community has stronger connections with teachers and schools that in other countries. It has also strong connections with the researchers in Latin American countries.

Switzerland Science Education National Context

National image of science and science teaching

Science education/Scientific literacy is regarded as important: In 2008, the time allocated to maths and science classes at grammar schools (all tracks) has been increased after it had been decreased in 1995. Simultaneously, the final marks of the single scientific disciplines have increased in importance for graduating from grammar school and attaining access to university again.
Recent results underpin the importance of improving maths and science teaching: 25% of graduates from grammar schools failed in maths (even 40% failed the final written exams but some could compensate this with the mark for the entire school year). This is a problem considering that graduation from grammar school gives access to all university studies. (EVAMARII, 2008)
Salaries after graduating from universities for teacher education are higher than from universities of applied sciences and from universities (S&T).

The relevance of science in the core curriculum

Absolute number of hours of maths taught during compulsory schooling 1^{st}-9^{th} grade: 1200-1500.
Primary level: 17% of lessons are maths (German-speaking part; similar to Austria, Germany, and France with 16-18%). Natural and social sciences: 20% and 18-21%, respectively; there is no possibility to differentiate between natural and social sciences.
Lower Secondary: 15% maths (14-15% in neighbouring countries), natural and social science 26% (22-26%).
Upper Secondary (grammar schools): 25-35% of lessons are maths and science.

Science Teachers education

For ca. 10 years, teacher education for all levels has been at tertiary level (7% of all graduates from grammar or generally educating schools enrol at a university for teacher education). Teachers at upper secondary level need a Master degree in their respective subject before taking subsequent didactical classes.
There has been a lack of S&T and maths teachers (except specialization biology) at lower and upper secondary level in the last decade. In the future, there will be a high demand of newly recruited teachers (each year 6% of all teachers at compulsory schools) to replace e.g. retiring teachers or teachers changing profession. A lack of qualified teachers is forecasted (all subjects).

Main national projects concerning science education

Education policy priorities (implicitly affecting sc. ed.):
HarmoS: harmonisation of the Cantons' educational systems through common objectives for compulsory schooling in all language regions (Lehrplan 21, Plan d'études romand): national standards at the end of 2^{nd}, 6^{th}, and 9^{th} grade have been formulated, among them maths and science. When the first comparative test will take place is open. In addition, structural differences such as age when entering pre-school, start of foreign language classes, and duration of compulsory schooling are unified. Up to now, 15 cantons from the German, French and Italian speaking region joined this consortium, 7 cantons rejected (status Sept. 26, 2010).

- Education for a sustainable development (ESD): subject will be integrated in curriculum and teacher education during the UNESCO decade of ESD (2005-2014).
- Lisbon strategy: increase the fraction of students attaining a certificate at Upper secondary level to 95% by 2015 (presently 90%) → improving interface Lower secondary – vocational training (Nahtstelle)
- EU benchmarks (2003): decrease the fraction of low achievers in PISA reading skills to 14% by 2015 (CH: significant decrease from 20.4% in 2000 to 16.8% in 2009).
- Initiative for ICT, in cooperation with enterprises
- Quality management: more responsibility for individual schools e.g. in resource allocation, external evaluation offices. School networks for support of teaching and school development are supported.

1st Swiss educational report (2010): monitoring of the educational system through compilation of contexts and available data → basis for educational policies

