




REPORT

Inspire: Motivating Students for Maths, Science & Technology using Learning Resources

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Foreword

Marc Durando, Executive Director of European Schoolnet

Since 2007, Ministries of Education have seen Maths, Science and Technology (MST) as one of the major thematic domains in which European Schoolnet (EUN) should play a role at European level. More than 15 different projects are currently running in the MST area, including awareness-raising campaigns in schools in specific subjects, policy studies, and validation projects. In order to pay this important field of MST its due respect and to further develop this research area, the Policy and Innovation Committee organised a special meeting in November 2009 devoted to MST. A draft for a European action plan on Maths, Science and Technology is also under preparation.











A further project connected to MST was the Learning Resource Exchange (LRE), which was launched by EUN at the end of 2008. This activity has been monitored through the LRE Working Group and more work is foreseen in 2010 to improve the quality of LRE resources, including the new eQNet project funded by the Commission's Lifelong Learning programme. The main aim for 2010 is to provide all teachers in Europe with an LRE service that will not only allow them to access digital resources from different Ministries of Education but also to participate in a variety of communities and learning events.

At the 2008 Eminent conference, Luigi Berlinguer, Chair of the Inter-ministerial Working Group for Scientific Culture Dissemination and Italian Minister of Education from 1996 to 2000, portrayed MST as a complex area to teach in modern schools. Maths, Science and Technology is a classical domain of theories, laws and experiments in which the synthesis of theory and practice is achieved. As such, it is a highly complicated area to teach in schools. One challenge is that teaching MST is not seen as an attractive, appealing and digestible domain for pupils and students. In Professor Berlinguer's words, *"The way of teaching MST is the first reason for the declining number of young people committed to this field. MST are learnt as a necessity, as something pupils must know. This is not what science is about, science is amazing and should arouse curiosity. In this sense, the use of ICT can help a lot. It is a method for experimenting new pedagogies that brings together experiments and theory. But most of all, we need a proper policy for MST: we don't have a policy in Italy and we don't have a proper one in Europe. Promoting innovation is also the real answer to the dramatic economic crisis of these days; therefore the dissemination of scientific culture should be one of the major current concerns"* [1]. According to Prof. Berlinguer, this challenge cannot be tackled by teachers alone. Ministries on a local and European level have to take the necessary measures to make MST teaching more inclusive and appealing - past systems can no longer give the right answers.

The Inspire project has been conducted and completed in line with the steps necessary to make MST more attractive among young people in Europe. This successful project has taken into account the fact that the driving forces of changes in MST education are teachers and it is of key importance to provide them with new tools and new approaches. In this sense, Inspire aimed at promoting the use of digital learning resources (also known as Learning Resources, or LR) in MST education but without forgetting the importance of testing and validating new ideas, methods and technologies to ensure the targets are met. And lastly, one should never forget to share and mainstream good results, which is the aim of the present report.

[1] Professor Berlinguer, Podcast recorded at EMINENT - Berlinguer, L., (2008, Dec. 5), EMINENT 2008 podcast. Podcast retrieved from <http://eminent2008.eun.org/podcasts/eminent2008/blog/episode3.mp3>

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INTRODUCTION

The Lisbon Declaration of March 2000 (Lisbon 2000) brought into the spotlight the need to increase the number of students going for careers in Maths, Science and Technology (Durando, Wastiau & Joyce 2009). Additional studies have highlighted the lack of interest of students in MST and ICT, especially among women (Sjøberg & Schreiner, 2008; Gras-Velázquez, Joyce & Debry, 2009), and the need to correct this situation and increase the numbers of MST graduates if Europe is to avoid the reduction of human resources in MST having an impact in the labour market in the near future (ERT, 2009). More precisely, one of the five EU benchmarks for 2010 is an *Increase of at least 15% in the number of tertiary graduates in Mathematics, Science and Technology (MST), with a simultaneous decrease in the gender imbalance* (Commission of the European Communities, 2008).

Among the reasons behind the lack of interest in MST subjects, Pollen (2009) found the lack of motivation from teachers themselves, while Gras-Velázquez, Joyce & Debry (2009) noted the still existing stereotyped thinking of parents and teachers towards science and technology careers especially concerning women. The unattractiveness or inadequacy of the curricula (Lipsett 2008, Ripoll Mira, Gras-Martí & Gras-Velázquez 2010) could also be influencing this rejection of MST.

Osborne and Dillon 2008 and Rocard 2007, among others, suggest that developing and extending the ways in which science is taught is essential for improving student engagement and that a reversal of school science-teaching pedagogy from mainly deductive to inquiry-based, 'hands-on' and other innovative methods is necessary if we are to increase interest in science (Kearney, Gras-Velázquez & Joyce, 2009).

One of the possible ways of bringing interactive technologies into the classrooms which will engage the students more and might make them more interested in MST classes is using learning resources. Learning resources (LR), digital (usually web-based) resources that can be used and re-used to support learning (Bratina, Hayes, & Blumsack, 2002), are believed to increase students' motivation in Maths, Science and Technology (MST) by providing them with visual and usually interactive representations of the topics discussed. Because of this belief more and more Ministries of Education and content providers are encouraging the use of resources in classes. A few examples are KlasCement, the educational portal of the Flemish Community in Belgium; the partnerships between content providers like SIVCO and the Romanian Ministry of Education; or the Learning Resource Exchange for Schools repository for Europe in general, covering virtually every curriculum subject and including resources created by Ministries of Education and other public bodies, as well as resources developed by teachers themselves (LRE 2009).

Although the LR benefits are widely assumed or even accepted, little research exists on actual proof of an increase in interest from students and teachers specifically as a direct result of the use of LR in class (Kay & Knaack 2008) and there are even a number of academics who warn about their generalized use as "problems of education are always more complex than technology alone can solve" (Parrish, 2004). A number of studies have started to compare the educational effects of using learning resources instead of or alongside traditional laboratories/teaching, e.g. Jaakkola, Nurmi & Ahokas (2005), or the effects of the resources in specific subjects/age-groups, e.g. Kay & Knaack (2008), but widespread research is still missing.

To contribute to the research on the effects of using learning resources in classes, the Inspire (Innovative Science Pedagogy in Research and Education) project set up a validation observatory where 62 schools in Europe tested and analysed the use of LR in the field of MST over a defined period of time. Through this experimentation, special attention was given to the impact of these LR at the level of pupils and their motivation, the analysis of the pre-requisites to be defined for enabling the teachers to integrate them in their pedagogy and the critical success factors to be mastered at the level of the teacher and the school for the generalization of such practices.

1. The Inspire project

The aim of the Inspire (Innovative Science Pedagogy in Research and Education) project was to experiment new teaching methods in the field of maths, science and technology (MST), to challenge the lack of interest of students in starting scientific studies and more widely to extend the supply of scientific specialists and to develop a scientific culture in European countries.

The project was carried out as a collaboration between the Bundesministerium für Unterricht, Kunst und Kultur (BMUKK, Austria), Educonsult (Belgium), Švietimo informacinių technologijų centras (ITC, Lithuania) and the Thüringer Institut für Lehrerfortbildung, Lehrplanentwicklung und Medien (ThILLM, Germany), coordinated by European Schoolnet (EUN, Belgium) and run under the European Commission's Lifelong Learning Programme within the context of the Lisbon agenda, supporting its strategic objectives:

- ▶ Improving the quality and effectiveness of education and training systems in Europe:

This includes improving education and training for teachers and trainers, developing skills for the knowledge society, ensuring access to Information and Communication Technologies (ICT) for everyone, and increasing recruitment to scientific and technical studies.

- ▶ Facilitating access of all to education and training systems:

This means open learning environments, making learning more attractive, and supporting active citizenship, equal opportunities and social cohesion.

- ▶ Opening up education and training systems to the wider world:

This includes strengthening the links with working life and research, and society at large, developing the spirit of enterprise, improving foreign language learning, increasing mobility and exchange, and strengthening European co-operation.

In line with these principles, Inspire wanted to test and analyse the use of digital learning resources designed for MST education in class. Over a period of ten months Inspire:

- ▶ Observed the impact of the LR on pupils and on their motivation.
- ▶ Analysed the pre-requisites to be defined for enabling teachers to integrate these new techniques in their pedagogy.
- ▶ Identified the critical success factors to be mastered at the level of the teacher and the school for the generalization of such practices.

This was done using a limited validation observatory of 62 pilot schools in Austria (23), Germany (19), Lithuania (10), Italy (5) and Spain (5). Altogether over 3400 students and almost 200 teachers took part in the testing and analysing of the LR. While students were surveyed before and after the pilot tests to measure the LR's impact on their motivation, teachers provided input on the characteristics and formats LR must have for their integration in the normal class lessons. Aspects like languages, LR technical formats, students' ages, genders, subjects and other issues were taken into account in the analysis.

All the data obtained was analysed and published in the project deliverables Kirsch & Beernaert (2009a) and Kirsch & Beernaert (2009b). The main results from these reports, as well as information obtained during the Inspire summer school and in one-to-one interviews with teachers, are discussed in the present report.

2. The protocol of experimentation

The experimentation consisted of three aspects:

1. A clear communication set-up between the different stakeholders and localized web pages.
2. A set of questionnaires to be filled in at the different stages of the Inspire activities: preparation, implementation, follow-up and monitoring, evaluation, documenting the activities, dissemination or valorisation;
3. A well defined selection of learning resources to be used for the testing in all five countries.

2.1 The communication plan and websites

To make sure communication ran fluidly both from top to bottom (i.e. the information from the coordinating body reached the teachers and students) and bottom to top (i.e. any problems / data from the schools reached European Schoolnet), a clear information chain was set up. As seen in Figure 1, each school had a School coordinator in charge of the teachers participating in the project of that school, the pilot schools were supervised by National Coordinators and the project partners were in charge of the National Coordinators.

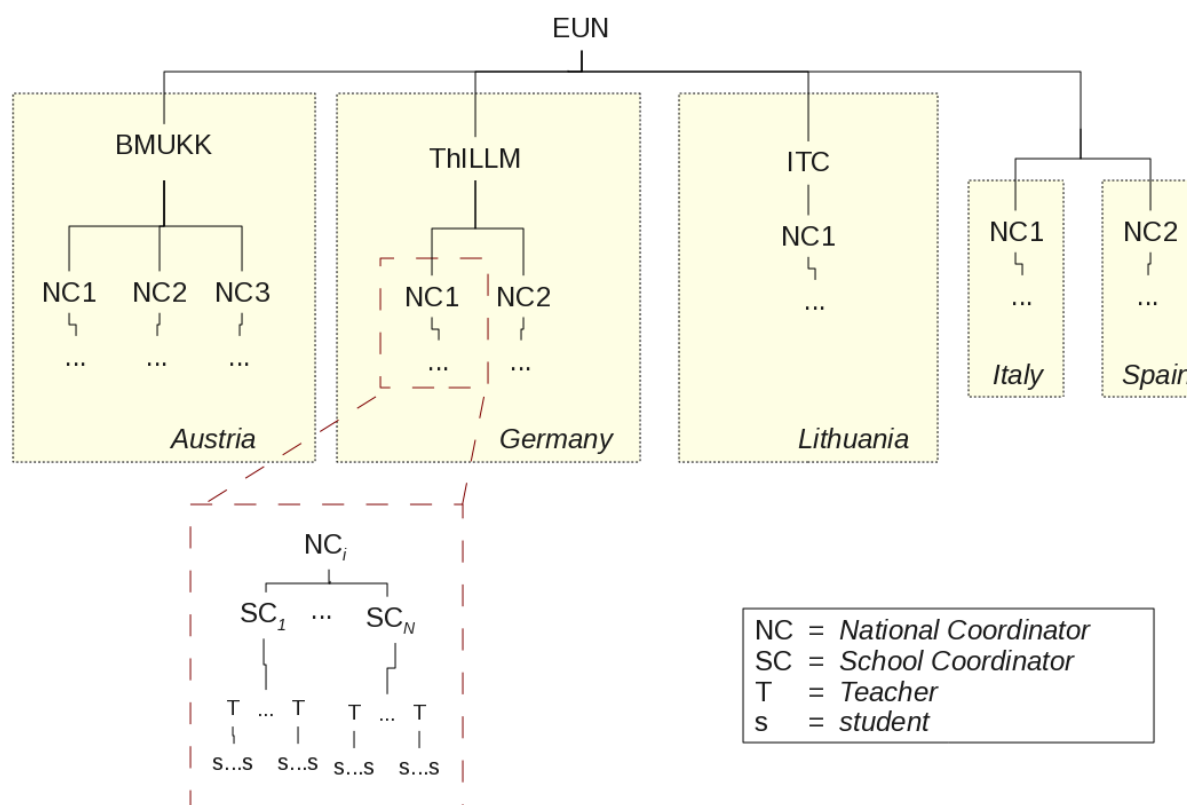


Figure 1: Inspire project communication set-up from the Project coordinator to the students

As the teachers from the pilot schools came from five different linguistic backgrounds, it was necessary to provide them with all the information in their native languages (Gras-Velázquez & Joyce, 2008a). All the information on the project, questionnaires and learning resources pages were therefore made available for

the teachers in six interconnected MediaWiki [2] installations, one per language of the teachers, plus English. In Table 1 the URLs of the 6 websites are found.

Table 1: Languages of the MediaWiki installations for the Inspire project and their URLs

Language	URL
English	http://inspire.eun.org
Catalan	http://ca.inspire.eun.org
German	http://de.inspire.eun.org
Italian	http://it.inspire.eun.org
Lithuanian	http://lt.inspire.eun.org
Spanish	http://es.inspire.eun.org

While the websites not in English acted as local versions of the Inspire portal specifically targeted for the teachers of the pilot schools, the English version constituted the main dissemination channel for the project, with a broader target audience than the project's teachers (Gras-Velázquez & Joyce, 2008b).

2.2 The Inspire questionnaires

Twenty-six questionnaires were designed to be filled in by the different actors: the National Coordinators, the school coordinator, the MST teachers and the students (Gras-Velázquez, Joyce & Beernaert, 2008). They were all available both as downloadable PDFs and either Google forms or spreadsheets, depending on the format of the questionnaire.

The questionnaires provided information on: 1. The school's characteristics and policies; 2. The teachers' views and uses of the Inspire LR and ICT in general; 3. The impact of the use of LR on the pupils; and 4. The organization of the piloting. More specifically, a form on the use of each LR had to be filled in by the teachers before and after using it, and both teachers and pupils were asked to fill in questionnaires on the expected impact or interest in MST before the use of the Inspire LR and the actual impact and interest once they were used.

The list of the questionnaires can be found in Annex 1.

