PROMOTING INQUIRY
IN MATHEMATICS AND SCIENCE
EDUCATION ACROSS EUROPE

CAPACITIES

The PRIMAS project: Promoting inquiry-based learning (IBL) in mathematics and science education across Europe

IBL implementation survey report

PRIMAS has carried out a pre-post survey on inquiry-based learning and teaching (IBL) across European partner countries. A successful implementation of IBL in different European countries is subject to various factors that may impede or foster its broad uptake. It faces various challenges like the broad variety of teaching cultures and a rather heterogeneous landscape of teacher professional development concepts in the various European countries. The evaluation on the development of teachers and students collected empirical knowledge and thus helps to reflect on the success of PRIMAS. The results of the survey are published in this report

www.primas-project.eu

SEVENTH FRAMEWORK PROGRAMME

The project PRIMAS has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 244380.

PROMOTING INQUIRY
IN MATHEMATICS AND SCIENCE
EDUCATION ACROSS EUROPE

Project Information
Project no. 244390
Project acronym: PRIMAS
Start date of project: 01/01/2010
Duration: 48 months
Project title:

Promoting inquiry-based learning in mathematics and science education across Europe

Dissemination level
Thematic Priority: Science in Society
Funding scheme: FP7/ CSA/ Capacities

Information about the deliverable
Deliverable N° 9.3
Due date of deliverable: Month 48
Actual submission date: 20/12/2013
Deliverable title:

IBL implementation survey report

Contact Information
Coordinator: University of Education Freiburg, Prof. Dr. Katja Maaß
Lead partner for this deliverable: IPN Kiel (Leibniz-Institut für die Pädagogik der Naturwissenschaften und Mathematik an der Universität Kiel), Dr. Katrin Engeln

Website: http://www.primas-project.eu/

The project PRIMAS has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 244380.

SEVENTH FRAMEWORK PROGRAMME

Table of Contents

The project PRIMAS has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 244380.

Executive Summary

Background

In many educational systems serious concerns are being raised about the status and the impact of science education and the decrease of students' interest in key science subjects. In the European context, reports by expert groups have identified the necessity of a renewed pedagogy in school that transforms the traditional mainly deductive teaching styles towards more appealing and cognitively activating forms of learning. Inquiry based science education is identified as the method of choice to increase students' interest and achievement in science. Accordingly, many projects funded within the FP7 framework focus on various ways to foster inquiry based approaches in mathematics and science education. A successful implementation of inquiry based learning (IBL) in different European countries is subject to various factors that may impede or foster its broad uptake. It faces various challenges like the broad variety of teaching cultures and a rather heterogeneous landscape of teacher professional development concepts in the various European countries. Bringing together 14 partner institutions and their associated teams from 12 different nations the PRIMAS project meets this challenge. The aim of the project is to effect a change across Europe in the teaching and learning of mathematics and science focusing on supporting teachers when developing inquiry based learning pedagogies. Ultimately, the objective is to ensure that a greater number of students develop more positive dispositions towards these subjects as well as additionally ensuring that students develop competencies that will prepare them well for life as critical inquirers in mathematics and scientific domains.

Aims and purpose of the PRIMAS evaluation work package

Within the work of the project, work package 9 (WP 9) aims to evaluate the overall success of implementation of inquiry-based learning. The evaluation will focus on teachers that were involved in professional development courses offered within the project. We want to find out whether their teaching practice has changed to be more IBL-oriented. To assure our findings we not only focus on the teachers but also investigate their students' perspective. Additionally, the survey aims to provide results about the status and the variety of teaching cultures with respect to IBL.

Methodology and research design

A multi-faceted perspective of an inquiry based teaching and learning culture was developed in cooperation with the consortium members. This approach represents the theoretical foundation of developing the questionnaires used in the study.

For the purpose of the study a teacher questionnaire was developed. Based on this questionnaire we made a student questionnaire. Both questionnaires have comparable sections on the actual teaching practice referring to a specified subject. In addition, teachers

The project PRIMAS has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 244380.

SEVENTH FRAMEWORK PROGRAMME

are asked about their views of IBL and students are asked about their subject preferences and their interests.

The questionnaires were distributed among the teachers at the first professional development meeting. The teachers were asked to distribute the student questionnaire to one of their classes as soon as possible. They were asked to choose a class which they expect to remain teaching until the professional development program is completed.

Summary findings and conclusions

The study shows an overall positive orientation towards IBL in all PRIMAS countries but also significant country-depended differences. The implementation of IBL is significantly influenced by the subject in question. Science teachers report to use more IBL than mathematics teachers. Interestingly, there is a strong interaction with the country. In some countries mathematics teaching seems to be more static, more defined und more sequential allowing little room for IBL.

Teachers address many problems that hinder a broad uptake of IBL. The difficulties that teachers see with respect to the implementation of IBL can be subsumed in three factors: systemic restrictions, classroom management, resource restrictions. There are big differences within the consortium members with respect to judging the relevance of systemic and resource restrictions. Therefore, an implementation of IBL across Europe faces very different problems.

The project PRIMAS met this challenge. We were able to confirm that through the professional development courses the project PRIMAS improved mathematics and science education. Our analysis of the data of the pre-post survey showed that teaching practices changed significantly. After the professional development courses the IBL-index indicating the frequency of IBL in classroom practice increased significantly. Therefore, we were able to prove that our efforts not only reached the teachers, even students were aware of these changes. This is a great success. The project PRIMAS used the unique opportunity to work internationally and especially with people from different professional backgrounds. This opportunity also involved working on a national level with experienced and motivated teachers and teacher educators as multipliers. Having developed a common understanding of IBL and a common model for professional development there was still enough room for nationally adapted courses to meet the needs within a specific teaching- and learning culture.

The project PRIMAS has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 244380.

SEVENTH FRAMEWORK PROGRAMME

1. Main Report

The aim of the WP9 was to get an overview about the European situation regarding the implementation of inquiry based learning (IBL) and about changes in the implementation of IBL in those schools who took part in the professional development courses delivered within the project PRIMAS. Therefore, both teachers and students from the twelve different countries of the consortium were asked to fill out two questionnaires within a pre-post design. The results give insight in the current status of IBL in the different teaching cultures. Furthermore, the results document the success of the project PRIMAS. First the theoretical background, especially the understanding of IBL is described. In addition, the questionnaires and the design of the survey are introduced. Afterwards, the results of the survey are reported and discussed.

1.1 Theoretical Background

In this section an overview of a multi-faced perspective on IBL is given. Based on this perspective the questionnaires for the survey have been developed. The design of the questionnaires and of the conducted survey will be presented.

1.1.1 Perspective on IBL

Inquiry based learning has a long history and there are many approaches to teaching and learning as inquiry (Barrow 2006; Prince and Felder 2007). In the USA the tradition of inquiry based learning goes back to Dewey (1859–1952) (Dewey 1910), whereas in Germany, for example, inquiry based learning was introduced within the reformist pedagogy in the 1920s (cf. Wagenschein 1962).

In discussions on improving education, the word “inquiry” is used in different ways and contexts. Not only is the term inquiry-based learning used without clarifying connections and distinctions, but also terms such as inquiry-based teaching, inquiry-based method, inquiry-based education and inquiry-based pedagogy are widespread. Furthermore, IBL is often conflated or used interchangeably with other terms that describe similar learning and teaching approaches such as anchored instruction, hands-on, problem-based, project-based, student-centered, inductive and dialogic approaches (Anderson 2002; Hayes 2002). For example, the Rocard Report (Rocard et al. 2007) identifies problem-based learning as the method of choice for mathematics education and inquiry-based learning for science education. Altogether, it is not clear whether problem-based learning and inquiry-based learning can be used interchangeably. The failure to give a concrete definition has led to misunderstandings and is one reason for discussions about the effectiveness of IBL. For example, Kirschner et al. (2006) characterize inquiry learning, inquiry-based teaching and problem-based learning as minimal guidance approaches and conclude that these approaches do not work. In a direct response Hmelo-Silver et al. (2006) argue that problem-based learning and inquiry learning are not minimally guided approaches but rather provide extensive scaffolding and guidance.

The project PRIMAS has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 244380.

SEVENTH FRAMEWORK PROGRAMME

In a narrow sense, IBL refers to learning that takes place following the processes that are involved in scientific inquiry. Students are encouraged to pose questions, to formulate assumptions and hypotheses, to gather and analyse data and to construct evidence-based arguments.