Main difficulties for developing and disseminating educational innovations

Federalist educational system: 26 Cantons built up and manage their own ed. system (different structures and curricula result in large differences in yearly hours taught), the people has the right to vote on educational issues → current status of HarmoS, s. above.
Multilingual country: 4 national languages and cultural regions: German, French, Italian, Romanic (in decreasing frequency) -> a locally adapted educational system (including contents) is considered as crucial.
Upper Secondary level very varied: 30% of the students graduate from grammar or other general schools. 70% take up vocational training (majority in a dual system with part time training on the job in an enterprise and part time schooling at vocational schools, "apprenticeship"). During or after vocational training, there is the possibility of a Professional Baccalaureate that gives access to universities of applied sciences.
Large migrant population: A fifth of the population is Non-Swiss, of which 85% originate from European countries and 20% are born in Switzerland. The latter category is well integrated in the schooling system. In contrast, 1st generation immigrant pupils and students are achieving far less at school and vocational training (PISA 2000/2006; data corrected for socio-economic status). However, the deficit in reading skills from immigrant students decreased significantly from 2000 to 2009 – the measures to enhance reading skills seem to have a positive effect esp. on these pupils and students (PISA 2009).
Low equity with respect to socio-economic status: students' performance in maths and language skills correlate with their parents' socio-economic status (several national and international studies (e.g. PISA)). So does their probability of attending a high level lower secondary school and university.
Highly heterogeneous classes with respect to ethnic and social background and therefore heterogeneous competencies pose major didactical, methodological, and social challenges. E.g., in the city of Zurich, the pupils and students with German as maternal language have been outnumbered by those with a different maternal language (49.8% vs. 50.2%, data from 2008).
Gender disparities:

- PISA studies: female students had better reading skills, but male students were better in maths and in science (Switzerland is among the six countries with male students being significantly better in science, more exactly in explaining scientific phenomena; female students were better at recognizing the question asked).
- European comparisons: career choices are still strongly gender biased, esp. in S&T. Fraction of female Ph.D. students is low (37%).

High workload of Swiss teachers in international comparison, multiple reforms of the educational system lately → in general, little engagement for testing and implementing innovations.
High input costs for innovations and the educational system in general in international comparisons (e.g. salaries, infrastructure, federalist system, multiple languages).
Lack of qualified science teachers in the past and in the future.
Lack of data on quality and effectiveness of the Swiss educational system, the few regional or national comparative test results are confidential and not accessible.
Lack of pilot schools that would try out innovations on a regular basis.

Perceived state of Science Educational Research

The science education research community in Switzerland is small and heterogeneous. While there are individual collaborations with research institutions abroad, there is little national collaboration (challenges see above). With the founding of the universities for teacher education about 10 years ago, science education research focussing on classroom and teacher education has increased. Master programmes in Discipline based education research have only recently started.
(Regula Kyburz-Graber, professor for general didactics, science ed. researcher, UZH, pers. comm.)

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In addition, four interviews with high school teachers and science education researchers were conducted.

United Kingdom Science Education National Context

Current financial climate

The English Education system is facing a crisis due to the global credit/banking slump, with a spending review of all Government funded services due in October 2010. Although Education is expected to be cut in all areas, the STEM (Science, Technology, Engineering and Maths) subjects are expected to be less severely cut than other areas such as the Humanities subjects.

A recent report on Science teaching in England: 27 July 2010

On July 7, the Royal Society released the State of the Nation report, which found that the majority of England's primary schools do not have the science specialist teachers needed to provide a high quality science education. Specifically, the report encouraged a recruitment drive for specialist science and mathematics teachers in order to triple the number of specialists. The report looks specifically at the structure and function of science and mathematics education for five to 14-year-olds and highlights some serious areas of concern, including an over-emphasis on 'teaching to the test.' Instead, the Society recommends an emphasis on practical work in order to increase engagement and understanding amongst pupils.(http://royalsociety.org/State-of-the-Nation-Science-and-Mathematics-Education-5-14/) However, data from TIMSS suggests that English pupils already spend a lot of time on practical science activities but do not necessarily relate the science they cover in lessons to their daily lives.