2.3 The learning resources

To be able to compare the effect of using LR in science classes on the interest of students in MST across five different countries, it was important to have all schools use the same resources. To allow at the same time some freedom for teachers to choose the LR that best fitted their curricula and personal teaching style, there had to be a few resources per subject to choose from. Sixty resources were selected according to three main criteria. The selected LR had to be scientifically correct; appropriate for students aged between 5 and 21, and "travel well", i.e. be usable by teachers with different curricula and languages (Gras-Velázquez, A. & Joyce, A. 2008c). Twelve resources were selected per subject and categorized under: Physics, Chemistry, Biology, Mathematics and Informatics (IT). The topics covered by the resources, their authors and the languages in which the LR were available can be found in Annex 2. Each of these Inspire resources was assigned a number to make it easily identifiable. This number started by a letter representing the subject for which it was most appropriate: Physics (P), Chemistry (C), Biology (B), Maths (M) and Technology/Informatics (T).

[2] MediaWiki is a free software wiki package originally written for Wikipedia.

For each LR, a page with basic information was designed and translated into the five languages in which the teachers would be working: German, Lithuanian, Italian, Catalan and Spanish. Each resource's information page contained five sections:

- a) Overview: this section explained in a few sentences the aim of the resource and how it worked. This text was available in all 5 languages plus English.
- b) Suggestions: the suggestions were intended to give the teachers some ideas for their lesson plans. While some teachers prefer to be completely free to use the resources in their classes as they decide, others prefer guidelines which these suggestions aimed to supply. This text was also available in all five languages plus English.
- c) Learning object available in: this section contained the links to the resource in English plus any additional languages of the pilot schools in which it was available. As seen in Table 2, all 60 resources were available in English (en), while some were also available in Catalan (ca), German (de), Spanish (es) and Italian (it). None was available in Lithuanian (lt).

Table 2: Number of resources available in each language per subject

	en	ca	de	es	it	lt
Physics	12	3	2	5	2	0
Chemistry	12	0	1	1	1	0
Biology	12	0	1	1	1	0
Mathematics	12	2	3	4	3	0
IT	12	0	0	0	0	0
Total	60	5	7	11	7	0

- d) Terms you need to know: embedded in the learning resources there are usually some words, or even sentences, which one must know to be able to use them. As the LR were not available in all the languages, it was important to provide a translation of the basic vocabulary for the teachers. A further aim was to encourage the teachers and students to learn basic scientific terms in English, which are necessary to know as one progresses in Science education.
- e) Additional information: this provided the teachers with basic information on the type and format of the Learning Resource. It also indicated whether the resource could be downloaded and/or modified for personal use, while providing the link to the full terms of use of the resource.

Figure 2 gives an example of one of the resources of the Inspire selection, and Table 3 shows the terms one needs to understand to be able to use it and their translation into Lithuanian, as provided in the Lithuanian version of the resource's information page. The basic information pages of all the LR can be found either in Inspire (2007) or (Gras-Velázquez & Joyce, 2008d).

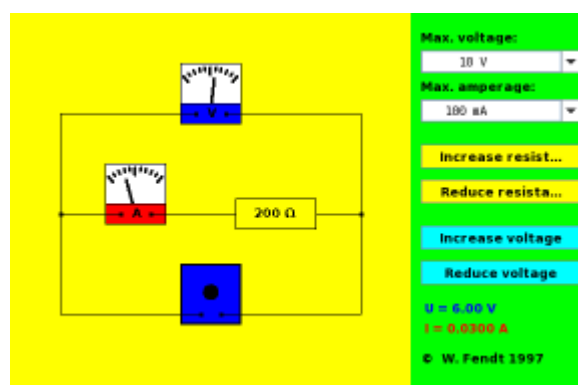


Figure 2: Inspire Learning Resource P1-13-5

Table 3: Terms one needs to understand to use Learning Resource P1-13-5 and their translation into Lithuanian

Terms in English	Terms in Lithuanian
Max. voltage	Maksimali įtampa
Max. amperage	Maksimalus srovės stipris
Increase resistance	Didinti varžą
Reduce resistance	Mažinti varžą
Increase voltage	Didinti įtampą
Reduce voltage	Mažinti įtampą

3. Overall results

3.1 The schools, teachers and students

Sixty-two schools in Austria (23), Germany (19), Lithuania (10), Italy (5) and Spain (5) participated in the Inspire testing between October 2008 and July 2009. The pilot schools had the following characteristics:

- ▶ 74% of them were Secondary schools (13 – 21 years old), 11% Primary schools (6 – 12 years old), 11% Vocational schools and 3% Pre-educational schools (3 – 6 years old).
- ▶ 72% were particularly interested in ICT, having a specific strategy to promote ICT in as many subjects as possible.
- ▶ Especially Lithuanian and Austrian schools had a lot of expertise as far as ICT is concerned while Spanish schools were fairly inexperienced. Nevertheless, all Spanish teachers involved in the project had experience in ICT, even if their schools did not.

And as regards the respondents:

- ▶ A total of 220 teachers filled in the questionnaires before the use of the LR, while 190 teachers completed the piloting (see Figure 3). The drop-out in participation among teachers was due in general to difficulties in the use of the LR in classes, language issues and mismatch of experience and resources available.
- ▶ As shown in Figure 4, a total of 4049 students filled in the initial questionnaire on their interest in MST (2059 were male students and 1990 female students), while 3411 students responded to the questionnaire on the impact of the LR on the MST lessons and interest after the tests (1742 male and 1669 female students). In addition to the students who filled in the questionnaires, 180 Italian primary students provided input on the tests through structured interviews, as they were too young to fill in the questionnaires by themselves. Finally, in Lithuania only between 5 and 12

students filled in the questionnaires per class, to represent the whole class. As the average size of their classes was 20 students, between 360 and 700 Lithuanian students attended the classes where the Inspire resources were used. The additional Italian and Lithuanian students bring the number of European students who participated in the Inspire project up to around 4500.

- ▶ The students who filled in the questionnaires were equally distributed between the ages of 5 and 18+, when the Italian students, but not the non-questioned Lithuanian ones, are included in the sample.
- ▶ The majority of pupils worked on their own (40%), and 33% in pairs and 12% in large groups. The remaining pupils worked partially in each of the previous distributions.

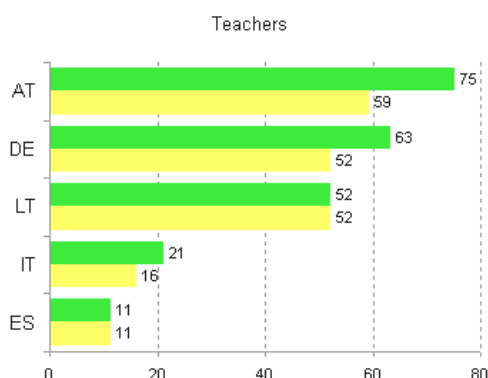


Figure 3: Number of questionnaires filled in by the teachers before (green) and after (yellow) the use of the LR per country.

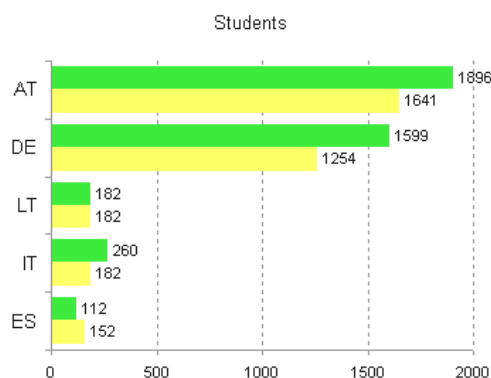


Figure 4: Number of questionnaires filled in by the students before (green) and after (yellow) the use of the LR per country.

3.2 Assessment of the learning resources

The 60 LR were used 904 times. The use of the LR per subject was practically equally split. All the LR from the Inspire selection were assessed and used at least ten times by the Lithuanian teachers. As the Lithuanian teachers did not select the LR to use by themselves, but were assigned to them, their selection criteria were not taken into account when analysing the data. The average time spent using a resource per class was between one and two hours, depending on the subject.

The main criterion for selecting a resource to use in class in all five subjects was that it illustrated a topic of the curriculum. As seen in Figure 5, the fact that the topic was part of the normal curriculum was a criterion used an average of 79% times.

This criterion was followed by:

- ▶ The resource took into account the ICT expertise of the teachers (76%) and pupils (75%); and:
- ▶ It clearly combined MST with ICT (71%).

Criteria such as a clear description of the resource (14%) or whether it had been used by another teacher (9%) were rarely used. Although we did not provide information on who had used the resources before, each resource basic information page had an associated discussion page where teachers were invited to comment on how they had used the resource, to upload lesson plans, etc. Although teachers from Germany, Austria and Spain shared their opinions and materials through the discussion pages, it would appear that other teachers did not use these opinions to be a basis on which to select whether to use a resource or not.

It is interesting to note that while three out of four Austrian and German teachers consciously looked for resources which had an inquiry-based approach, only half of the Italian and Lithuanian teachers used this criterion to select the resources. According to the results, all 11 teachers from the Spanish pilot schools needed the inquiry-based approach criterion met when selecting the resources.

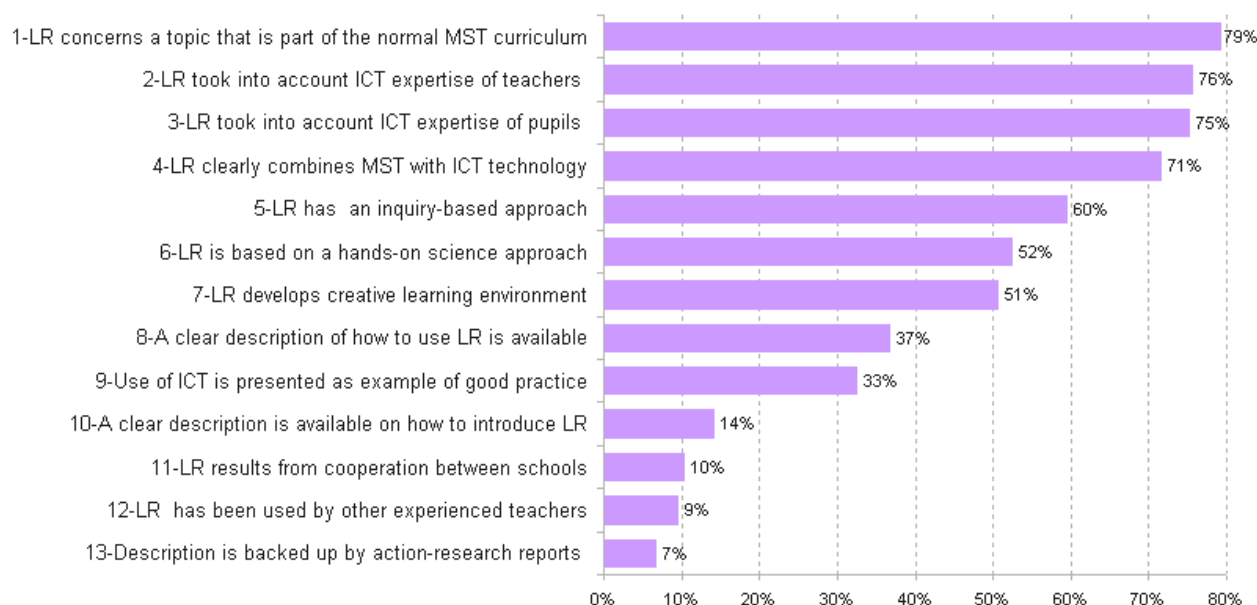


Figure 5: Selection criteria for the learning resources

The selection criteria did not differ significantly according to subject, as can be seen in Figure 6.

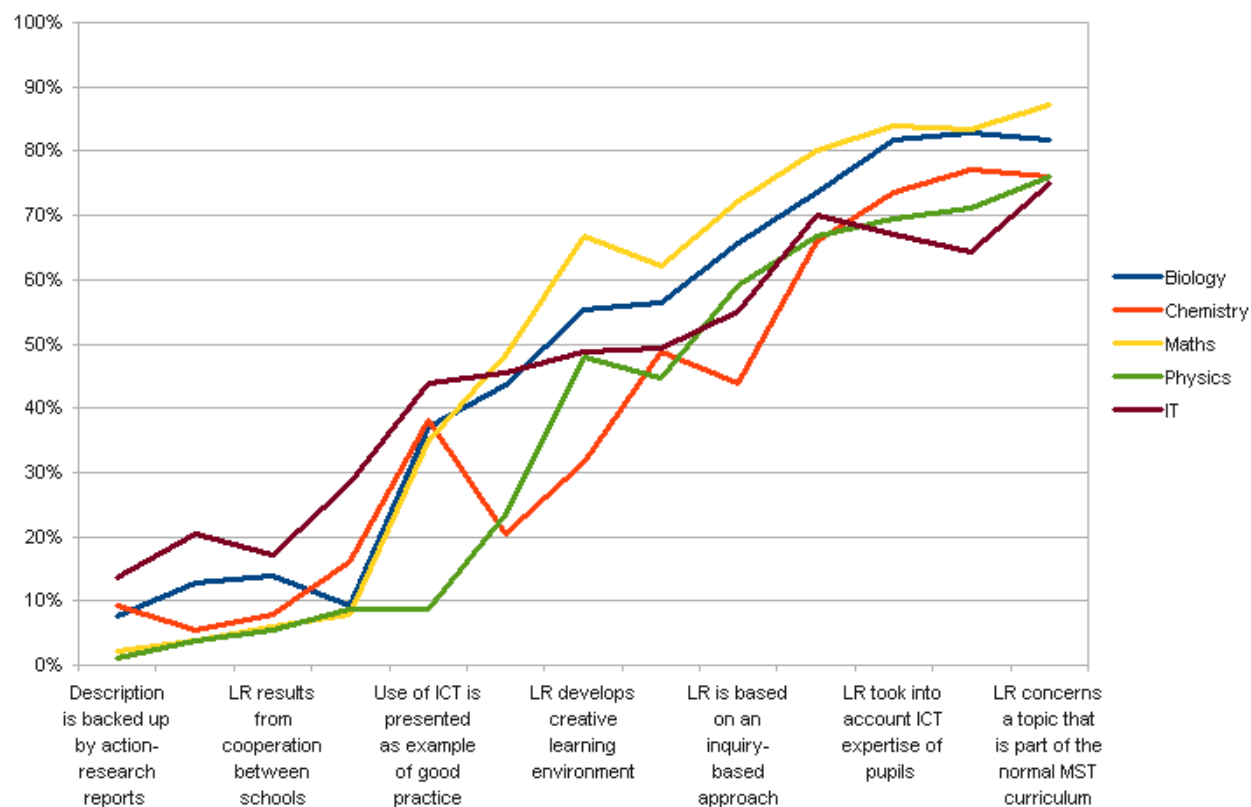


Figure 6: Overall selection criteria depending on the subject.