Subject-specific differences in the understanding and the implementation of IBL exist. These differences can be related to the nature of the subject in question that is transformed to a certain degree to the school subject. For instance, mathematics teachers tend to see their subject much less related to empirical findings, and at the same time more axiomatically oriented, more deductive and sequential and more structured, than science teachers see their subjects (e.g. Stodolsky and Grossman 1995). Experiments are more prominent in science than in mathematics and serve a spectrum of purposes, for instance in gaining knowledge, in grounding knowledge in experience and in testing hypotheses. In spite of their central role in the scientific method the actual practice of experimental work in school has been critically discussed; in particular, the so-called cookbook exercises where students follow recipes to reach particular, pre-determined outcomes have been subject to criticism for different reasons. They give an inadequate picture of scientific inquiry and they fail to motivate students. The resulting tension between inquiry in classrooms and the scientific inquiry process and related problems are discussed elsewhere (e.g. Chinn and Malhotra 2002a; Hodson 1996; Hodson and Brencze 1998; Hofstein and Lunetta 2004; Kirschner 1992; Lunetta 1998).

Due to the different understandings of IBL as discussed above and due to the different perspectives of the countries involved in PRIMAS, a broader definition of IBL was elaborated within the project (**Fehler! Verweisquelle konnte nicht gefunden werden.**). According to this definition, IBL is seen as a multi-faceted teaching and learning culture which sees the process of inquiry central for learning but also emphasizes that:

- students construct meanings,
- meaningful learning takes place in a social context,
- learning is supported by meaningful contexts (situated cognition) and
- learning is a dialogic process (e.g. Cunningham and Helms 1998; Duit and Treagust 1998; Mortimer and Scott 2003).

The project PRIMAS has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 244380.

SEVENTH FRAMEWORK PROGRAMME

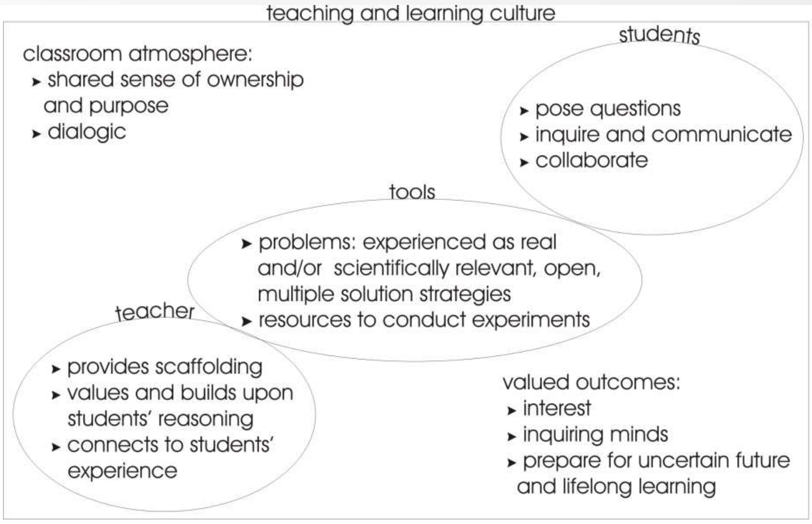


Fig. 1 A multi-faceted approach to IBL

Students take responsibility for their own learning as they learn to work individually as well as in groups. The covered topics are relevant to the students and their prior experience is adequately taken into account. Thus, by engaging students actively in the construction, evaluation and reflection of knowledge, inquiry-based education promotes competencies that are relevant for lifelong learning and for a successful orientation in a complex world. On the teachers' part, orchestrating and facilitating learning processes, for example through modeling and coaching, is a subtle skill that is critical in making IBL function well (Barrow 2006; Colburn 2006; Hmelo-Silver 2004; Prince and Felder 2007).

There are different factors that teachers see as problematic concerning the implementation of IBL into classroom practice. All of them have to be taken seriously. Walker and Colburn (Colburn 2000; Walker 2007) give an overview on the problems teachers see with the use IBL. They can be divided into two groups:

- Problems related to the school environment,
- Problems related to the individual teacher.

The requirements of the school system which can hinder the uptake of IBL are specifications of the curriculum, especially on content, the time being available for instruction and the existing assessment practice. All this is seen as problematic even though the PRIMAS analysis of the national context (see Deliverable 2.1) points out that at least the curricula of the European countries participating in the PRIMAS project support the uptake of IBL. In addition teachers have insufficient access to continuous professional development courses regarding IBL and do not feel supported by the school environment, e.g. colleagues. Furthermore there is a lack of resources that are necessary or that facilitate the use of IBL. Teachers miss appropriate textbooks, teaching materials and in many cases, especially in science, access to materials such as computers and laboratories.

The project PRIMAS has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 244380.

Also there is disaffirmation towards IBL on a more individual level. Teachers do not feel confident with rethinking their rule from initiator and controller to guide and facilitator. They worry about the possibility for discipline problems, exorbitant preparation requirements, and their lack of knowledge in a particular topic.

One has to be aware that the "task of preparing teachers for inquiry teaching is much bigger than the technical matters...the matter must be addressed... at a level that includes central attention to beliefs and values" (Anderson 2002). The uptake of IBL highly depends on teachers' attitudes and beliefs.

According to a multi-faced understanding IBL is not only characterized by the relevance of the process of inquiry but although by the classroom atmosphere, the rule of the teacher, the used tools and the aim.

1.1.2 Teacher and student questionnaire

Within the project PRIMAS a teacher questionnaire has been developed to take a closer look at the European situation regarding inquiry-based learning and teaching differentiating countries (consortium) and disciplines (see Deliverable 9.1 of Primas). This baseline questionnaire had been developed based on a multi-faced understanding of IBL. It has been adapted for the pre-post study. The student questionnaire has been developed on the basis of the teacher questionnaire. In each case the same questionnaire was used within the pre and the post survey.

Constructing the questionnaires it was tried to keep the questionnaire as short as possible for not deterring the teachers and the students to take part in the survey and at the same time long enough to get rich data. On the basis of the PISA study (OECD 2009) four-point Likert-type items were used when ever suitable. These items do not allow teachers and students to opt for a neutral response. Based on the PISA study the used categories of the four-point scales reflect frequencies or agreement (never or hardly ever, in some lessons, in most lessons, in almost all lessons and strongly disagree, disagree, agree, strongly agree).

The teacher questionnaire is composed of three sections (Appendix 1: Teacher questionnaire):

- Personal data,
- Current practice at classroom level referring to a certain subject,
- Inquiry based learning,

Within the first section (question 1 to 6) some background information about the individual teacher is gathered. Probable the most important variable in the context of the European project PRIMAS is the country. Furthermore a code is generated to match the pre-and the post-questionnaires.

Within the second section teachers are asked to describe their current teaching practice with reference to a particular subject and age group. The items of question 9 and 10 refer to the

The project PRIMAS has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 244380.

facets of IBL described in 1.1.1. These items probe deeply into the scripts of the teachers and their views of teaching and learning. In this part we expect change to occur, provided that the ideas of IBL have been successfully taken up by the teachers. Ten items are adapted from the 15 items about science learning and teaching (OECD 2009, pp. 333-336) used in the Pisa student questionnaire. These items are part of the scale int “students' interaction”, app “reference to application”, hon “hands-on experience” and inv “investigation”. According to the multi-facet understanding of IBL these scales give insight into the implementation of facets of ILB.

The final section information about teachers' beliefs and practice in relation to implementing inquiry based learning are collected. The items refer to the school system oriented and the individual problems described in 1.1.1. In particular they relate to the requirements of the school system including assessment practice, the available resources and classroom management. In addition, teachers are about their satisfaction with the exiting situation.

An overview about characteristics of the items used in the teacher questionnaire is given in Appendix 3: Teacher questionnaire: Item scale documentation.

Consistent with the teacher questionnaire the student questionnaire has been developed (Appendix 2: Student questionnaire). The student questionnaire has only two sections:

- Personal data
- Current practice at classroom level referring to a certain subject

With the first section students are asked for their age, their gender and their subject preferences. Furthermore, a code is generated to match the student questionnaires within the pre-post study. This code can also be used to match the student data with the corresponding teacher data. The second part, question 10 and question11, includes exactly the same items describing teaching practice as they have been used within the teacher questionnaire (question 9 and 10). Additionally, there are items asking student about students' interest in the subject in question and as the same items. These items are based on the interest theory of Krapp and others which takes into account that interest is multi-dimensional construct (Krapp 2005). In this context it is important that the students like the subject, that the think that is worthwhile to be engaged with the subject and that they have a desire to know more about the subject.