Raising the academic profile of newly qualified teachers

Initial Teacher training in science can be done through postgraduate training courses in universities or through School centred training courses (a quick search of the TDA website showed 54 such courses). Growing concerns about the **quality of teaching**, fuelled by doubts over the calibre of teachers hired to fill vacancies (especially in the secondary sector, and in relation to science, mathematics and other hard-to fill subjects) have led to calls to raise the GCSE entry requirements for teacher training from a grade C to a grade B in English and mathematics (and, for primary teachers, science), and to raise the minimum qualifications for entry into a PGCE to a 2.2 (Williams 2008; Gove 2009; Politeia 2009) or even, eventually, to 'an upper second or above'(House of Commons 2010).

Professional development for Science Educators

Science Learning Centres are a national network for professional development in science teaching. Their aim is to improve science teaching and to inspire pupils by providing them with a more exciting, intellectually stimulating and relevant science education, enabling them to gain the knowledge and the understanding they need - both as the citizens and as the scientists of the future. There are nine regional Centres in England and one National Centre, each with a number of satellite Centres to provide additional facilities. The National Science Learning Centre is run by the White Rose Consortium. Details of the organisations running the regional Centres can be found in the FAQ section.

TIMSS 2007 data

Some data on English science scores from the TIMSS 2007 survey shows that English pupils, both boys and girls, do perform well in grades 4 and 8, although there are some differences when compared to PISA results where girls perform less well that boys.

Grade 4 science (year 5)

- England's score, 542, was one of the highest, and is statistically significantly higher than the TIMSS scale average of 500.
- In summary, England's performance in science at year 5 remains amongst the best in the world.

Grade 8 science (year 9)

- England's score for grade 8 science, 542, was again one of the highest.
- Countries outperformed by England included the Russian Federation, the United States, Italy, Sweden, Scotland and Australia.

Gender and Science
• England was one of only seven of the 26 countries which tested both grades to show no overall gender differences in mathematics or science at either grade. Japan, Chinese Taipei and Hong Kong, all high scoring Asian Pacific Rim countries, also shared this pattern.
• In grade 4 science girls outscored boys on life science while the reverse was true for earth science. Girls also outscored boys on items addressing reasoning.
• In grade 8 science boys outperformed girls in physics and earth science. Boys also outscored girls on items assessing knowing and applying, but not reasoning.
In grade 4 and grade 8science there were no changes over time by gender, matching the overall lack of change over this period.
The overall gender differences in favour of boys found in the 2006 PISA assessment of scientific literacy in 15 year olds were not found in TIMSS, possibly because of differences in focus between the two assessments.

Attitudes to science
Grade 4 science (year 5)
• Fifty-nine per cent of pupils had highly positive attitudes to science, fewer than in countries scoring at a higher level than England or at a similar level. The percentage of pupils with highly positive attitudes has fallen by 13 percentage points since the last comparable data, in 1995.

Self confidence in science
Grade 4 science
Fifty-five per cent of pupils had a high level of self-confidence in learning science. This was comparable to, or higher than, other high scoring countries.
• Significantly more boys than girls showed a high level of confidence in learning science, although there were no differences in attainment.

Grade 8 science (year 9)
Comparisons with other countries in this section are with countries with integrated science data: that is, pupils were asked about science rather than separately about physics, chemistry or biology.
• Fifty-five per cent of pupils had highly positive attitudes to science. This is within the range shown by other high scoring countries.
• The percentage of pupils with highly positive attitudes has fallen by 21 percentage points since the last comparable data, in 1999.

Significantly more boys than girls showed a high level of confidence in learning science at grade 8, as they did at grade 4, although there were no differences in attainment.

Science Resources
Schools in England are well-resourced at both grade 4 and grade 8 compared with the international average, with almost all pupils taught at schools that are resourced at a high or medium level. This applies to both science and mathematics resources.
England's grade 8 science pupils are more likely to spend their lesson time doing practical science activities than many of their international counterparts. However, pupils in England do not necessarily relate the science they cover in lessons to their daily lives.

Conclusion
In conclusion, the Coalition government of the UK is attempting to cut money from many educational institutions, but most science technology and engineering subjects are being protected, since the current government recognises the importance of science and associated subjects for the future prosperity of the country.