In Table 4 we show the two resources most used per subject, as well as some of the resources which were available in a larger number of languages and a few least-liked resources. As can be seen, there was no clear correlation between the use of the resources and the languages in which they were available (see the Maths or Chemistry resources, for example), nor with the authors or content providers (see the resources from Walter Fendt or David Harrison). On the other hand, more “modern” or visually attractive resources such as those from the BBC – Science Clips or eChalk – were clearly preferred, in spite of only being available in English.

Table 4: Percentage of usage of selected resources. P = Physics, C = Chemistry, B = Biology, M = Maths, T = Technology/Informatics. lang = languages the resource in which was available, besides English. # = number of times the resource was selected by teachers, excluding the ten times they were used by the Lithuanian teachers. % = percentage of usage per subject.

LR ID	Subcategory	Title	Author	lang	#	%
P3-13-7	Mechanics	Galilean relativity	PhysicsUNSW	0	1	2%
P4-13-8	Nuclear Physics	Radioactive decay	David Rea	0	1	2%
P2-17-10	Dynamics	Forces on pendulum	David Harrison	2	11	17%
P4-5-4	Dynamics	Conservation of Energy	B. Surendranath Reddy	0	12	19%
C2-17-22	Inorganic chemistry	Why things have colour	TheChemCollective	0	0	0%
C2-13-18	Gas laws	Processes in an ideal gas	Walter Fendt	3	2	5%
C4-5-16	Physical chemistry	Characteristics of materials	bbc.co.uk Science clips	0	7	17%
C3-5-15	General Chemistry	Periodic table Tetris	eChalk.co.uk	0	13	31%
B4-13-32	Immunology	Life cycle of a malaria parasite	Malaria Welcome Trust	0	1	2%
B3-5-27	Animals	Virtual frog builder	David Robertson	3	13	21%
B2-5-26	Animals	Habitats	bbc.co.uk Science clips	0	16	26%
M1-17-45	Calculus	Area of circle as a limit	David Harrison	2	0	0%
M2-17-46	Complex numbers	Operations with complex num.	Walter Fendt	3	2	3%
M2-13-42	Trigonometry	sin, cos, tan	Walter Fendt	3	11	16%
M2-5-38	Numbers	Maya numbers	Michiel Berger	0	13	19%
T1-17-57	Processes	Quiz maker	Attotron	0	0	0%
T1-5-49	Applications	Typing course	Peter Hudson.	0	6	8%
T4-13-56	Hardware	Click and learn (PC parts)	Mike Barnard.	0	20	28%
T3-13-55	Hardware	Computer Parts Hangman	Sabrina Sterling	0	23	32%

It is interesting to note that besides the use of the resources in the five subjects for which they were initially intended, some teachers used them also in other classes, like English, German and music education.

3.3 The pedagogical approach used

Teachers who used the LRs were invited to state which specific elements had been included in the pedagogical approach they had used while using the learning resources. The teachers could choose from the elements which are the key elements of the Inquiry-Based Science Education (IBSE) approach as defined in national action plans or initiatives such as the French “La main à la Pâte” initiative which is now generalized across all primary schools and also largely in lower secondary schools in France.

The key elements from the IBSE approach are:

- Raising the interest and curiosity of the pupils for a scientific problem or challenge;

- ▶ Moving from the state of curiosity towards an educational process; inviting pupils to express in words what the problem is about;
- ▶ Giving explicit pedagogical action to move from the definition of the problem to planning an inquiry-based process;
- ▶ Implementing inquiry-based process activities planned by setting up tests, experiments making use of the ICT based tools / techniques;
- ▶ Confronting the results with the reality; comparing the concrete results or outcomes with the expected results. Organising an individual or collective validation of the outcomes;
- ▶ Drawing conclusions highlighting what scientific knowledge has been acquired; possible links are made with new scientific problems;
- ▶ Finding out how the use of ICT based tools / techniques has facilitated the whole process;
- ▶ Making the link between science and ethics, technology, (political) decision-making, the making of choices.

The teachers who filled in the questionnaires were not explicitly told these were the key elements that composed the IBSE approach. Nevertheless, in most answers the teachers stated that they integrated more or less all of those elements except the last two. All teachers started by arousing the interest and the curiosity of the children and then built on this curiosity. Translating the problems into words and having young people explain what it is all about was also considered to be very important. The planning of an inquiry-based process focusing on tests and experiments was also used by most teachers. In most cases the results of the testing and experiments were compared with reality and individual or collective conclusions are drawn highlighting the scientific knowledge acquired.

However, as mentioned at the beginning of this section, few teachers stated that they tried to find out how the use of the ICT based tools or techniques facilitated the whole pedagogical process. In addition, very few teachers made the link between science and ethics and political decision-making.

As most teachers involved used or applied the core elements of the inquiry-based science education method, maybe even without knowing, it can be concluded that the use of LR facilitates and/or strengthens the use of the IBSE approach.

3.4 Assessment of the impact of the use of learning resources in class according to teachers

Teachers were asked about their expectations from the use of resources in class at the beginning of the project. According to around 90% of the teachers, the highest expectations were for an increase in both the pupils' motivation for learning MST and their understanding and use of ICT in general.

However, when the teachers assessed the impact of the LR after having used them, they stated that they noticed the LR had the highest impact on the autonomous learning of the pupils (85%), as we show in Figure 7. Additionally,

- ▶ 77% found the resources made it easier for students to understand and learn MST;
- ▶ Nearly three quarters of the teachers found that the LR stimulated their own interest and motivation for teaching MST;

- ▶ 73% said the LR increased the pupils' understanding and use of ICT in general;
- ▶ Around two thirds of the teachers noticed that the LR stimulated pupils' interest and motivation for learning MST (70%);
- ▶ They also experienced that thanks to the LR their own interest for teaching MST using LR increased (66%) and that the LR facilitated differentiated teaching of sciences in the classroom (64%);
- ▶ 63% of the teachers experienced that the LR helped students link science to everyday life more easily;
- ▶ 52% found that they made the pupils better understand tests and experiments carried out in labs or developed pupils' ability to use scientific methods.

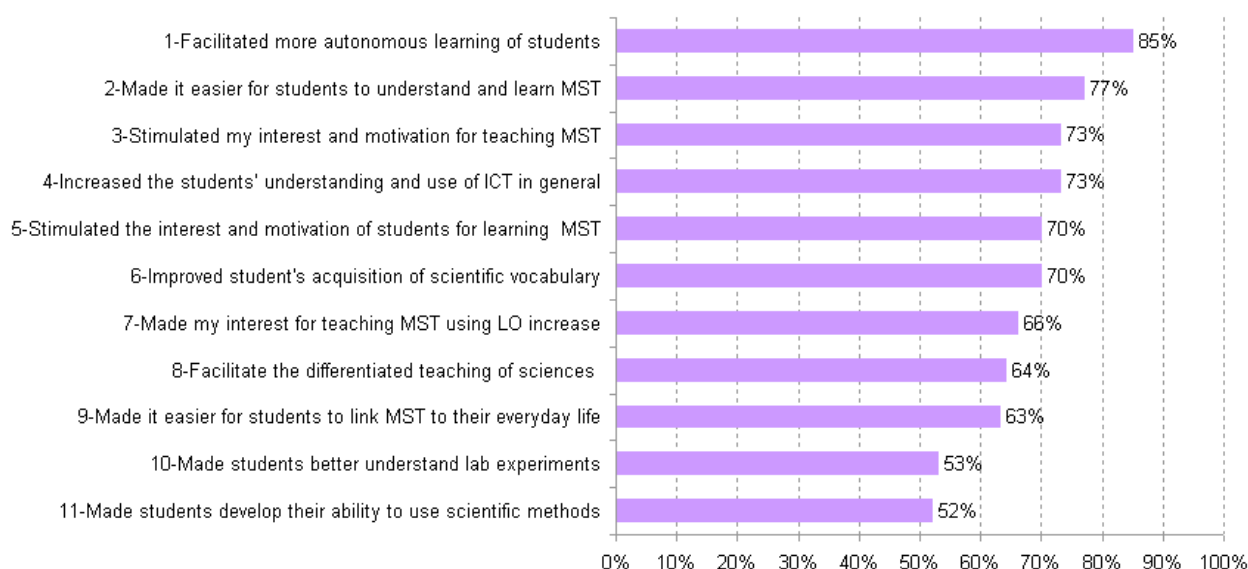


Figure 7: Teachers' assessment of the impact of the use of resources in their classes on themselves, the pupils and the classes.

Although the results are highly favourable, it is important to note that the teachers' high expectations were not met 100%. Reasons for this include the difficulty teachers from all countries, except Lithuania, had in integrating LR which were not in their local language into their classes; technical constraints (lack of access to computer labs or Internet) experienced in Italy and Spain impairing the use of the LR, or being used to different (more modern/advanced?) resources in the case of some of the Austrian and German teachers.

While in Figure 7 we have the average answers from the teachers, in Figure 8 we show the impressions from the teachers from each country. As can be seen overall, teachers from Spain, followed closely by Italy and Lithuania, found the use of the resources in classes significantly more effective than teachers from Germany and Austria.

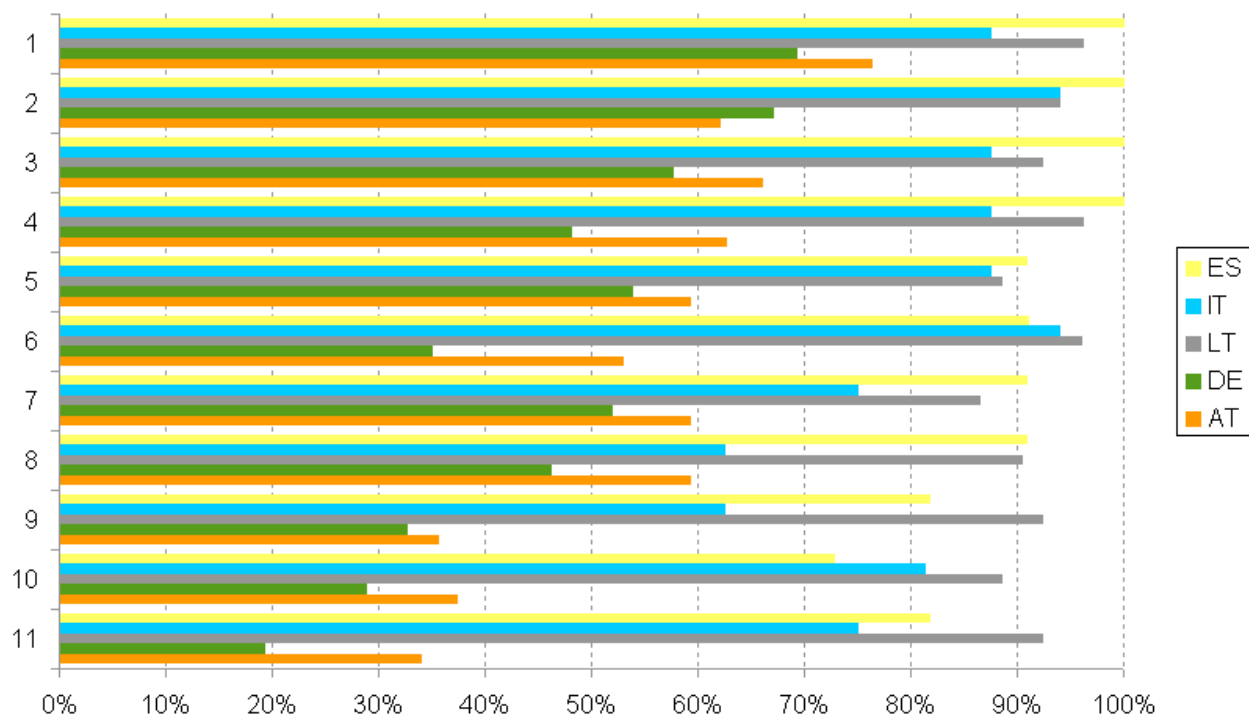


Figure 8: Assessment of the impact of the resources on the students, teachers and classes, per country. 1: Facilitate more autonomous learning of pupils at their own pace; 2: Made it easier for students to understand and learn MST; 3: Stimulated teacher's interest and motivation for teaching MST; 4: Increased the pupils' understanding and use of ICT in general; 5: Stimulated the interest and motivation for learning MST; 6: Improved student's acquisition of scientific vocabulary; 7: Increased my interest in teaching MST using LR; 8: Facilitated the differentiated teaching of sciences; 9: Made it easier to link science with everyday life; 10: Made the pupils better understand tests & experiments in labs; 11: Developed pupils' ability to use scientific methods.

3.5 Assessment of the impact of the use of learning resources in class among pupils

To set the picture, 4049 students from the pilot schools participated in a survey to assess their appreciation of MST before the project. As mentioned in Section 4.1, 2059 were boys and 1990 girls. Corroborating once more studies on male and female students' perceptions of MST and ICT (PISA 2000-2006; Gras-Velázquez, Joyce & Debry, 2009) the impact of MST subjects is generally more prominent with boys than with girls. As in the previous studies, the biggest impact MST lessons have is on their choice of careers, with 74% of the boys seeing these subjects as weighing on their selection of future career path, compared to only 60% of the girls. Additionally, 73% of the boys in the survey were interested in and motivated for MST compared to only 53% of the girls. Other interesting results were that:

- ▶ 66% of the boys and 58% of the girls found it easy to study MST by themselves at their own pace.
- ▶ 60% percent of the boys and 52% of the girls agree that MST lessons are organized in such a way that it is easy to study and remember what they have learned.

The final survey on the appreciation of the impact on MST after the use of the LR by the students was filled out by 3403 pupils: 1740 boys and 1663 girls. In Figure 9 we show the answers of students who agreed with the statements versus the responses of the pupils who stated that there was no added value/impact at all. The missing answers which correspond to "undecided" are not included.