1.1.3 Survey

The questionnaires have been developed with support from the Consortium by WP9. Members of the consortium were responsible for translating the questionnaires in the required languages. We conducted a pre-post study to get insight into the effect of the professional development courses. The questionnaires were distributed to the teachers at the first professional development meeting. The teachers were asked to distribute the student questionnaire to one of their classes as soon as possible. They were asked to choose a class which they expect to remain teaching until the professional development program finishes. Just before the last meeting participating teachers gave the second questionnaire to their students. They brought the student questionnaires to the last meeting and filled out the second questionnaire themselves. In most cases a paper pencil approach was used. The main purpose of the survey was to test for effects of the project PRIMAS on the implementation of IBL. There we intended to look for changes in the frequency of IBL in daily teaching practice. Furthermore, we intended to look for the effect of the country (cultural background) and the subject in question on beliefs and teaching practice.

The student questionnaire was intended to give insight into students' interest in mathematics and the sciences depending on gender and the country (cultural background). In addition, we were interested to see whether the frequency of IBL in daily teaching from the stundets' perception is related to the teachers' viewpoint. Finally, we wanted to find out if changes reported by teachers can already be detected from the students' viewpoint.

1.2 Survey

A pre-post study was conducted to gain insight into the effects of the PRIMAS intervention. Both teachers and students taught by the participating teachers took part in the survey. Both groups filled out questionnaires at the beginning of the interventions and also after the PRIMAS interventions finished. First, we will report the variation of implementation strategies within the participating countries. The professional development courses followed the same framework: They were based on the same theoretical basis, the same pedagogical principles. In particular, the PRIMAS professional development program offered support for all components of professional competence (belief, motivation and self-reflection); relevance for day-to-day teaching; opportunities to experiment with new pedagogies in seminars and in daily teaching practice; changes to discuss and exchange experiences with new pedagogies; possibilities for teachers to connect reflections with beliefs by presenting and discussing example opinions in favour or against IBL aspects and a clear focus on IBL (Maaß and Doorman 2013). All partner countries used a selection of professional development modules provided by WP3. Furthermore, in order to ensure a widespread implementation of IBL multipliers who carried out professional development courses were educated. These multipliers were either motivated teachers or teacher educators. Due to different national contexts as reported in the deliverables of WP2 and WP7 national adoptions were necessary. These adaptations did not concern main principles but rather the organisational framework of the professional development courses as reported below.

Following this introduction, we will report the results from the analyzed teacher data. To begin with, we give an overview of the sample. Following this, we will analyze the pre teacher data, especially with respect to subject and cultural differences. Finally, we will inform the reader about matching the pre and the post data and the results of paired-samples t-tests. The paired t-test is commonly used to compare a sample group's scores before and after an intervention. In this case we tested the effect of the professional development courses on beliefs of the teachers and their teaching.

The project PRIMAS has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 244380.

SEVENTH FRAMEWORK PROGRAMME

The last section of this chapter reports the results of analyzing the student data. As with the teachers, we first give an overview of the sample before presenting the analysis of the pre data. Here, we focus on country, subject and gender differences. Finally, we show the results of matching the pre and the post data and conducting paired-samples t-tests.

1.2.1 Implementation strategies in the countries

Within the PRIMAS project different ways of organizing the professional development courses were used in the partner countries:

- The courses were either voluntary or compulsory; however; the majority were voluntary.
- The multipliers were either motivated teachers or teacher educators.
- The duration of the professional development courses varied due to national requirements. Some had three day meetings; other consisted of up to fourteen meetings.
- Some courses were held within three days while others ran for over two years.
- In some cases credit point were given for attending the courses.
- The courses took place at the University, teacher training centers, the head department, schools and also at museums.

Even within the countries there is a variety of courses offered. In all countries a selection of the seven PRIMAS CPD modules developed within WP 3 were used (Module 1 “Student-led Inquiry”, Module 2 “Tackling unstructured Problems”, Module 3 “Learning Concepts through IBL”, Module 4 “Asking Questions that promote Reasoning”, Module 5 “Students working collaboratively”, Module 6 “Building on what Students already know”, Module 7 “Self and Peer Assessment”) (http://www.primas-project.eu). This variety between the countries and in some cases within a country makes it challenging to implement a centralized program evaluation.

The PRIMAS team in **Cyprus** mainly provided three types of courses. In total, eight courses were provided. All of the courses were voluntary, since in-service training in Cyprus is mainly on a voluntary basis, and organised by the experienced teacher educators. The first type of course (five courses) was provided by PRIMAS team members and multipliers. A number of these courses had been accredited by the Cyprus Pedagogical Institute and participating teachers received a letter of participation from the Cyprus Pedagogical Institute (part of the Ministry of Education and Culture). The duration of these courses was 15 hours and were delivered in five three-hour sessions. Additionally, some courses had an extra meeting. Between ten and 25 teachers participated in each of these courses. The second course type was provided in cooperation with other projects (and initiatives), such as the Geogebra Institute and the Release project (Teachers’ Self Regulation Strategies). Two courses were provided, and between ten and 25 teachers participated in each course. In addition to these

The project PRIMAS has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 244380.

courses, school-led CPD courses were implemented in three secondary schools. At each school two to five one-hour sessions took place.

In **Denmark** ten courses were offered. All courses were voluntary and were led by experienced teacher educators. Seven of them had a similar structure. They were held within three to four months, had five meeting days out of which two or even three were blocked. Around ten to twenty teachers joined these CPD courses. Furthermore the Danish PRIMAS team offered an intensive week course on "inquiry in mathematics teaching". Twenty-six teachers attended this course.

In **Germany** nine different CPD courses were offered within the PRIMAS project. All courses were voluntary. They started between February 2012 and September 2012. Two of the courses addressed primary school teachers whereas the rest addressed secondary school teachers. All courses were conducted by motivated teachers. They all took place at different schools and had between eight and 18 participants. All these courses had between four and seven half-day meetings with about three months in between the meetings. Furthermore, there were two day events for all CPD members led by members of the PRIMAS consortium at the University of Education in Freiburg. Eighty teachers attended these CPD events.

In **Hungary** eight more or less identical CPD courses took place at eight different Hungarian cities. The courses had four day-long meetings. In one case these meetings were held within one week apart from that within three to six weeks (including Christmas break). The courses had between 15 and 20 participants and were led by motivated teachers as multipliers. All courses had a comparable content containing a theoretical „warm-up" session based on the special issue of the journal „Iskolakultúra" and the PRIMAS Nottingham PD modules from one to five. Teachers earn state approved credit points for participation.

In **Malta** there were eleven comparable CPD courses. All of them took place at different secondary schools. In nearly all cases there were two different CPD courses at the same Venue – one for maths and one for science teachers. All courses were led by motivated and trained teachers and had between four and six voluntary participants. All the sets started to meet in October 2011 with the exception of one set which commenced one year later. The teachers of one set met regularly in their school during school time. Multipliers met their school sets either every week or every fortnight. The meetings lasted around one hour. The courses were based on the PRIMAS Nottingham PD modules, especially the modules "Asking Questions that promote Reasoning", "Tackling unstructured Problems" and "Students working collaboratively" were used.

In the **Netherlands** ten similar CPD courses were implemented at different schools for secondary maths and science teachers. Within the courses the PRIMAS Nottingham PD modules with extra science tasks were used. The first course ran from September 2011 to April 2012. Based on the experience from this course nine additional courses started in September 2012. These courses involved between four and six meetings each lasting approximately three hours. Ten to twenty teachers attended each of the courses. They were led by both experienced teacher trainers and motivated teachers. For some of the

The project PRIMAS has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 244380.

SEVENTH FRAMEWORK PROGRAMME

participating teachers the offered courses were compulsory. In addition, the Dutch team also implemented the PRIMAS Nottingham modules "Student-led inquiry", "Building on what students already know" and "Self and peer assessment" into four courses on promoting beta-excellence. They started in September 2011. All of them had eight full day meetings within one year. The courses had 20 to 25 participants each.

In **Norway** eight different CPD courses for teachers were held within the PRIMAS project. All courses took place at the schools where the teachers worked. With one exception all started in the second half of 2012. Except for one course teachers were expected to participate in the offered courses. The courses had between ten and 40 participants. There were between three and twelve meetings of one to four hours length. In between the meetings there were often intervals of more than one month. All courses were led by trained and motivated teachers, and in most cases two multipliers worked together to give a course. The multipliers had been trained by the PRIMAS team within seven full day meetings.

In **Romania** fourteen CPDs were offered within the PRIMAS project. All activities were voluntary. They took place at the Babes-Bolyai University, the Lyceum foundation and also at schools where the multipliers or the participating teacher work. The multipliers were experienced teacher trainers. Some of the courses addressed between 20 and 60 teachers and were run within three to six days. During this time, the participants had intense contact with the ideas of IBL. They had up to 50h of meetings, for example they had eighteen three-hour meetings. Besides these courses, eight CPD courses were offered at different schools. They started in the second half of 2012. They were organised by a team of multipliers. These courses had around ten participants; and around ten four-hour meetings. In between the meetings there were breaks of approximately four weeks.