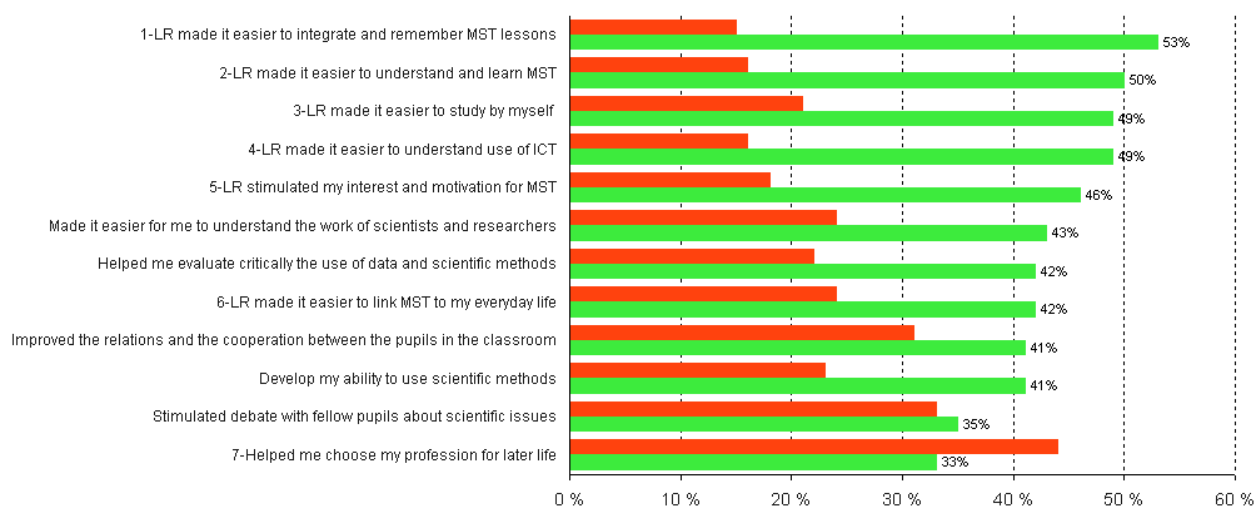


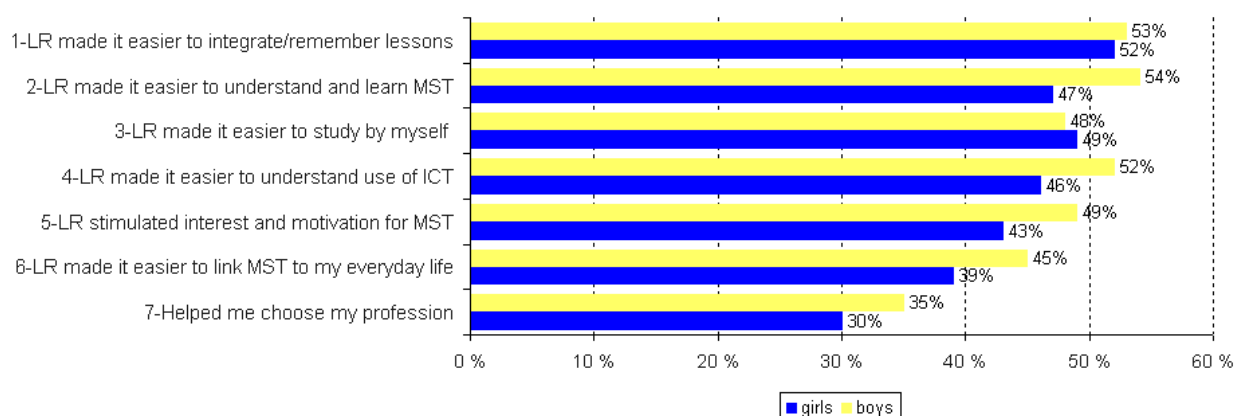
Figure 9: Impact of using LR on the students. Red bars represent “no added value” answers. Green bars represent positive answers. Missing percentages correspond to “undecided” answers.

As seen in Figure 9, the LR had a major impact on pupils regarding better understanding and learning MST and making it easier to integrate and remember what they had learned.

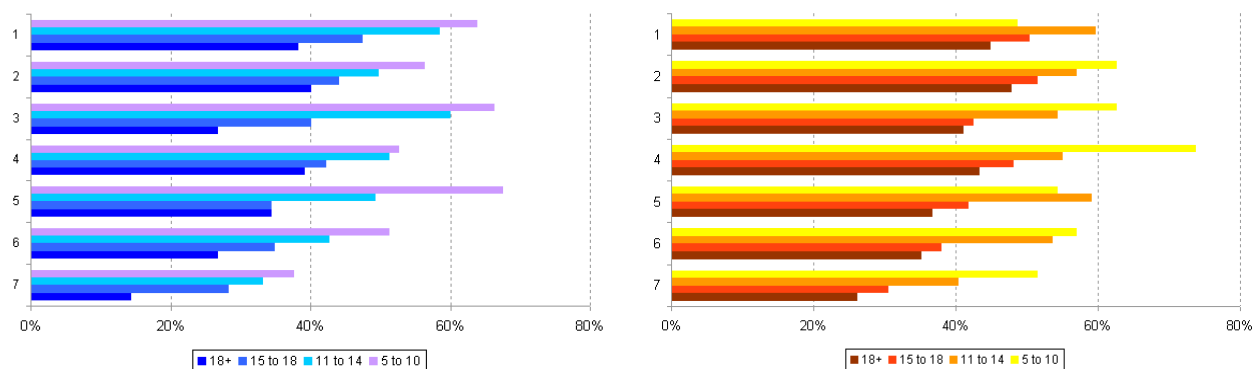
Furthermore, nearly half of the pupils (49%) found the LR facilitated autonomous learning and made it easier to understand the use of ICT in general; and 46% of the pupils thought the LR stimulated their interest in and motivation for MST. So, overall, around 50 % of the students found the use of LR in class had a positive effect in their lessons, although in some aspects this effect is only moderate.

Interestingly, almost as many students said the use of learning resources would not influence their career choices, maybe failing to see that if the LR improve the MST classes and they are influenced by the MST classes in their decisions regarding their professional paths, then in effect the learning resources do affect these decisions.

The results shown in Figure 9 were also analysed according to gender, age, country and amount of LR used per student during the piloting. In Figure 10 we show seven of the items questioned, filtered by gender and age.



a) Added value of using the LR in MST classes, according to the students' gender



b) Added value of using the LR in MST classes, filtered by age, according to female students

c) Added value of using the LR in MST classes, filtered by age, according to male students

Figure 10: a) impact of the use of LR in MST classes filtered by gender. Blue bars are female students, Yellow bars are male students. b) Average number of resources used per student in each age group. c) Impact of the LR according to female students, depending on their age. d) Impact of the LR according to male students, depending on their age. Note: 1 = LR made it easier to integrate / remember MST lessons; 2 = LR made it easier to understand and learn MST; 3 = LR made it easier to study MST by oneself 4 =LR made it easier to understand the use of ICT in general; 5 = LR stimulated interest and motivated for MST; 6 = LR helped make a better link between MST and everyday life; 7 = LR Helped me choose my career path.

As seen in Figure 10a, in general male students seem to find the use of resources more effective than female students. This difference in perception of the resources could be the result of their different attitude towards science, as discussed at the beginning of this section, rather than the use of the resources themselves.

In Figure 10b we have grouped the answers from the female students according to age. There is a clear tendency to find the effects of the resources less effective as age increases. It is important to note that less than 15% of the female students aged 18+ and still in school found that the resources had any influence on their choice of career. This corroborates the finding from other studies that trying to encourage students, and female students especially, to embark on MST careers should be done at an earlier stage than when they are about to choose their university degree or profession.

Similar results are found among the male students, where the older the students, the less effective the use of resources in class becomes, although the pattern is somewhat less marked than in the case of their female counterparts (Figure 10c).

The average number of resources used per student in each age group can be found in Figure 11.

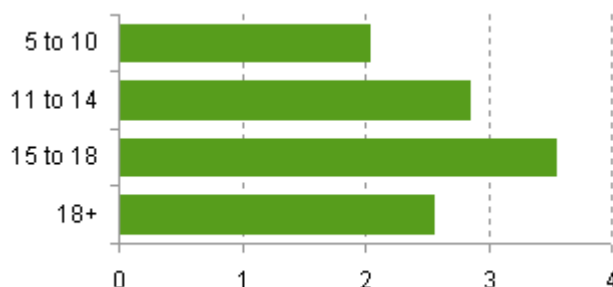


Figure 11: Average number of resources used per student

As seen by comparing Figures 10 and 11, there seems to be no clear correlation between the number of resources and their effects. This could mean that the fact of using a resource has effects on the students' motivation, but there seems to be no risk of using "too many" resources. A number of classes used over ten

resources, and their results did not differ from those of classes that used only one, either by age or by gender.

In Figure 12, we have split the answers per country. As regards the impact as perceived by the pupils, there are enormous differences between students from the different pilot countries. For example, 82% of the Lithuanian pupils thought that the LR made a better link between MST and everyday life whereas only 36% of German pupils noticed this. For virtually all items surveyed the impact perceived by the Lithuanian and Spanish pupils, followed closely by the Italian students, is considerably higher than that perceived by the Austrian and German students.

The lower perceived impact might be explained by the lower expectations of the German and Austrian teachers but might also be the result of the fact that LR are considered to be something relatively new by the Italian, Spanish and Lithuanian pupils whereas they have already become mainstream in Germany and Austria. It would be interesting to carry out a simple test to check if the effects of using the resources are indeed because of the resources and not only novelty, by for example having the teacher make his or her students wear a funny hat for one lesson and use a learning resource in another. If it is only about novelty, both days should result in students remembering the lessons more.

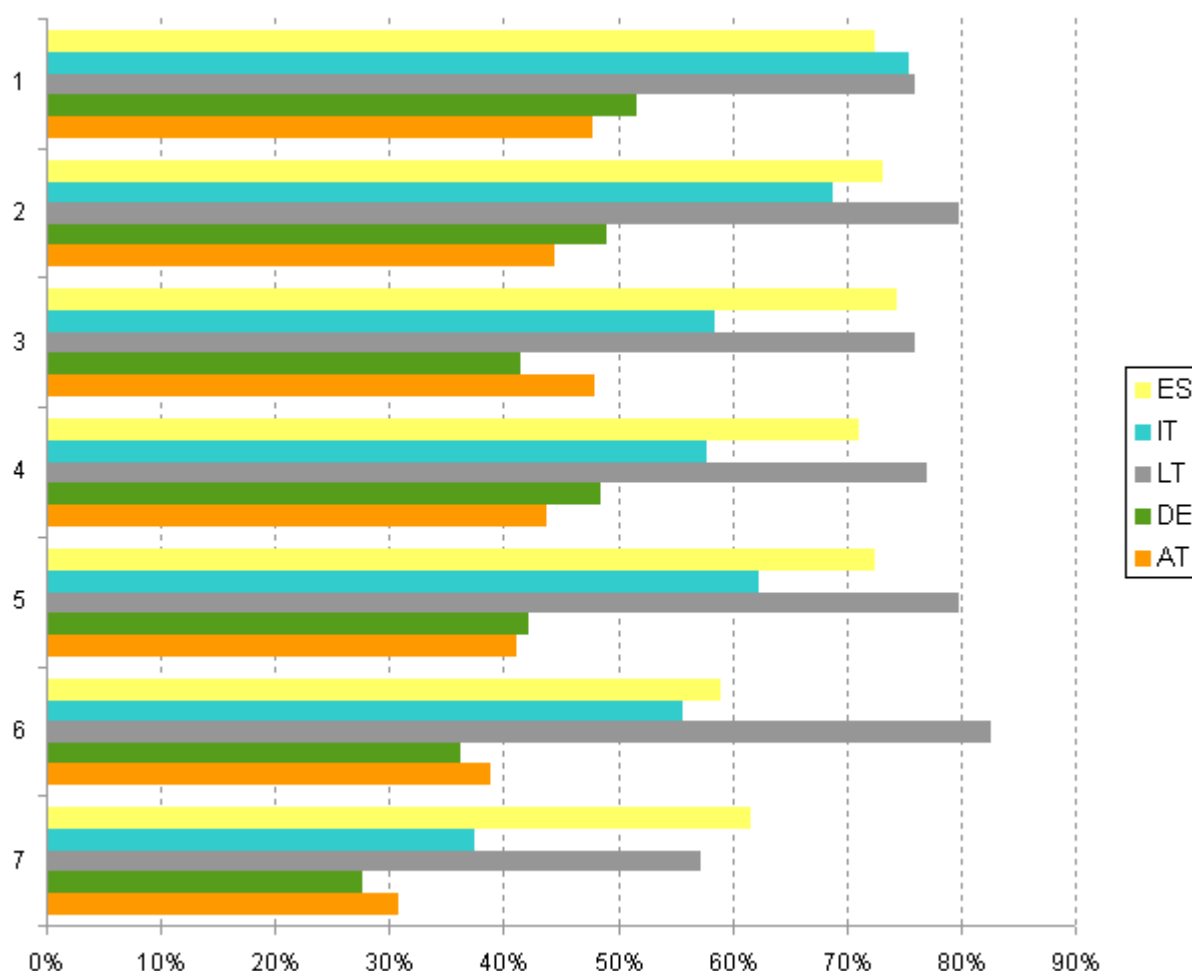


Figure 12: Added value of using LR in MST classes according to the students in each country. Note: 1 = LR made it easier to integrate / remember MST lessons; 2 = LR made it easier to understand and learn MST; 3 = LR made it easier to study MST by oneself 4 = Made it easier to understand the use of ICT in general; 5 = LR stimulated interest and motivated for MST; 6 = Helped make a better link between MST and everyday life; 7 = Helped choose career path

4. Results per country

While in Section 3 we presented the overall results and comparisons between the responses of the different countries, here we highlight the main results within each country. In the figures, the numbering corresponds to the item's ranking within the overall average results within that category, but ordered according to the results in the country in question.

4.1 Germany

In Germany, 19 schools participated in the Inspire project. Eleven were secondary schools, four primary schools and 4 vocational schools. In these schools 63 teachers were involved in the testing and 1599 students (55% male students and 45% female students). On one hand 58% of the schools had a specific strategy in place to promote ICT in as many disciplines as possible, but only 5% were involved in any pilot projects to promote ICT in MST classes (whether regional, national or European).

From the 113 times the LR were used by the teachers, 35 times were Biology LR, 30 Maths, 24 Physics and 19 Technology. The Chemistry LR were only used 5 times by the German teachers. German teachers used 11 of the 12 Biology resources, 10 of the Physics ones, 8 from Maths, 6 from Technology and 3 from Chemistry. Mathematics teachers initially refused to work with the LR because they were in English. As could be expected, most teachers chose the LR because it concerned a topic part of the MST curriculum (see Figure 13). This criterion was followed by the LR having an inquiry-based approach and it combining MST with ICT.

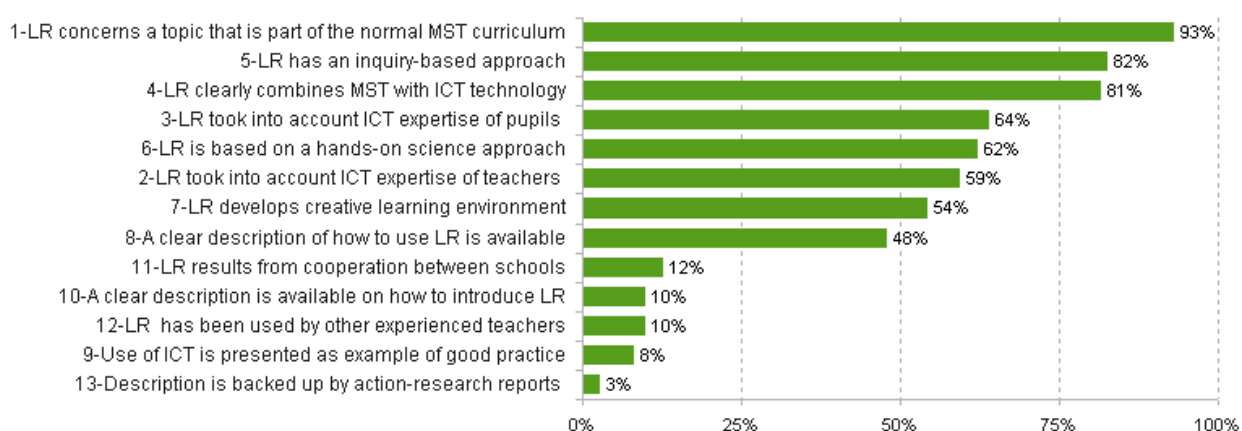


Figure 13: LR selection criteria of the German teachers.

On average, German teachers used 2.5 LR during the project and invested slightly more than two hours per learning resource per class. They used one computer per student in general, but the Internet was not always accessible. According to the teachers, the greatest impact of using the LR was in facilitating the learning of students at their own pace (see Figure 14) and making it easier for the students to understand and learn MST. Over half of the teachers found not only the students' interest and motivation for learning MST but also their own interest in teaching it increased. Improving the students' acquisition of scientific vocabulary or making it easier to link science with everyday life were impacts less noticed by the teachers.

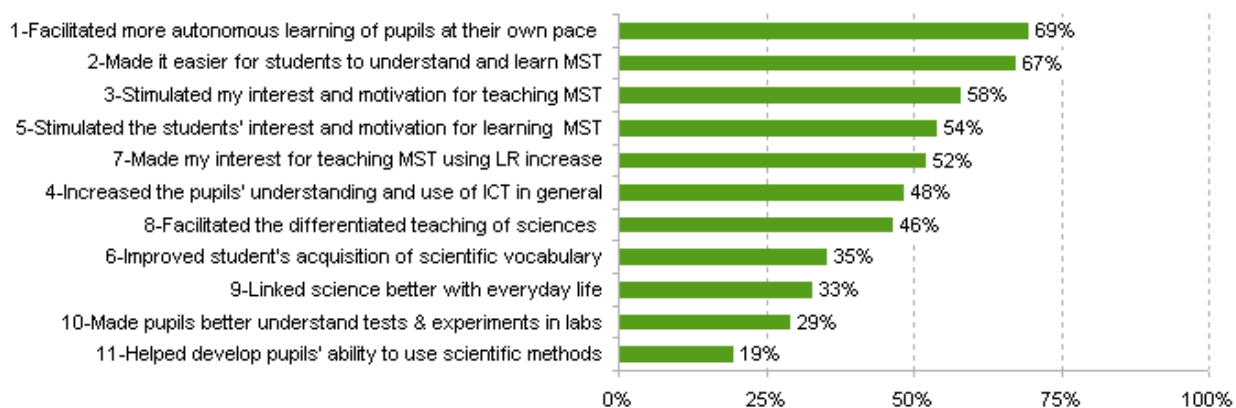
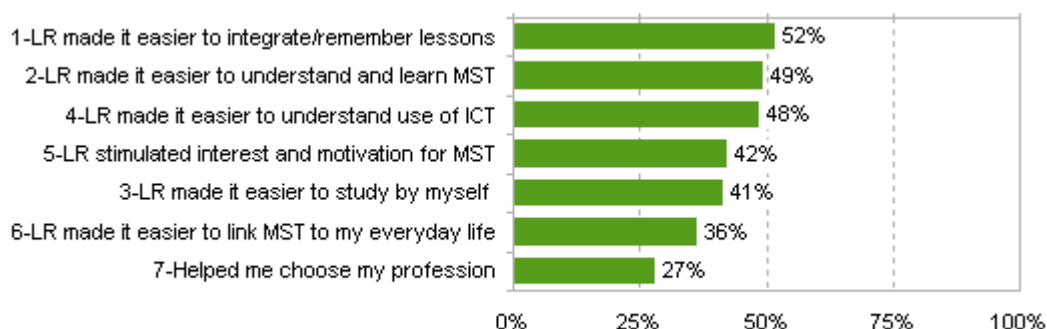
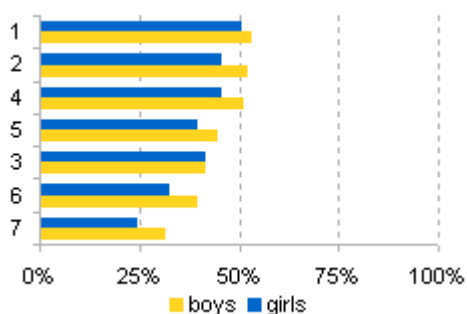


Figure 14: Teachers' appreciation of the impact of using LR in MST classes on themselves and the students in Germany.

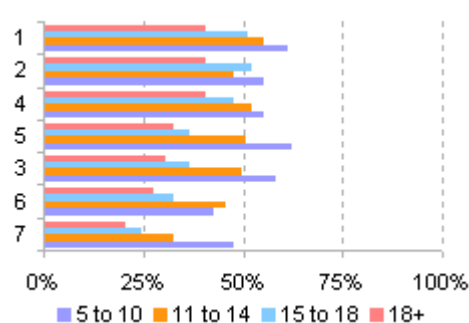
During the project, German students used on average 2.3 LR. As found in other studies on ICT knowledge and skills (e.g. Gras-Velazquez, Joyce & Debry, 2009) boys claimed they liked and understood MST much more than girls. As seen in Figure 15a, although almost half of the students found the use of LR in class made their comprehension and learning increase thanks to the use of LR, only one out of four students found they had an influence in their decisions on their future profession. Although it is clear that the use of LR had an impact on the students' appreciation of MST, with the exception of "making it easier to study by oneself", the impact seemed to be greater on male students than female students (Figure 15b). Finally, from Figure 15c, it can be seen that the younger the age, the greater the impact of the LR.



a) Impact of the LR on the German students.



b) Impact of the LR on the German students according to gender



c) Impact of the LR on the German students according to age

Figure 15: Impact of the LR on the German students (a); filtered by gender (b) and age (c). 1 = LR made it easier to integrate / remember MST lessons; 2 = LR made it easier to understand and learn MST; 3 = LR made it easier to study by myself; 4 = LR made it easier to understand the use of ICT; 5 = LR stimulated interest and motivation for MST; 6 = LR made it easier to link MST to my everyday life; 7 = Helped me choose my profession.

4.2 Austria

In Austria, 23 schools participated in the Inspire project. Among the 23 schools, one was a primary school and one a vocational school and the rest were secondary schools. However, several of these secondary schools provided education at different levels. Of the 75 teachers who filled in the initial questionnaires, only 59 made it to the end of the project. The drop out is believed to be due to two main causes: the LR not being up to the standards they are used to (in the case of some more advanced teachers) and the language of the most of the resources being English (in the case of the less advanced teachers). 42% of the Austrian schools had experience with EU projects (Comenius, eTwinning, etc) and their teachers a large expertise in ICT.

The Austrian teachers used the LR 130 times, mainly the IT ones (50 times), followed by the Physics and Maths LR (about 30 times each). As seen in Figure 16, the criterion of the resource fitting the subject's curriculum was followed by it having an inquiry-based approach. Not surprisingly, the Austrian teachers did not consider the LR taking into account the teachers' ICT knowledge as necessary but the resources had to clearly combine MST with ICT technology.

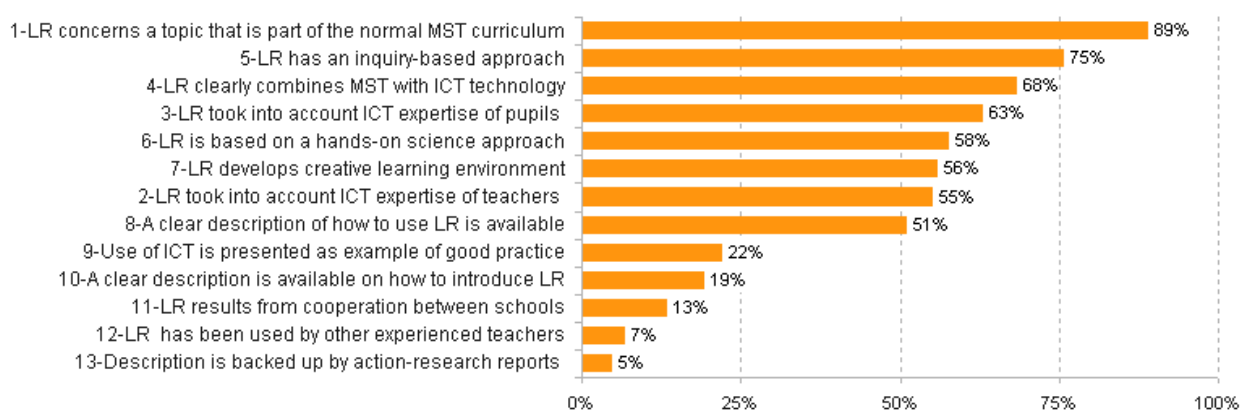


Figure 16: LR selection criteria of the Austrian teachers

Austrian teachers used an average of over two LR during the project and invested nearly two hours per learning object per class. The largest impact they found of the use of the resources in class was on the autonomous learning of the students (Figure 17). The increase in their own interest in teaching MST thanks to the use of the resources ranked higher than getting students to link science with everyday life. Almost 60% of the Austrian teachers found the resources increased the motivation and interest of students in MST.

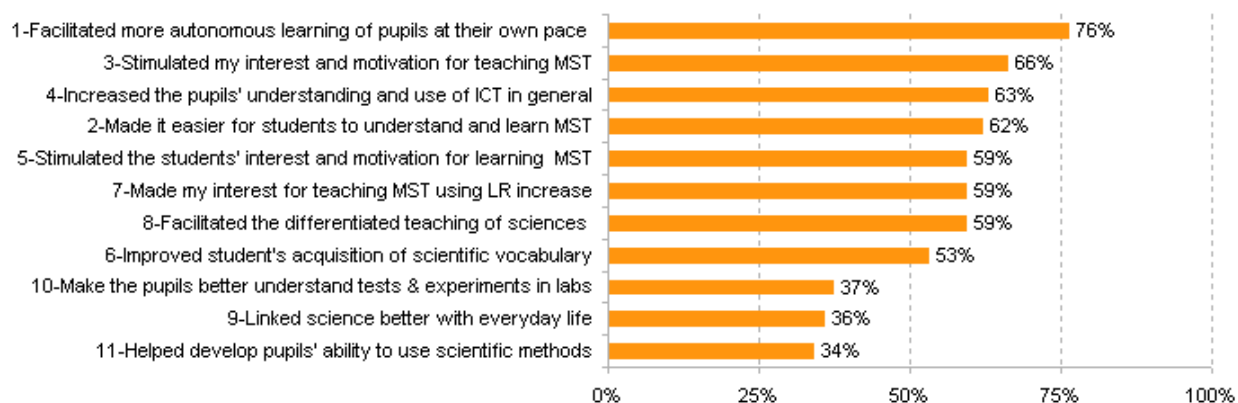
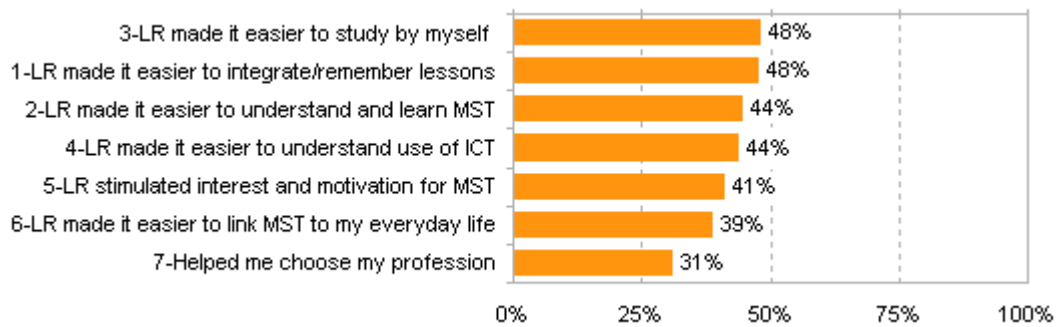
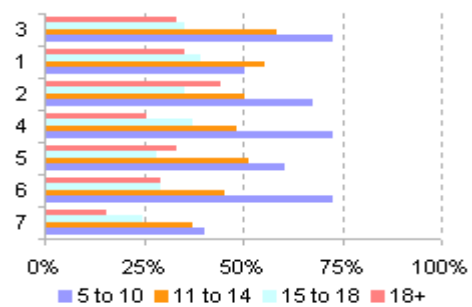
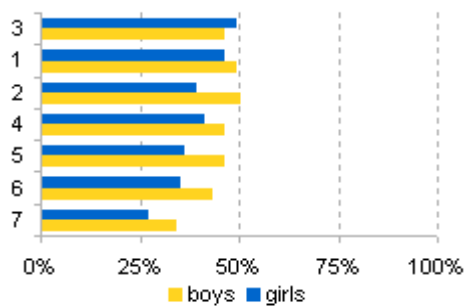


Figure 17: Teachers' appreciation of the impact of using LR in MST classes on themselves and the students in Austria.

1,896 Austrian students participated in the project (47% male, 53% female), split between ages 5 to 10 (4%), 11 to 14 (50%), 15 to 18 (43%) and 18+ (3%), and on average they used 3 LR. More than two-thirds of the male students indicated interest in MST to start with, compared to only 46% of the female students. After the tests, 41% of the students found the LR increased their interest in MST (Figure 18a), again, with more positive answers coming from the boys than the girls (Figure 18b). The biggest impact of the LR was on it making it easier to study by oneself, with more female students agreeing than their male counterparts. Besides this item, the rest followed the general trend of male students perceiving greater influences on their understanding, learning and studying than female students. As in Germany, the impact of the resources clearly decreased with age (Figure 18c).



a) Impact of the LR on the Austrian students.



b) Impact of the LR on the Austrian students according to gender

c) Impact of the LR on the Austrian students according to age

Figure 18: Impact of the LR on the Austrian students (a); filtered by gender (b) and age (c). 1 = LR made it easier to integrate / remember MST lessons; 2 = LR made it easier to understand and learn MST; 3 = LR made it easier to study by myself; 4 = LR made it easier to understand the use of ICT; 5 = LR stimulated interest and motivation for MST; 6 = LR made it easier to link MST to my everyday life; 7 = Helped me choose my profession.