In **Slovakia** eight different CPD courses were offered within the PRIMAS Project. They had between ten and thirty voluntary participants. The CPDs were settled at the university and were situated at particular departments' facilities (PC laboratories, chemistry, physics and biology laboratory). Some courses took place at an external location. Each course had around six meetings within three months. One of the courses was held within a week. PRIMAS CPDs were accredited by the Ministry of Education of Slovak Republic. The number of lessons in all of them was 110 (per 45 minutes) divided into presence (50 – 55 lessons) and distance learning with e-learning support (Moodle). Participants received credits after graduating from the course. The credits allowed them to ask for a higher salary level. The courses were led by experienced teacher trainers in cooperation with motivated teachers. The multipliers were trained by using all seven PRIMAS Nottingham CPD modules. Another important feature of PRIMAS CPD in Slovakia was that it was free of charge. Other CPD courses which are offered by Faculty of Natural Sciences have to be paid for personally by teachers.

The **Spanish** PRIMAS team implemented seven comparable CPD courses at six teacher centers and a science center in the Andalusia area. They took place in the first half of 2012. All courses were led by teams of multipliers. Except for one course which had less, all other

The project PRIMAS has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 244380.

SEVENTH FRAMEWORK PROGRAMME

courses had between eleven and 26 participants. The groups met between five and eight times for three to four hours within three months. All the courses included a similar number of hours for teachers' autonomous work. Most of the courses were planned with 20h of face-to-face sessions and 20h of teacher work. Between the meetings teachers gained experience with IBL and then reported back in the next session. All seven courses were based on the PRIMAS Nottingham modules (Module 1 “Student-led Inquiry”, Module 2 “Tackling unstructured Problems”, Module 3 “Learning Concepts through IBL”, Module 4 “Asking Questions that promote Reasoning”, Module 5 “Students working collaboratively”).

The **Swiss** PRIMAS team together with multipliers offered a compulsory course. The course was held for eighteen groups of fifteen to twenty teachers each time. Each course had three meetings, two half-days and one full day. The Swiss PRIMAS team collaborated with the Ministry of Education and reached all the teachers of lower secondary education in the region of Geneve. Being compulsory brought about the fact that the training could not exceed two days (for obvious practical reasons). An additional reason was that some teachers did not like to be forced to follow the course and therefore frequently offered some strong resistance. Besides the compulsory courses the Swiss PRIMAS team offered a two day CPD at the museum of history of science for 14 teachers. It also offered three two-day CPD with some experiments from participants between the different training days. This was on a volunteer's basis, two CPD were for secondary school teachers, one for primary school teachers, and all got about 20 participants. Basically each group followed an annual teaching corresponding to 60h and several occasion to experiment.

The PRIMAS team from the **United Kingdom** offered a variety of courses. All of the courses were voluntary and conducted by members of the PRIMAS team. Some courses were in cooperation with other projects such as “Bowland Lesson Study” or “NRICH”. Besides these courses, school-led CPD courses were implemented in four secondary schools. At each school four one-hour meetings took place. The schools chose two modules from the PRIMAS Nottingham modules and worked on them without external support. They ran their own meeting with their departments. Altogether forty teachers participated in this school-led CPD. Eleven teachers were observed and videotaped during the process.

A variety of courses is offered within the PRIMAS project. For example duration, content, number of meeting and number of participants show differences.

1.2.2 Teachers sample

The teacher pre-questionnaire was distributed in all twelve participating countries. Altogether it was filled out by 1219 teachers. The number of teachers varies between 46 (4%, Malta) and 192 (16%, United Kingdom) within the countries. In all, 37% of the sample is male. The proportion of male teachers varies significantly between the countries. In Hungary and Slovakia, for example, only 11% of the sample is male while in Denmark, the Netherlands

The project PRIMAS has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 244380.

SEVENTH FRAMEWORK PROGRAMME

and Switzerland more than half of the teachers are male (Table 1). More than three quarters of the sample teach mathematics. The variation between the countries is significant. At least 90% of the Norwegian, Swiss and British sample teach mathematics while the same applies for less than 50% of the Dutch and the Slovakian sample. In all, 63% of the sample refers to maths and 37% to science (physics/chemisty, biology, general science) when answering the questions about teaching practice. Moreover, 64% of the sample teaches only one of the subjects mathematics, physics, chemistry, biology and general science. Again, significant differences between the countries exist. More than 80% of the sample from Cyprus, Malta, Romania and the United Kingdom teaches only one of the subjects of interest. For Hungary this holds true for only 35% (Table 1). Furthermore, the teachers in the sample refer to different age groups. Only 8% of the sample refers to the age group ten years and younger, while 47% chose the age group ten to 14 years and 45% the age group 14 years and older. Again, conspicuous differences between the countries exist. In Romania and Denmark more than 70% of the teachers refer to ages 14 years and older, where in Malta more than 70% refer to the age group 12 to 14 years. Noticeably, in Spain nearly 40% of the teachers refer to the age group 10 years and younger (

Figure 2). The post sample shows a similar structure (Table 2).

Table 1

Overview of the sample of the sample of the teacher pre-study

	Sample size (proportion)		Male porportion	proportion mathematics teacher	Proportion teaching only 1 subject
Cyprus	117	(.10)	.33	.61	.86
Denmark	70	(.06)	.56	66	.57
Germany	70	(.06)	.37	.87	.41
Hungary	103	(.08)	.11	.58	.35
Malta	46	(.04)	.37	.52	.87
Netherlands	83	(.07)	.52	.41	.71
Norway	68	(.06)	.48	.90	.28
Romania	106	(.09)	.33	.76	.95
Slovakia	119	(.10)	.11	.48	.47
Spain	156	(.13)	.36	.77	.46
Switzerland	89	(.07)	.60	.91	.66
UK	192	(.16)	.48	.94	.86
Total	1219	(1.00)	.33	.72	.64

note: Teachers are only asked whether they teach mathematics, physics, chemistry, biology or science – therefore one subject only refers to this group of subjects.

The project PRIMAS has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 244380.

SEVENTH FRAMEWORK PROGRAMME

Figure 2

Age groups teachers refer to in the different countries.

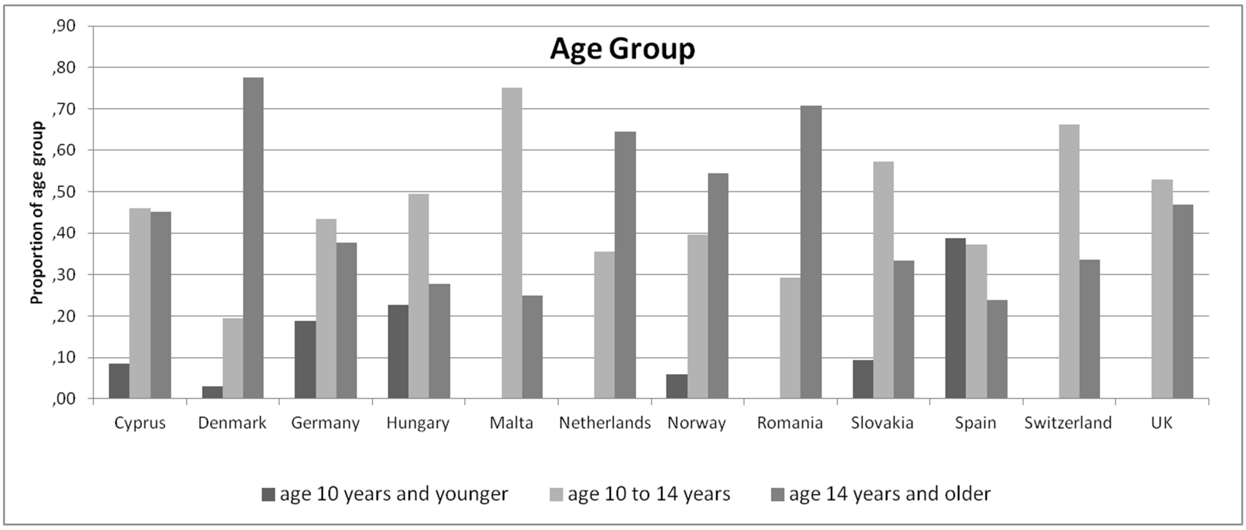


Table 2

Overview of the sample of the sample of the teacher post-study

	Sample size (proportion)		Male porportion	proportion mathematics teacher	Proportion teaching only 1 subject
Cyprus	68	.08	.28	.59	.97
Germany	29	.04	.52	.86	.24
Hungary	98	.12	.13	.60	.34
Malta	34	.04	.35	.53	.82
Netherlands	60	.07	.53	.28	.80
Norway	27	.03	.39	.96	.41
Romania	106	.13	.34	.76	.95
Slovakia	108	.13	.09	.42	.49
Spain	110	.13	.29	.69	.40
Switzerland	73	.09	.56	.93	.64
UK	113	.14	.44	.99	.94
Total	826	1.0	.33	.69	.66

note: Teachers are only asked whether they teach mathematics, physics, chemistry, biology or science – therefore one subject only refers to this group of subjects.