4.3 Lithuania

In Lithuania ten schools participated in the Inspire project; one was a vocational school, the rest were secondary schools. Of the ten schools, nine had already been involved in regional, national or European projects to promote ICT in education. 52 teachers actively participated in the project. 182 students (52% boys, 48% girls) filled in the questionnaires, representing between a quarter and half of the students who attended the classes where the LR were used.

As each of the LR was used 10 times in Lithuania, it can be assumed the teachers did not actually choose them but were allotted to them. Nevertheless, the teachers still filled in the questionnaires on the criteria they would use to select LR in general. On average just over an hour was invested per learning object per class and usually one computer per pupil was used. In contrast to the teachers from the other schools in the project, they were mostly interested in resources that took into account their ICT experience and that of their students. The need for the LR to fit the national curriculum came in third place (see Figure 19). Although in the preparation of the project the Lithuanian national coordinator stated that Lithuanian teachers preferred resources with explanations on how to integrate them in class (or even full lesson plans), only one in three teachers declared this criterion to be important.

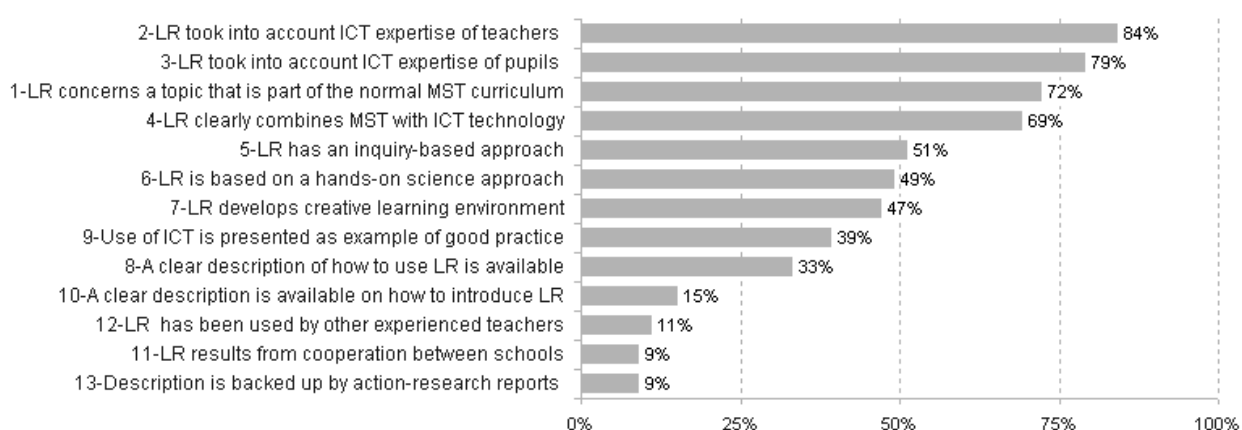


Figure 19: LR selection criteria of the Lithuanian teachers

In Figure 20 one can see that the teachers found the greatest impact of the resources to be on the autonomous learning of the students, an increase in the students' understanding of ICT and an improvement in the students' acquisition of scientific vocabulary.

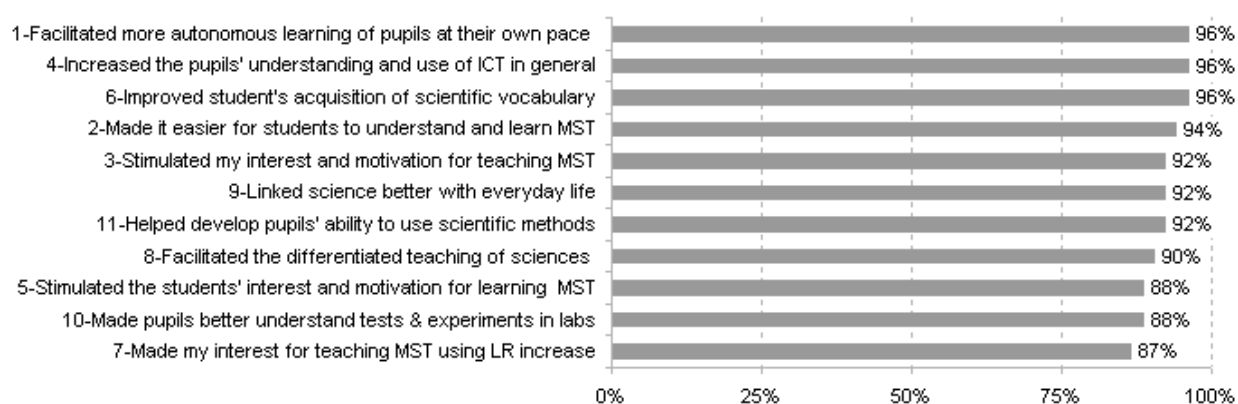


Figure 20: Teachers' appreciation of the impact of using LR in MST classes on themselves and the students in Lithuania.

It is interesting to note that Lithuanian teachers ranked the effect on the acquisition of scientific vocabulary highest among all countries, and at the same time were the ones who least complained that the resources were only in English. Overall, they found the use of resources in classes provided a clear added value on all items studied.

According to the Lithuanian students, the use of the LR in class had a tremendous impact in their MST classes. As seen in Figure 21a, 82% of the students found it made it easier to link the MST classes with their everyday life, followed by noticing an effect on their interest and motivation to study MST and decrease in difficulty to understand and study these subjects. On the other hand, compared to these high results, only 57% of them thought this increase in interest and decrease in difficulty had an effect on their choice of future careers. Given that in Lithuania the students were only from secondary school, this could result from the students having already decided what they want to do in the future, so that nothing in the last years of school will change their minds.

The gender differences seen in the other countries are not so marked among the students in the project from Lithuania. As many female students as male students, or even more, found the resources increased their interest in and understanding of MST and even in ICT (Figure 21b). Although this result is surprising when compared to the students from the other countries in the study, it matches the initial position, as 79% of the girls were already interested in MST, compared to 67% of the male students.

The decrease in the impact with age was also present among the Lithuanian students but not as marked, especially as we lacked primary schools and students over 18 to compare the results with (Figure 21c).

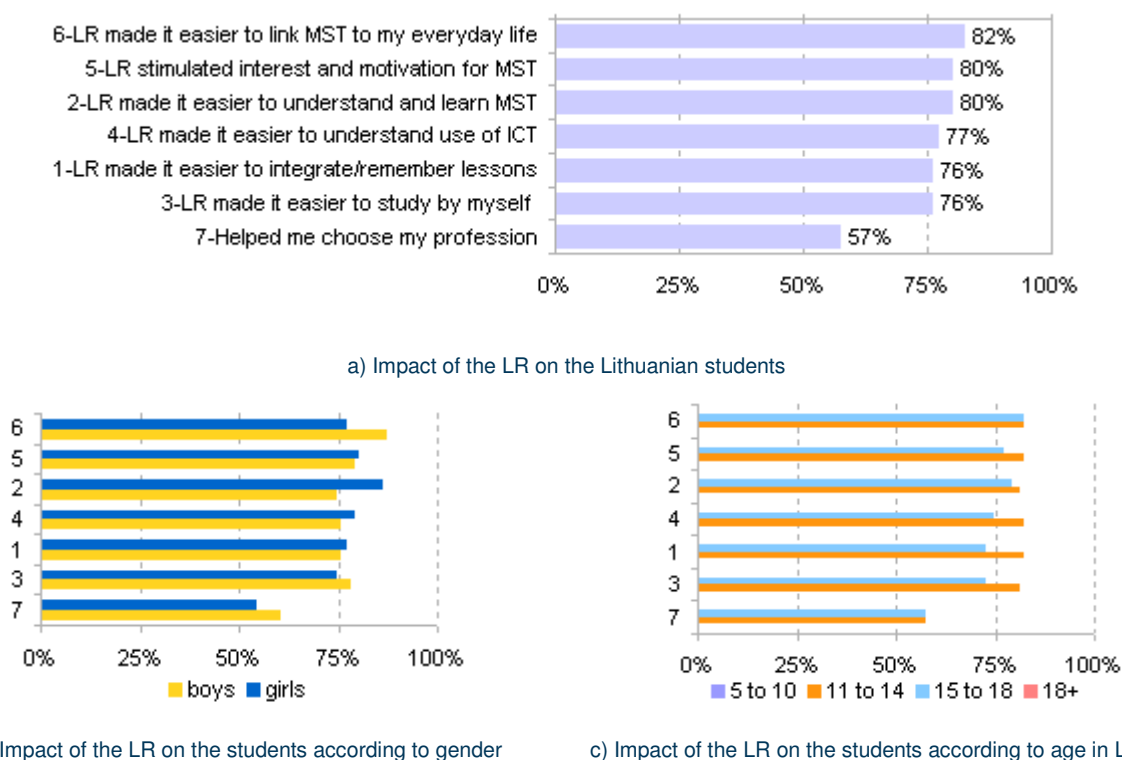


Figure 21: Impact of the LR on the Lithuanian students (a); filtered by gender (b) and age (c). 1 = LR made it easier to integrate / remember MST lessons; 2 = LR made it easier to understand and learn MST; 3 = LR made it easier to study by myself; 4 = LR made it easier to understand the use of ICT; 5 = LR stimulated interest and motivation for MST; 6 = LR made it easier to link MST to my everyday life; 7 = Helped me choose my profession

4.4 Italy

In Italy 5 schools participated in the project: two schools with primary and pre-primary education and three secondary schools. One of the secondary schools was unable to follow through the implementation of the project in full, owing to organizational and infrastructural problems which provided important insight into the difficulties many schools still have in integrating new technologies into their teaching (from lack of equipment, including Internet access, to teachers' lack of confidence in using ICT or basic knowledge of English). The other four schools already had experience in participating in European ICT pilot projects.

21 teachers participated in the project and 260 students (52% boys and 48% girls). The teachers used the learning resources 43 times in MST classes. They used the Physics resources three times and the Biology ones up to 19 times. The IT resources were not used by any of the Italian teachers. From Figure 22 it is clear that unless the resource concerned a topic part of the curriculum, it would not be used, while the fact that the resource had an inquiry-based approach was considered by less than half of the teachers.

According to the Italian teachers the LR had an impact on a large number of the items studied (Figure 23). Teachers found that the biggest impact of the use of the resources in class among their students was on their understanding of MST and acquisition of basic scientific vocabulary. 88% of the teachers also found that their own interest and motivation to teach MST increased with the use of the LR.

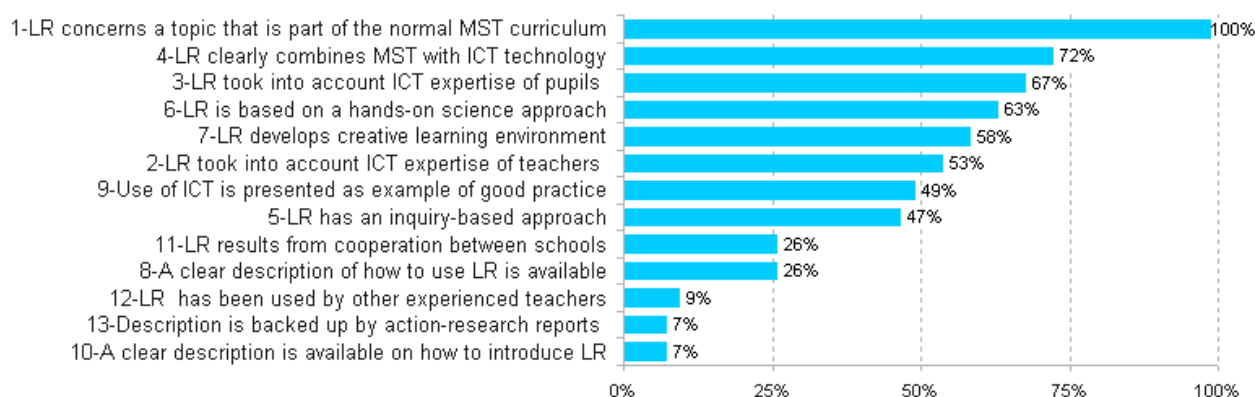


Figure 22: LR selection criteria of the Italian teachers

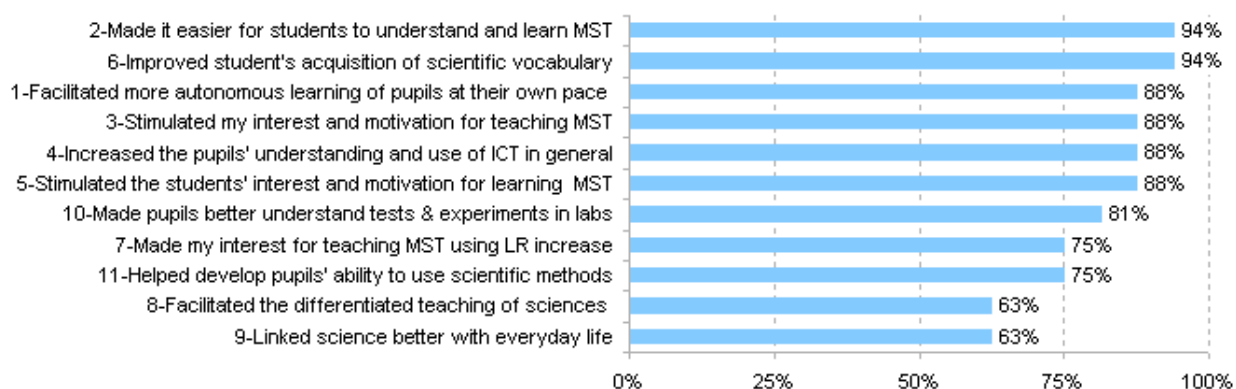


Figure 23: Italian teachers' appreciation of the impact of using LR in MST classes on themselves and the students.

On average the Italian students used the LR 2.6 times in class. In Figure 24a we show the added value Italian students found in working with the LR in their MST classes. Overall, the largest impact found was on their being able to remember the lessons better. It is important to take into account that this could be related to novelty in the use of resources in class, more than an effect of the resources themselves. As with other

countries, the fact that their interest in MST increased thanks to the LR seemed to have little effect on their choice of future profession.

Not only is it that obvious the LR had a high impact on all the pupils, but it appears to be slightly higher on girls than on boys except as far as making it easier to understand ICT is concerned (Figure 24b). The largest differences were on the LR making it easier to integrate / remember MST lessons and easier to link MST to their everyday lives.

As the questionnaires proved to be too difficult to answer by the pre-primary students in Italy, the Italian teachers carried out structured interviews by adapting the questionnaires to their young students. 82% of the younger students said the use of the LR increased their interest in MST. Not surprisingly, 97% of the younger girls and 80% of the boys said they would like to work more with LR (especially understandable if they see them as games).

These students' answers to four questions could be compared to the older students' replies (three of which can be found in Figure 24c). The impact perceived by the Italian students as regards the LR making it better to integrate / remember the MST lessons, easier to understand and learn MST and stimulating their interest and motivation for MST followed the same pattern as in other countries of decreasing with age, with one exception: 18+ year old students found the resources as positive, or even more so, than the younger ones. Taking into account that the age group of 18+ was formed of only 12 students, their greater interest might be not significant and just the result of having found a group of enthusiastic more mature students.

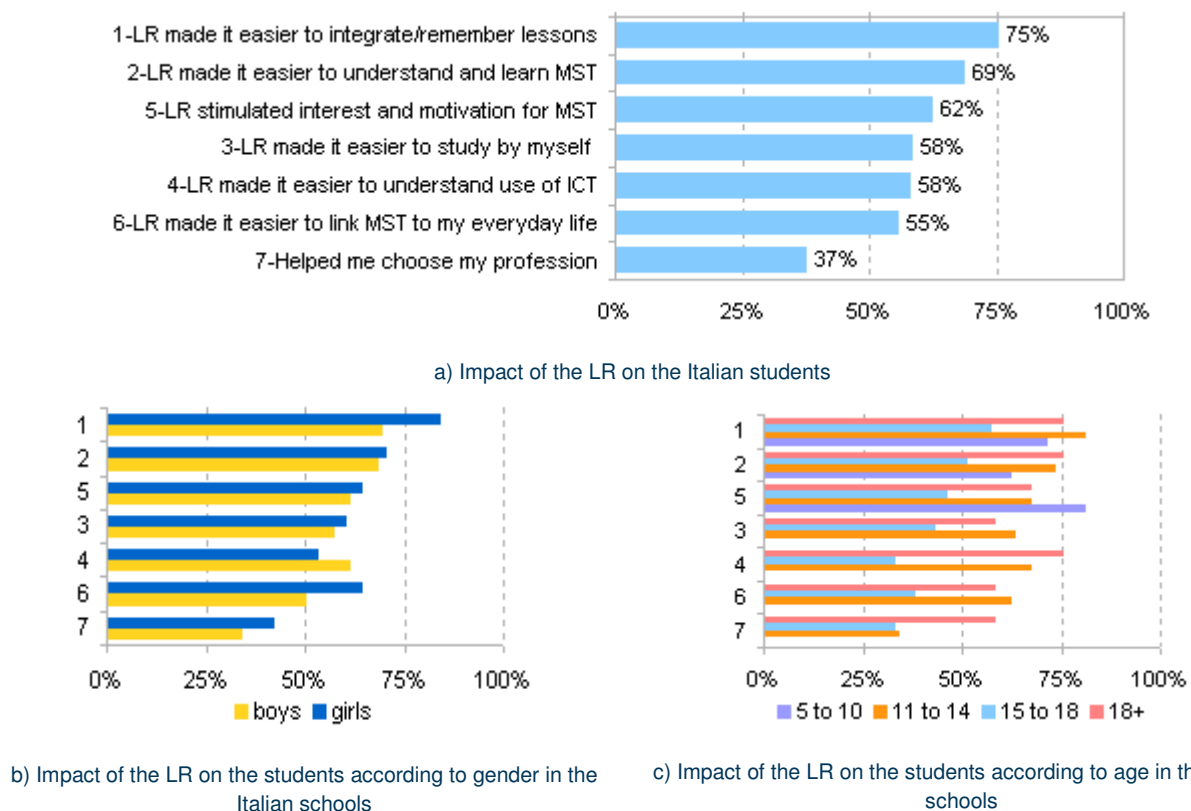


Figure 24: Impact of the LR on the students in the Italian schools (a); filtered by gender (b) and age (c). 1 = LR made it easier to integrate / remember MST lessons; 2 = LR made it easier to understand and learn MST; 3 = LR made it easier to study by myself; 4 = LR made it easier to understand the use of ICT; 5 = LR stimulated interest and motivation for MST; 6 = LR made it easier to link MST to my everyday life; 7 = Helped me choose my profession

4.5 Spain

In Spain, five schools participated in the project. These schools covered several educational levels so we had the equivalent of one pre-primary school, one primary, five secondary schools and one vocational school. Although the 11 teachers who participated in the project had experience in ICT, none of the schools had previously participated in any regional, national or European projects to promote ICT in education. These teachers only used the resources 18 times, of which ten were Maths resources, four Chemistry, two Physics and two IT. No Biology resources were selected by the Spanish teachers.

From Figure 25, it is clear that the teachers selected the resources not only on the basis of their fitting the national curricula but also on combining MST with ICT and on their inquiry-based approach. The explanations on how to use the resources provided in the Inspire websites were never a factor in their selection procedure. As the Chemistry and Physics resources were used within the Natural Sciences classes, in which Biology would have also been taught, it would follow that the selection of Inspire Biology resources available cannot have fitted the Spanish curricula at all.

Teachers' expectations on the impact of the LR on their students and themselves were very high and according to the views they expressed after using them (see Figure 26) they were not disappointed. All Spanish teachers found the LR made it easier for students to learn at their own rhythm and to understand MST and ICT better and even increased their own interest and motivation.

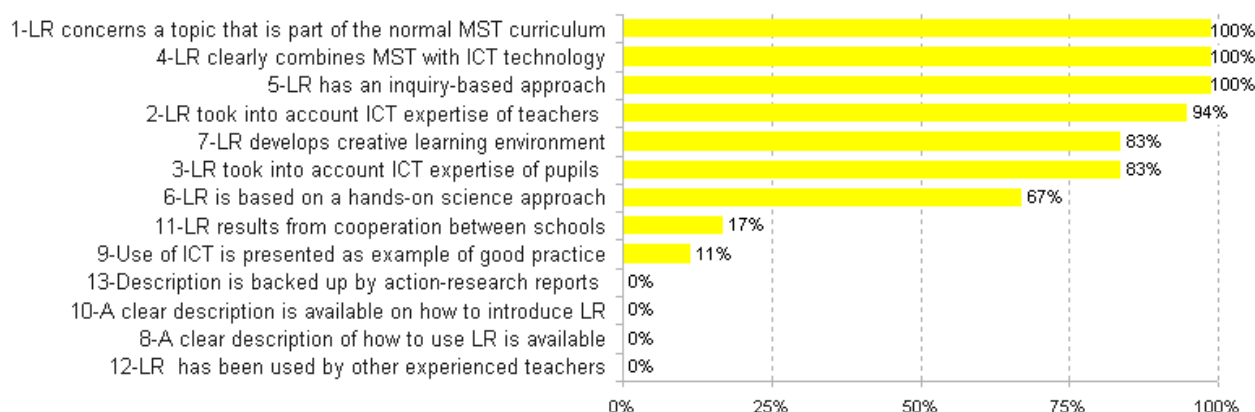


Figure 25: LR selection criteria of the Spanish teachers

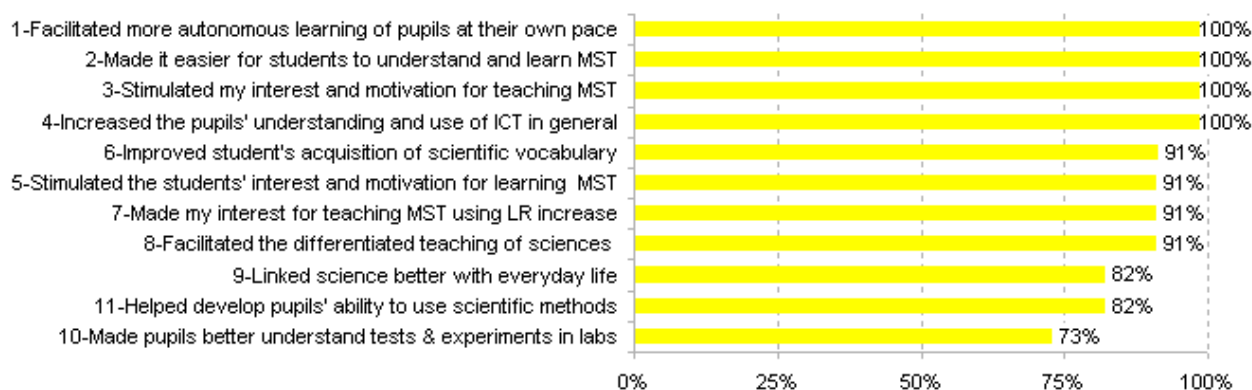
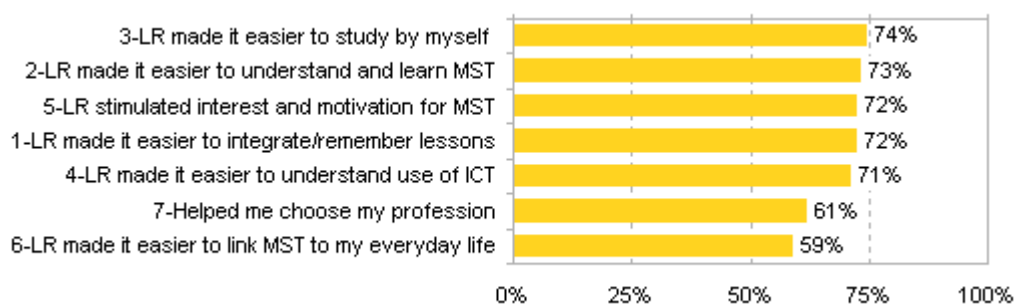


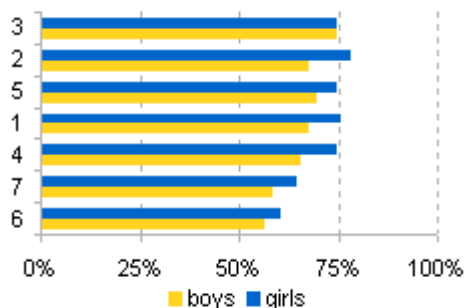
Figure 26: Teachers' appreciation of the impact of using LR in MST classes on themselves and the students in the Spanish schools.

152 students took part in the Inspire project (48% boys and 52% girls). Initial surveys showed that 73% of the boys and 64% of the girls had a strong interest and motivation for MST but, at the same time, 59% of the male students and 71% of the female students said they did not like ICT in general. The use of LR nevertheless proved positive in making it easier for them to understand the use of ICT (see Figure 27a). Additionally, over 70% of the students found the LR increased their interest in MST even more. These results were even more prominent among the female students (Figure 27b) and, in contrast to students in other countries, more than half of the students saw the use of LR as influencing their future studies. So the LR had a tremendous impact on the Spanish pupils, not only according to the teachers, but the pupils themselves.

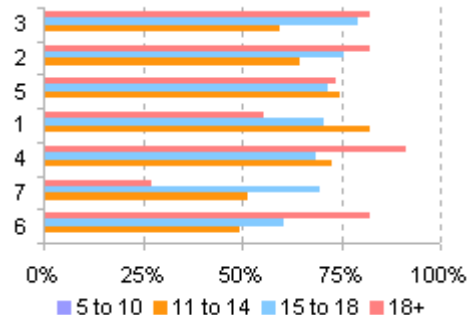
In Figure 27c we show the added value of using LR in class depending on the students' ages. In contrast to the findings in other countries, there seems to be a larger impact with increasing age. Although, as in Italy, the group aged 18+ had only 11 students and could be considered a 'blip' in the results more than an actual finding, there were 39 pupils aged 11-14 in the tests and their replies compared to those of the 15 to 18 year olds also show an increase of interest with age. The results would need respondents younger than 11 to confirm this finding.



a) Impact of the LR on the Spanish students



b) Impact of the LR on the students according to gender in the Spanish schools in the project



c) Impact of the use of the resources in class in the Spanish schools according to age

Figure 27: Impact of the LR on the students in the Spanish schools of the project (a); filtered by gender (b) and age (c). 1 = LR made it easier to integrate / remember MST lessons; 2 = LR made it easier to understand and learn MST; 3 = LR made it easier to study by myself; 4 = LR made it easier to understand the use of ICT; 5 = LR stimulated interest and motivation for MST; 6 = LR made it easier to link MST to my everyday life; 7 = Helped me choose my profession

5. Conclusions

Overall we found that:

- ▶ LR had a major impact on pupils regarding better understanding and learning of MST and making it easier to integrate and remember what pupils have learned;
- ▶ LR seemed to have a greater impact on boys than on girls;
- ▶ The impact of the learning objects decreases with age, especially among female students;
- ▶ For virtually all items surveyed, the impact perceived by the Lithuanian and Spanish pupils, followed by the Italian students, is considerably higher than the impact perceived by the Austrian and German students;
- ▶ No real impact could be noticed as regards the number of LR that were used.

We found that the use of LR in MST classes increases students' understanding of MST. Additionally, it allows for differentiated learning within a class. The use of LR has a larger impact among boys than girls, decreases with age and does not seem to depend on the number of LR used. The drop-off is more acute among girls, perhaps due to increased pressure of gender stereotypes (Gras-Velázquez, Joyce & Debry, 2009). Overall, it appears the use of LR has a positive impact on MST education but special attention has to be given to technical requirements and localisation of the LR.