There are differences between the teacher pre-samples of the countries. Especially, teachers have a different subject background and teach different age groups.

The project PRIMAS has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 244380.

1.2.3 Routine use and perception of IBL

The questionnaire measured the status of routine use of IBL in daily teaching practice (*rou*). Furthermore, the teachers' orientation towards IBL (*ori*) and their belief that students' will benefit from the implementation of IBL are assessed (*mot*). Each of the three mentioned scales is constructed with three items (4.3). The belief that students' benefit from IBL is significantly related to the routine use of IBL, r=.33, p<.001. The orientation towards IBL (ori) is also correlated with the belief that students' benefit from IBL, r=.58, p<.001. This indicates that the assumed or experienced effect IBL has on students is important for teachers' disposition to implement IBL. Teachers with a stronger belief that students benefit from IBL are more likely to be positive oriented towards IBL. Also, the correlation between routine use (rou) and orientation (ori) is significant, but this correlation coefficient Pearsons' r is comparably small, r=.10, p<.001.

All teachers participating in PRIMAS are positively oriented towards IBL. The mean of the orientation scale *ori* is 3.18. Furthermore, teachers believe that students will benefit from the implementation of IBL. The mean is 3.16. In addition, all over Europe there are teachers that already have experience with implementing IBL, the mean of the routine use scale *rou* is 2.3 (Table 3).

Table 3

Orientation towards IBL (ori) , use of IBL (rou), benefit for students (mot)

		rou				ori				mot			
Country	N	Mean rou	SD	95%-CI Lower	95%-CI Upper	Mean ori	SD	95%-CI Lower	95%-CI Upper	Mean mot	SD	95%-CI Lower	95%-CI Upper
Cyprus	117	2.55	.69	2.42	2.68	2.98	.56	2.88	3.08	3.11	.59	3.00	3.21
Denmark	67	2.52	.61	2.37	2.67	3.11	.49	2.99	3.23	3.12	.36	3.01	3.21
Germany	66	2.07	.64	1.91	2.22	3.31	.43	3.21	3.42	3.13	.42	3.03	3.23
Hungary	98	2.21	.58	2.09	2.32	3.13	.35	3.06	3.20	3.14	.37	3.07	3.21
Malta	46	2.41	.59	2.23	2.58	3.27	.40	3.15	3.39	3.12	.43	2.99	3.24
Netherlands	83	2.04	.57	1.92	2.17	3.01	.38	2.92	3.09	2.88	.30	2.81	2.94
Norway	60	2.24	.49	2.12	2.37	3.10	.34	3.01	3.18	3.05	.31	2.97	3.13
Romania	105	2.20	.63	2.08	2.32	3.12	.53	3.02	3.22	3.19	.52	3.09	3.29
Slovakia	119	2.43	.67	2.31	2.55	3.38	.43	3.30	3.46	3.43	.42	3.35	3.51
Spain	154	2.28	.66	2.17	2.38	3.33	.42	3.27	3.40	3.39	.43	3.32	3.46
Switzerland	88	2.24	.63	2.10	2.37	2.82	.53	2.70	2.93	2.88	.42	2.79	2.97
UK	188	2.15	.71	2.05	2.25	3.33	.46	3.26	3.40	3.18	.46	3.11	3.24
Total	1191	2.27	.69	2.23	2.31	3.18	.48	3.15	3.21	3.16	.47	3.14	3.19

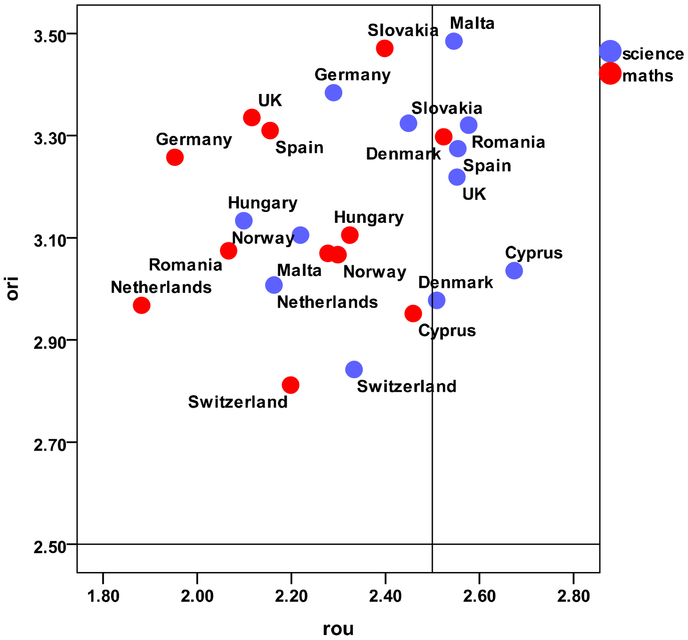
Note: Judgments were on a 4-point scale (1: strongly disagree, 2: disagree, 3: agree, 4: strongly agree)

The project PRIMAS has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 244380.

SEVENTH FRAMEWORK PROGRAMME

Concerning the routine use of IBL (*rou*), the orientation towards IBL (*ori*) and the belief that students will benefit from the implementation of IBL (*mot*) country and subject specific differences and interaction effects can be detected (Table 3, Figure 3).

Figure 3: Scatterplot of orientation towards IBL versus routine use of IBL



There is a significant main effect of the country and the subject referred to on the routine use of IBL, $F(11,1100)=4.86$, $p<.001$ and $F(1,1100)=19.297$, $p<0.001$. Furthermore, there is a significant interaction between the country and the subject referred to, $F(11,1100)=2.39$, $p<=.01$.

Differences between the countries

For teachers referring to maths and for teachers referring to science, a one-way ANOVA was used to test for routine use differences among the twelve participating countries. Bonferroni post hoc test revealed that the differences among science teachers are less than those among mathematics teachers. Only science teachers in Cyprus differ significantly from their colleagues. They report more frequent use of IBL than science teachers in Hungary and in the Netherlands. Interestingly, between the mathematics teachers of the participating countries Bonferroni post test revealed more significant differences. Mathematics teachers in Cyprus, Denmark and Slovakia report more routine use than there colleagues in the Netherlands, Germany, the United Kingdom and Romania.

Furthermore, a significant main effect of the county on the orientation towards IBL exits, $F(11,1005)=10.46$, $p<.001$. The main effect of the subject on the orientation towards IBL is not significant, $F(1,1005)=1.07$, $p=.30$. The interaction effect between the country and subject is significant, $F(11,1005)=2.70$, $p<.01$.

The project PRIMAS has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 244380.

A one-way ANOVA was used to test for orientation differences among the twelve participating countries. Orientation towards IBL differed significantly across the twelve countries, $F(11,1186)=14.98$, $p<0.01$. The assumption of homogeneity of variance was violated; therefore, the Brown-Forsythe-F-ratio is also reported $F(11,987.16)=15.41$, $p<0.01$. Tamhane post-hoc comparisons of the twelve countries confirm that significant differences between the countries exist. As Figure 3 and Table 4 indicate, the countries can be divided into two groups. Teachers in Switzerland, Cyprus, the Netherlands, Norway, Denmark, Romania and Hungary are less positively oriented towards IBL than teachers in Malta, Germany, the United Kingdom, Spain and Slovakia. Table 4 gives an overview of significant differences between countries of these two groups. Besides these differences teachers in Switzerland are also significantly less oriented towards IBL than teachers in Norway, Denmark, Romania and Hungary.

Table 4

Orientation towards IBL: an overview of significant Tamhane post-hoc comparisons (p<.005)

	Malta	Germany	UK	Spain	Slovakia
Switzerland	X	X	X	X	X
Cyprus	X	X	X	X	X
Netherlands	X	X	X	X	X
Norway			X	X	X
Denmark					X
Romania				X	X
Hungary			X	X	X

Subject differences

On average, science teachers report a more frequent use of IBL ($M=2.40$, $SE=.67$) than mathematics teachers ($M=2.20$, $SD=.64$). This difference is significant $t(1122)=5.16$, $p<.001$; it presents a medium-sized effect, $d=.32$. Additionally, science teachers have a stronger believe that students benefit from IBL ($M=3.20$, $SD=.45$) than have mathematics teachers ($M= 3.13$, $SD=.47$), $t(1121)=2.25$, $p=.025$. However, it represents a small-sized effect, $d=.14$. Concerning the orientation towards IBL, no significant differences can be detected.