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REFERENCES

- Bratina, T. A., Hayes, D. & Blumsack, S. L. (2002). *Preparing Teachers To Use Learning Objects The Technology Source*, November/December 2002 (Online) Available from <http://ts.mivu.org/default.asp?show=article&id=1034> [Accessed: 24 July 2009]
- Commission of the European Communities. (2008). *Commission Staff Working Document – Progress towards the Lisbon objectives in education and training - indicators and benchmarks - 2007* (Publication based on document SEC (2008) 2293) (Online) Available from http://ec.europa.eu/education/policies/2010/doc/progress08/report_en.pdf [Accessed: 7 November 2009]
- Durando, M., Wastiau, P. & Joyce, A. (2009). *Women in IT: The European situation and the role of public-private partnerships in promoting greater participation of young women in technology* Special Insight Report (Online) Available at <http://resources.eun.org/insight/Science%20girls5.pdf> [Accessed: 20 July 2009]
- ERT (2009). *Mathematics, Science & Technology Education Report: The Case for a European Coordinating Body* (Online) Available at <http://www.ert.be/DOC%5C09113.pdf> [Accessed: 7 November 2009]
- Gras-Velázquez, À. & Joyce, A. (2008a). Inspire Deliverable D.2.1 *LRE Documentation* (Online) Available at: <http://inspire.eun.org/index.php/Publications> [Accessed: 20 November 2009]
- Gras-Velázquez, À. & Joyce, A. (2008b). Inspire Deliverable D.6.1 *Website* (Online) Available at: <http://inspire.eun.org/index.php/Publications> [Accessed: 20 November 2009]
- Gras-Velázquez, À. & Joyce, A. (2008c). Inspire Deliverable D.2.3 *Quality criteria and analysis of LOs in MST, Confidential*
- Gras-Velázquez, À. & Joyce, A. (2008d). Inspire Deliverable D.2.2 *List of Learning Objects* (Online) Available at: <http://inspire.eun.org/index.php/Publications> [Accessed: 20 November 2009]
- Gras-Velázquez, À., Joyce, A. & Beernaert, Y. (2008). Inspire Deliverable D.3.2 *Protocol of experimentation with the pilot schools. Confidential*
- Gras-Velázquez, À., Joyce, A. & Debry, M. (2009). *Women and ICT, Why are girls still not attracted to ICT studies and careers?* Cisco White paper (Online) Available at <http://eun.org/whitepaper> [Accessed: 7 November 2009]
- Inspire (2007). Innovative Science Pedagogy in Research and Education project, <http://inspire.eun.org>, [Accessed: August 2009]
- Jaakkola, T., Nurmi, S. & Ahokas, P. (2005). *Exploring the basics of electricity - Can online electricity simulation enhance learning?* In C. P. Constantinou, D. Demetriou, A. Evagorou, M. Evagorou, A. Kofteros, M. Michael, C. Nicolaou, D. Papademetriou & N. Papadouris (eds.) Integrating Multiple Perspectives on Effective Learning Environments. Abstracts of 11th biennial conference of EARLI (European Association for Research on Learning and Instruction). Nicosia, Cyprus, 23.-27.8.2005. Nicosia: Kailas Printers and Lithographers Ltd.
- Kay, R. & Knaack, L. (2008). *Investigating the Use of Learning Objects for Secondary School Mathematics*, Interdisciplinary Journal of E-Learning and Learning Objects, Vol. 4, 2008
- Kearney, C., Gras-Velázquez, À. & Joyce, A. (2009). *Stimulating teachers' and students' engagement in science education through the use of ICT-based tools and involvement in inquiry-based European projects*, STELLA eBook "Science Education in European Schools – Selected Practices from the STELLA Catalogue" (Online) Available from http://www.stella-science.eu/pool_good_practices.php

[Accessed: 18 November 2009]

- Kirsch, M. & Beernaert, Y. (2009a). Inspire Deliverable D.4.1 *Report of the experimentation in each of the 3 pilots. Objects* (Online) Available at: <http://inspire.eun.org/index.php/Publications> [Accessed: 20 November 2009]
- Kirsch, M. & Beernaert, Y. (2009b). Inspire Deliverable D4.2 *Final report and consolidated report on the 3 pilots. Objects* (Online) Available at: <http://inspire.eun.org/index.php/Publications> [Accessed: 20 November 2009]
- Lipsett, A. (2008). *Teens do not see science as route to good career.* (Online) Available at: <http://www.guardian.co.uk/education/2008/nov/07/science-careers-hamilton> [Accessed: July 2009]
- Lisbon (2000). Lisbon European Council 23 and 24 March 2000, Presidency Conclusions http://www.europarl.europa.eu/summits/lis1_en.htm
- LRE (2009). (Online) Available at <http://lre.eun.org/node/1> [Accessed: 10 November 2009]
- Osborne, J. & Dillon, J. (2008). Science Education in Europe: Critical Reflections: http://www.nuffieldfoundation.org/fileLibrary/pdf/Sci_Ed_in_Europe_Report_Final.pdf
- Parrish, P. E. (2004). *The trouble with learning objects.* Educational, Educational Technology Research and Development, Published by Springer Boston, Vol. 52, Num. 1, 49-67
- PISA (2000-2006). Results of the international studies PISA 2000 – 2006, reports. (Online) Available at: <http://www.pisa.oecd.org> [Accessed: 15 October]
- Pollen (2009). *Guide for the Seed City Trainer* (Online) Available at: <http://www.pollen-europa.net/telecharger.php?rep=A4GBpvsWB5RQFIr51PVPFQ%3D%3D&nom=3OLu8tmjtbP%2B9vqapVDTWO5YQj%2F0YX9c> [Accessed July 2009]
- Ripoll Mira, E., Gras-Martí, A. & Gras-Velázquez, À. (2010). *A inadecuación do currículo de Física no bacharelato*, Revista Enciga, *In preparation*
- Rocard et al. (2007). High Level Group on Science Education, Directorate General for Research, Science, Economy and Science, European Commission, *Science Education Now: A Renewed Pedagogy for the Future of Europe*: http://ec.europa.eu/research/science-society/document_library/pdf_06/report-rocard-on-science-education_en.pdf
- Sjøberg, S. & Schreiner, C. (2008). *Young people, science and technology; Attitudes, values, interests and possible recruitment; Selected results from recent research.* (Online) Available at: <http://www.ils.uio.no/english/rose/network/countries/norway/eng/nor-sjoberg-ert2008.pdf> [Accessed: 7 November 2009]

Annex 1: Forms filled in during the project by the different stakeholders

Forms (All the questionnaires can be found at http://inspire.eun.org/index.php/All_Forms)	Due Date	Expected	PDF	Electronic
Forms to be filled in by the School coordinator				
Form 1.1. Administrative information	At the beginning	1 per school	1.1	1.1 (xls)
Form 1.2. The monitoring by the national Inspire coordinator	At the end	1 per school	1.2_1.4	1.2 (Gf)
Form 1.3. The evaluation (in general)				1.3 (Gf)
Form 1.4. Evaluation by the pupils				1.4 (Gf)
Forms to be filled in by the MST teachers				
Form 2.1. Evaluation of the possible impact on the teachers BEFORE the pilot	At the beginning	1 per teacher	2.1	2.1 (Gf)
Form 2.2. Key selection criteria of the LR used by teachers	Before using each LR	1 per LR used	2.2	2.2 (xls)
Form 2.3. Disciplines or extracurricular activities to test the LR	After using each LR	1 per LR used	2.3	2.3 (xls)
Form 2.4. Evaluation of the possible impact on the teachers AFTER the tests	At the end	1 per teacher	2.4	2.4 (Gf)
Form 2.5. Evaluation of the impact on the pupils; opinion of the teachers	At the end	1 per teacher	2.5_2.6	2.5 (Gf)
Form 2.6. Impact on skills and attitudes of pupils; opinion of teachers				2.6 (Gf)
Form 2.7. Opinion of teachers on the follow-up by the Inspire school coordinator				2.7 (Gf)
Form 2.8. Appreciation of the monitoring by the teachers	At the end	1 per teacher	2.7_2.9	2.8 (Gf)
Form 2.9. The pedagogical approach to use the Learning Objects				2.9 (Gf)
Forms to be filled in by the Pupils				
Form 3.1. Impact of MST lessons / activities on pupils BEFORE the Inspire tests	At the beginning	1 per student	3.1	3.1 (Gf)
Form 3.2. Impact of MST lessons / activities on pupils AFTER the Inspire tests	At the end	1 per student	3.2	3.2 (Gf)
Forms to be filled in by the Inspire National Coordinator				
Form 4.1. ICT strategy of the school	At the beginning	1 per school	4.1_4.2	4.1 (Gf)
Form 4.2. Involvement in European, international. or bilateral projects				4.2 (Gf)
Form 4.3. Characteristics of classes expected to be involved/involved	At the beginning & end	2 per school	4.3	4.3 (xls)
Form 4.4. Planning / preparation / information	At the end	1 per school	4.4_4.5	4.4 (xls)
Form 4.5. Special organizational measures to facilitate the Inspire tests				4.5 (xls)
Form 4.6. Evaluation by the teachers	At the end	1 per school	4.6	4.6 (Gf)
Form 4.7. Impact on the school	At the end	1 per school	4.7_4.9	4.7 (Gf)
Form 4.8. Evaluation of the impact on the education system				4.8 (Gf)
Form 4.9. Documenting the project activities				4.9 (Gf)
Form 4.10. Dissemination of the project outcomes	At the end	1 per school	4.10_4.11	4.10 (xls)
Form 4.11. Facilitators				4.11 (xls)

Annex 2: The Inspire Learning Resources

Physics

LR ID	Subcategory	Title	Author	en	ca	de	es	it	lt
P1-5-1	Kinematics	Distance-displacement	David Harrison	✓	✓		✓		
P2-5-2	Kinematics	Motion with constant acceleration	Walter Fendt	✓		✓	✓	✓	
P3-5-3	Sound	Changing sounds	National Council of Teachers of Mathematics, USA	✓					
P4-5-4	Dynamics	Conservation of Energy	B. Surendranath Reddy	✓					
P1-13-5	Electricity	Ohm's law	Walter Fendt	✓		✓	✓	✓	
P2-13-6	Optics	Reflection-refraction	David Harrison	✓	✓		✓		
P3-13-7	Mechanics	Galilean relativity	Physics@UNSW	✓					
P4-13-8	Nuclear Physics	Radioactive decay	David Rea	✓					
P1-17-9	Oscillations	Beats	Walter Fendt	✓					
P2-17-10	Dynamics	Forces on pendulum	David Harrison	✓	✓		✓		
P3-17-11	Relativity	Time dilation	Joakim Linde	✓					
P4-17-12	Optics	Young's Double Slit Experiment	B. Surendranath Reddy	✓					

Chemistry

LR ID	Subcategory	Title	Author	en	ca	de	es	it	lt
C1-5-13	Molecules	Molecular weight calculator	Bruno Herreros	✓					
C2-5-14	Physical Ch	Additive colours: RGB	ChemConnections R. Rusay	✓					
C3-5-15	General Ch	Periodic table Tetris	eChalk.co.uk	✓					
C4-5-16	Physical Ch	Characteristics of materials	bbc.co.uk Science clips	✓					
C1-13-17	General Ch	Advanced periodic table	Bruno Herreros	✓					
C2-13-18	Gas laws	Processes in an ideal gas	Walter Fendt	✓		✓	✓	✓	
C3-13-19	Reactions	Stoichiometry	TheChemCollective	✓					
C4-13-20	Chemical equilibrium	Le Chatelier's principle	Essential Chemistry, 2/e Raymond Chang	✓					
C1-17-21	Structure of crystals	Table salt	EdInformatics.com	✓					
C2-17-22	Inorganic Ch	Why things have colour	TheChemCollective	✓					
C3-17-23	Gases	Gas simulator	Bruno Herreros	✓					
C4-17-24	Spectroscopy	Molecular vibrations	Edwin A. Schauble	✓					

Biology

LR ID	Subcategory	Title	Author	en	ca	de	es	it	lt
B1-5-25	Environment issues	Fishing	Greenwings Ducks Unlimited, Inc.	✓					
B2-5-26	Animals	Habitats	bbc.co.uk Science clips	✓					
B3-5-27	Animals	Virtual frog builder	David Robertson	✓		✓	✓	✓	
B4-5-28	Anatomy	Skeletons	University of Texas at Austin	✓					
B1-13-29	Population dynamics	Predator prey	D. Zachmann	✓					

B2-13-30	Cells	Mitosis Animation	Jeff Bell	✓
B3-13-31	Cells	Diffusion across a plasma membrane	Rick Mynark Mark Ronan	✓
B4-13-32	Immunology	The life cycle of a malaria parasite	Malaria Welcome Trust	✓
B1-17-33	Zoology	Animal diversity	University of Michigan	✓
B2-17-34	Genetics	Pea experiment	Bill Kendrick	✓
B3-17-35	Biochemistry	Photosynthesis	Reginald H. Garrett Charles M. Grisham	✓
B4-17-36	Immunology	Retrovirus	http://www.whfreeman.com/ Richard A. Goldsby, Thomas J. Kindt and Barbara A. Osbor Kuby Immunology	✓

Maths

LR ID	Subcategory	Title	Author	en	ca	de	es	it	lt
M1-5-37	Geometry	Sum angles triangle	Walter Fendt	✓		✓		✓	
M2-5-38	Numbers	Maya numbers	Michiel Berger	✓					
M3-5-39	Geometry	Elementary geometry	Silvia Díez de Rivera	✓					
M4-5-40	Geometry	Conservation of area	IES Inc.	✓					
M1-13-41	Calculus	Derivative of sinus function	David Harrison	✓	✓		✓		
M2-13-42	Trigonometry	sin, cos, tan	Walter Fendt	✓		✓	✓	✓	
M3-13-43	Statistics	Handling data	David Lane	✓					
M4-13-44	Calculus	Plotting functions & continuity	Eric Carlen	✓					
M1-17-45	Calculus	Area of circle as a limit	David Harrison	✓	✓		✓		
M2-17-46	Complex num.	Operations with complex num.	Walter Fendt	✓		✓	✓	✓	
M3-17-47	Probability	Random Birthdays	Susan Holmes	✓					
M4-17-48	Geometry	Equation of a plane	Franz Embacher, Petra Oberhuemer	✓					

IT

LR ID	Subcategory	Title	Author	en	ca	de	es	it	lt
T1-5-49	Applications	Typing course	Peter Hudson.	✓					
T2-5-50	Modelling	Rubik's cube	Lars Petrus	✓					
T3-5-51	Hardware	Computer block diagram	Peter Ruwoldt (watiwara)	✓					
T4-5-52	Offimatics	Display photos (posters)	Teaching ideas	✓					
T1-13-53	Media technology	How does TV work?	Alexander Repenning	✓					
T2-13-54	Offimatics	Teachers' Templates	NPS Instructional Tech. & Media Services	✓					
T3-13-55	Hardware	Computer Parts Hangman	Sabrina Sterling	✓					
T4-13-56	Hardware	Click & learn computer parts	Mike Barnard.	✓					
T1-17-57	Processes	Quiz maker	Attotron Biosensor Corp.	✓					
T2-17-58	Processes	CD/DVD Duplication Process	Marshall Brain	✓					
T3-17-59	Offimatics	Gif maker	3DTextMaker	✓					
T4-17-60	Storage media	Memory remanence	J. Alex Halderman Seth Schoen Nadia Heninger et al	✓					