Interestingly, significant differences between mathematics and science teachers concerning the routine use of IBL cannot be detected in all countries. In one of the countries, Hungary, mathematics teachers even report higher routine use of ILB than their colleagues from mathematics. In Germany, the Netherlands, Romania, Spain and the United Kingdom science teacher report significantly more use of IBL than their colleagues from mathematics (Table 5). Remarkably, in all these five countries mathematics teachers report less routine use of IBL than their colleagues in the other countries of the survey. This indicates that it is the tradition of mathematics teaching in these countries that provokes the significant differences between mathematics and science teachers. Finally, it can be said that lesson pattern not only depend on the subject but also on the cultural background and that there is an interaction effect between the subject and the country.

The project PRIMAS has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 244380.

SEVENTH FRAMEWORK PROGRAMME

Table 5

Routine use of IBL: differences between the subjects in selected countries

	Subject				
	Science teacher	Mathematics teacher	*t*	*df*	*d*
Germany	2.29 (.59)	1.95 (.65)	2,06*	63	.54
Netherlands	2.16 (.57)	1.88 (.53)	2.20*	76	.52
Romania	2.58 (.52)	2.07 (.61)	3.80***	99	.87
Spain	2.55 (.69)	2.1550 (.58)	3.23*	118	.66
UK	2.55 (.60)	2.12 (.71)	2.39	182	.62

Note: * difference are significant at p<.05
***differences are significant at p<.001

The reported frequency of routine use of IBL and the orientation towards IBL are both significantly correlated with the belief that IBL motivates students. The implementation of IBL (rou) is significantly influenced by the subject in question. Science teachers report using more IBL than mathematics teachers. Interestingly, there is a strong interaction with the country. The orientation towards IBL is significantly dependant on the country.

1.2.4 Difficulties with the implementation of IBL

A three-factor structure for the items which are asking for problems when implementing IBL was evident, based on a principal components exploratory factor analysis with an *oblimin* rotation. The three factors are named *system restrictions (syr)*, *classroom management (cla)* and *resources (res)* (4.3).

These three factors are also found in the answers of open questions regarding difficulties that hinder the implementation of IBL. Two teachers from the United Kingdom gave the following answers:

> *"I feel my lessons are quite active/practical; however, on choosing to answer the previous questions on KS4 I have realised how different my teaching/planning is for this age group compared to KS3. As soon as they enter KS4, investigation and group work are out of the window and we go into exam preparation mode!"*

> *"lack of preparation time; finding good resources; tension between IBL and exam preparation"*

The project PRIMAS has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 244380.

SEVENTH FRAMEWORK PROGRAMME

Two teachers from Malta made the following comments:

> *"Sometimes students exhibiting challenging behaviour make it very difficult for me to find ways and means of how I can make them enjoy the maths lesson. In addition, time is very limited for me to make certain maths activities in class."*
>
> *"Students take too much time to settle down and so a double lesson is reduced to one hour due also to some interruptions by the students - Too many topics to cover in a year - Lessons lost due to school activities - Some lack of equipment and no access to internet."*

Analysing the data of the questionnaires indicates that teachers see the three factors *classroom management*, *system restrictions* and *resources* as relevant. Whereas the average of *classroom management* is only 2.3 the other two are rated more important: *system restrictions* and *resources* have an average of 2.8 and 2.7 (1: strongly disagree, 2: disagree, 3: agree, 4: strongly agree) (Figure 4 and Table 6). To have a comparative look at the results, several analyses were carried out to give an insight into differences between the countries.

One-way ANOVA was used to test for differences in the three factors among the twelve participating countries. All three factors, *classroom management (cla)*, *resources (res)* and *system restrictions (syr)* differed significantly across the twelve countries. The F-ratios were $F(11,1181)=8.0$, $p<.01$, $F(11,1183)=20.67$, $p<.01$ and $F(11,1187)=32.92$, $p<.01$ respectively. The assumption of homogeneity of variance for these three variables was violated; therefore, the Brown-Forsythe-F-ratio are also reported: $F(11,1026.28)=8.40$, $p<0.01$, $F(11,901.05)=33,29$, $p<0.01$, $F(11,926.25)=21.23$, $p<0.01$. These results show that significant differences exist amongst the groups. Pair wise comparisons give a more profound insight.

In all countries actual classroom management is seen as the least significant problem out of the three reviewed problems. In none of the participating countries is classroom management seen as a severe problem, in none of the countries is the average value higher than 2.5. The Netherlands has the smallest value and the United Kingdom the highest. Post-hoc analysis using the Tamhane-test to test for significance differences of *cla* among the twelve countries indicates that teachers in Denmark, Germany and the Netherlands report significantly fewer problems related to classroom management when implementing IBL.

The project PRIMAS has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 244380.

SEVENTH FRAMEWORK PROGRAMME

Figure 4

Problems with implementation of IBL: classroom management (cla), resources (res) and system restrictions (syr) (1: strongly disagree, 2: disagree, 3: agree, 4: strongly agree)

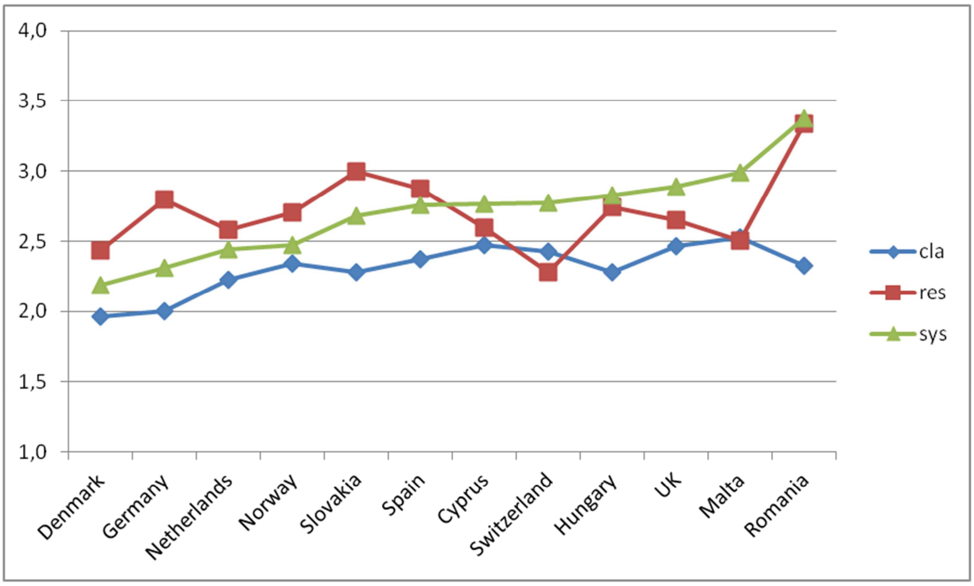


Table 6

Resources and system restrictions as a problem hindering the implementation of IBL

		cla				res				sys			
Country	N	Mean cla	SD	95%-CI Lower	95%-CI Upper	Mean res	SD	95%-CI Lower	95%-CI Upper	Mean sys	SD	95%-CI Lower	95%-CI Upper
Cyprus	116	2.47	.60	2.36	2.59	2.60	.63	2.48	2.71	2.77	.45	2.68	2.85
Denmark	67	1.96	.51	1.84	2.09	2.43	.54	2.30	2.56	2.19	.46	2.07	2.30
Germany	68	2.00	.62	1.85	2.15	2.79	.79	2.60	2.99	2.31	.70	2.14	2.48
Hungary	103	2.28	.49	2.19	2.38	2.75	.54	2.634	2.85	2.83	.60	2.71	2.95
Malta	46	2.53	.45	2.39	2.66	2.50	.57	2.33	2.67	2.99	.45	2.86	3.13
Netherlands	78	2.22	.50	2.11	2.34	2.58	.54	2.46	2.70	2.44	.44	2.35	2.54
Norway	61	2.34	.37	2.26	2.43	2.70	.45	2.59	2.82	2.49	.44	2.36	2.58
Romania	104	2.32	.58	2.21	2.44	3.33	.58	3.22	3.45	3.38	.46	3.29	3.47
Slovakia	119	2.28	.54	2.18	2.38	3.00	.61	2.88	3.11	2.68	.52	2.58	2.77
Spain	154	2.37	.55	2.28	2.46	2.88	.58	2.78	2.97	2.75	.44	2.68	2.83
Switzerland	88	2.42	.60	2.30	2.55	2.28	.54	2.17	2.40	2.78	.52	2.67	2.89
UK	189	2.47	.59	2.38	2.55	2.65	.67	2.55	2.75	2.89	.57	2.81	2.97

Note: Judgments were on a 4-point scale (1: strongly disagree, 2: disagree, 3: agree, 4: strongly agree)

As Table 6 and Figure 5 indicate, Tukey post-hoc comparisons show that the relevance of resources as a hindrance for implementing IBL is rated significantly different. For example, pair-wise comparison show, that teachers in Romania gave significantly higher ratings than teachers in all other countries. Teachers in Slovakia also gave significantly higher ratings

The project PRIMAS has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 244380.

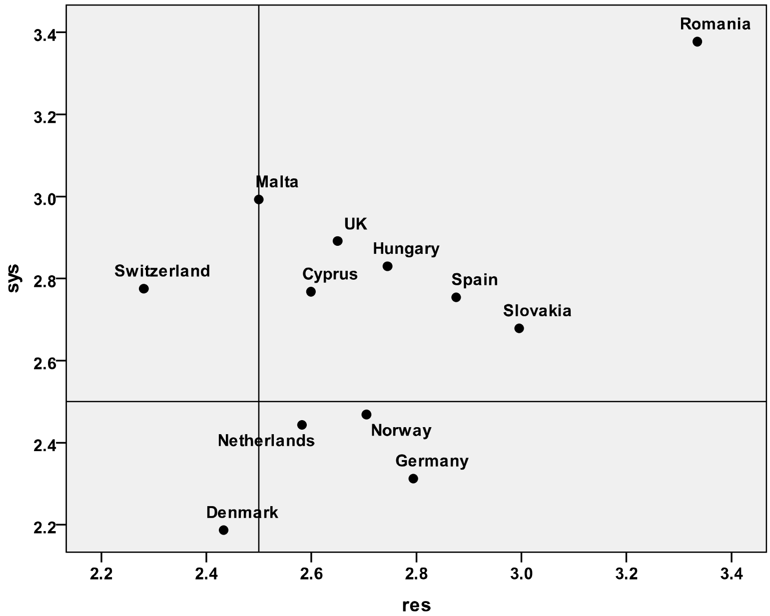
SEVENTH FRAMEWORK PROGRAMME

than teachers in Switzerland, Denmark, Malta, the Netherlands, Cyprus and the United Kingdom.

The Tukey post-hoc comparison of the twelve countries indicates that the relevance of system restriction is rated prominently different (Table 6, Figure 5). Forty pair wise comparisons are significant at $p<.05$. For example, teachers in each of the countries Denmark, Germany, Netherlands and Norway see system restrictions as less of a hindrance than their colleagues in Spain, Cyprus, Switzerland, Hungary, the UK, Malta and Romania. Strikingly, teachers in Romania see system restriction significantly more as a hindrance for implementing IBL than their colleagues in all other participating countries.

Figure 5

Scatter plot of system-related problems versus resources-related problems (1: strongly disagree, 2: disagree, 3: agree, 4: strongly agree)



Taken together, the results indicate that from the teachers' perspective classroom management is not seen as a major problem. Examining responses on the two other categories (system restrictions and resources) shows that teachers in Denmark and the Netherlands see fewer problems with the implementation of IBL than in the other countries. Especially, teachers in these two countries and in Norway and in Germany do not see system restriction as a severe problem. Teachers in Romania have the greatest worries about implementation. Here, system restrictions and lacking resources are rated nearly equally obstructively. With the remaining five countries it is striking that in Switzerland and in Malta teachers see system restriction clearly as more of a hindrance than the availability of resources.

Additionally, teachers were asked how satisfied they are with the existing situation in the classroom. If teachers are comfortable with the existing situation they will not see a need for

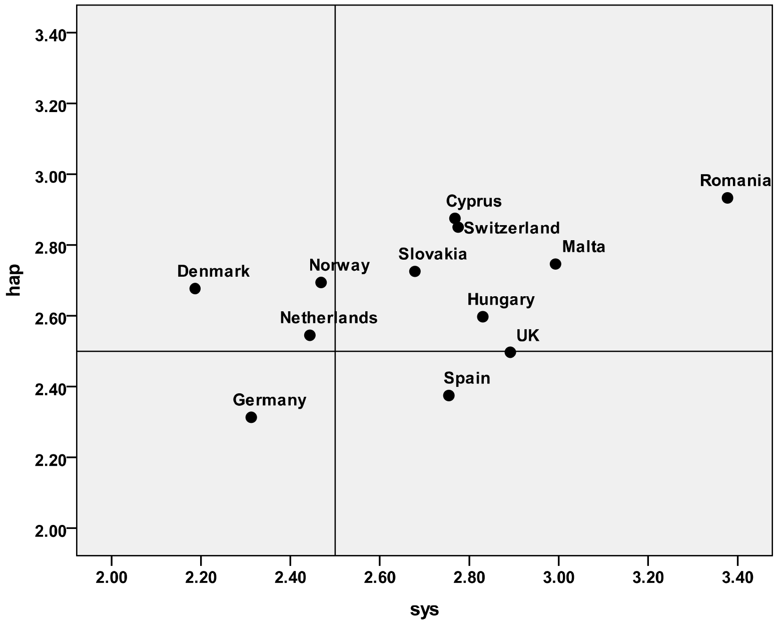
The project PRIMAS has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 244380.

SEVENTH FRAMEWORK PROGRAMME

a change. This might add to the problems teachers see with the implementation of IBL. Therefore, three items are used to analyse the happiness *(hap)* of the teachers *hap* with the existing situation they have in their classroom (4.3). A one-way ANOVA was used to test for differences in the happiness among the twelve participating countries. The happiness *hap* differed significantly across the twelve countries, F(11,1178)=15.4, p<.01. Scheffé-post-hoc comparison shows that teachers in Germany, Spain and the UK are significantly more dissatisfied with the existing situation than their colleagues in classrooms than their colleges Switzerland, Cyprus, and Romania.

Figur 6

Scatter plot of happiness with the situation versus system-related problems of implementation (1: strongly disagree, 2: disagree, 3: agree, 4: strongly agree)



It can be postulated that implementing IBL will be most challenging in countries where teachers report high system restrictions for change and where teachers are satisfied with the existing situation.

The project PRIMAS has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 244380.

SEVENTH FRAMEWORK PROGRAMME

Table 7

Happiness with the exiting teaching situation

Country	N	Mean hap	SD	95%-CI	
				Lower	Upper
Cyprus	116	2.88	.52	2.78	2.97
Denmark	66	2.68	.52	2.55	2.81
Germany	66	2.31	.55	2.18	2.45
Hungary	101	2.60	.44	2.51	2.68
Malta	46	2.75	.41	2.62	2.87
Netherlands	81	2.55	.43	2.45	2.64
Norway	61	2.69	.44	2.58	2.81
Romania	105	2.93	.56	2.83	3.04
Slovakia	119	2.73	.54	2.63	2.82
Spain	152	2.38	.49	2.30	2.45
Switzerland	88	2.85	.52	2.74	2.96
UK	189	2.50	.54	2.42	2.57

Note: Judgments were on a 4-point scale (1: strongly disagree, 2: disagree, 3: agree, 4: strongly agree)

Teachers anticipate system restrictions and missing resources as hindrances for implementing IBL. Within Europe the relevance of these categories varies. Furthermore, the teachers in different countries differ according to the happiness with the existing teaching situation.

1.2.5 Description of current teaching practice

Items measuring teachers' reports on the frequency of selected teaching practices are included in the teacher questionnaire. Here, we report the scales interaction (*int*), application (*app*), hands-on (*hon*), investigation (*inv*) and exercise (*exe*). Each of these scales is constructed with three items. The first four scales give insight into the frequency of different aspects of IBL. The interaction scale (*int)* measures the frequency of students interacting with each other. The application scale (*app*) *gives* insight into the frequencies of references to students' daily life. The following two scales measure the frequency of practical activity. While the first one focuses on having practical "hands-on experiences", the second one captures the frequency of more investigative activities (inv). The last scale we report here gives insight into the frequency of doing exercises (*exe*) (4.3)

These five scales give insight into characteristics of current teaching practice with a focus on IBL. From the teachers' point of view interaction of students and references to application are already integrated into daily teaching practice. While hands on experiments are already visible, investigations are seldom part of daily teaching. On the other hand, doing exercises is an important element of daily teaching practices (Figure 7).

The project PRIMAS has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 244380.

SEVENTH FRAMEWORK PROGRAMME

Correlation between the four scales describing aspects of IBL is significant. Especially, the frequency of investigation is significantly related to hands-on activities and also to application (Table 8).

Figure 7

Mean and standard derivation of the frequency of students interaction, reference to application, hands-on experiences and investigation in daily teaching practice (1: never or hardly ever, 2: in some lessons, 3: in most lessons, 4: in almost all lessons)

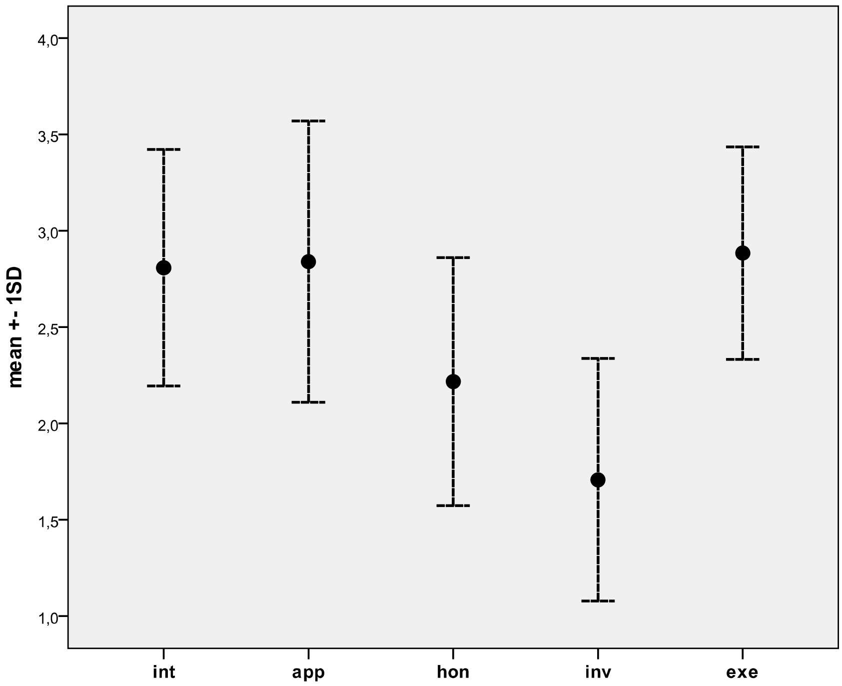


Table 8

Correlation of five scales describing teaching practice

	int	app	hon	inv	exe
int	1	.29**	.35**	.42**	.00
app	.29**	1	.30**	.33**	.02
hon	.35**	.30**	1	.55**	-.04
inv	.42**	.33**	.55**	1	.00
exe	.00	.02	-.04	.00	1

**Correlation is significant at the .01 level (2-tailed).

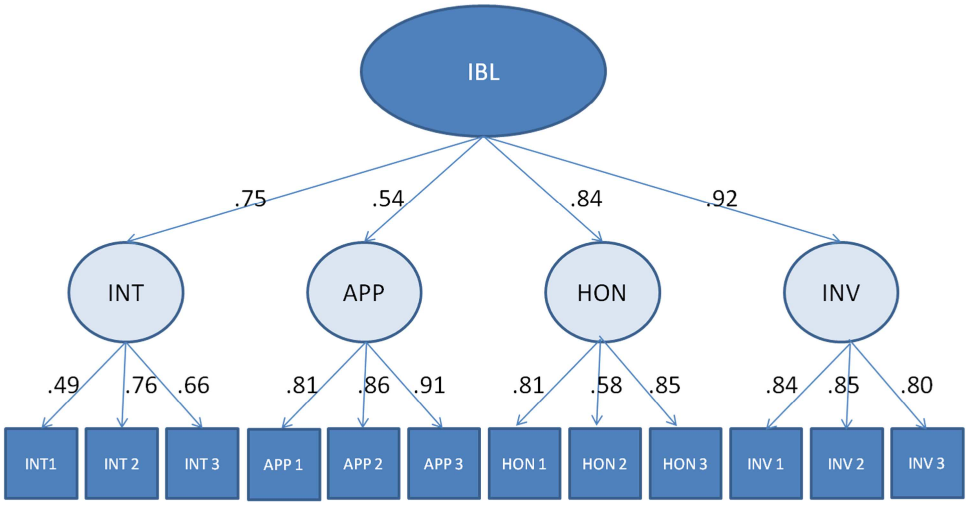
Therefore, we specified a second-order factor model to calculate the so-called IBL-index based on the four first order factors. Second-order models are potentially applicable when the lower order factors are substantially correlated with each other and there is a higher order factor that is hypothesized to account for the relations among the lower order factors.

The project PRIMAS has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 244380.

Figure 8 shows the specified model and the factor loadings calculated with the specified model.[1]

Figure 8

Results of the second-order factor model: Standardized solution



As expected, the IBL-index significantly depends on the country and also on the subject. There is a significant main effect of the subject referred to on the IBL-index, $F(1,984)=63.96$, $p<.001$. There is also a significant main effect of the country on the IBL-index, $F(11,984)=31.31$, $p<.001$. Most interestingly, a significant interaction between the subject referred to and the country on the IBL-index can also be observed, $F(11,984)=6.81$, $p<.001$. This effect indicates that the existing differences between maths and science lessons are dependent on the country.

In the Netherlands, Spain, Malta, Switzerland, Romania, the United Kingdom and Germany the differences between the subjects are significant. Except for Spain and Switzerland the effect is strong in these countries. Only in Norway, Denmark, Hungary and Cyprus the status of IBL does not differ significantly between the subjects. Interestingly, Denmark, Hungary and Cyprus are the three countries with the highest IBL-index for maths teachers.

[1] To calculate the factor loadings and the correlation we used the pre- and the post teacher data.

Figure 9

IBL-Index describing teaching practice in the different countries in dependence of the subject. (Only 7 teacher from the United Kingdom refer to science)

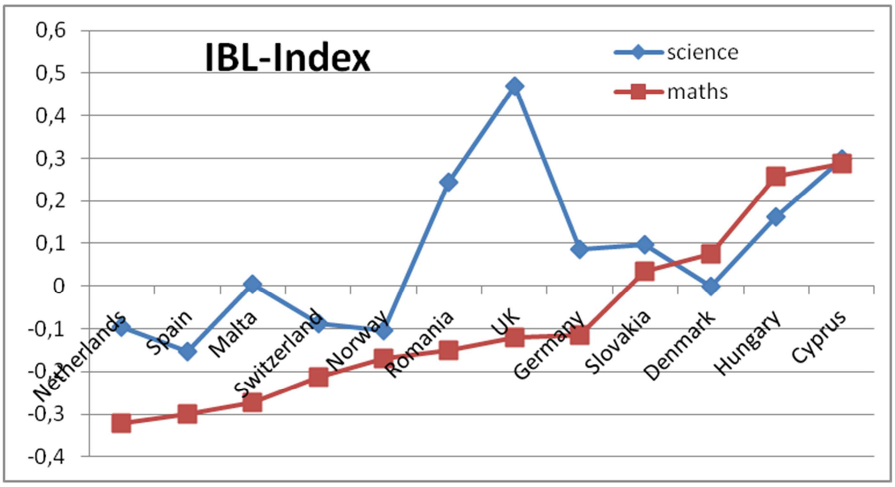


Table 9

IBL-index: Differences between the subjects in selected countries

	Subject				
	Science teacher	Mathematics teacher	*t*	*df*	*d*
Netherlands***	-.09 (.23)	-.32 (.20)	4.159	66	1.04
Spain*	-.15 (.32)	-.30 (.27)	2.42	104	0.52
Malta***	.01 (.25)	-.27 (.27)	3.57	43	1.09
Switzerland*	-.09 (.21)	-.21 (.25)	2.00	84	0.52
Romania***	.24 (.24)	-.15 (.34)	5.15	96	1.24
United Kingdom*1	.47 (.50)	-.12 (.29)	3.07	6.28	1.95
Germany*	.09 (.24)	-.12 (.23)	3.24	59	0.87

Note: *difference are significant at p<.05
***differences are significant at p<.001
[1] Only seven teachers refer to science in the UK.

A significant relationship between the IBL-index and the three scales measuring the problems hindering the implementation of IBL exists. Interestingly, the absolute values of the correlation coefficients are all not greater than .25. Furthermore, classroom management (cla) which is seen as the least severe problem has a higher correlation than system-related and resources-related problems. This indicates that there is a relationship between the problems teachers expect when implement IBL and the frequency of IBL-related teaching practice. Higher rated classroom management problems, system-related problems and

The project PRIMAS has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 244380.

resources-related problems go with a lower frequency of ILB-related teaching practice. Nevertheless, only 0.06 of the variance can be accounted for.

Table 10

Correlation of five scales describing teaching practice

	cla	sys	res	ibl
cla	1	.33**	.15**	-.25**
sys	.33**	1	.42**	-.18**
res	,15**	,42**	1	-,12**
ibl	-,25**	-,18**	-,12**	1

**Correlation is significant at the .01 level (2-tailed).

Teaching practice with respect to IBL depends on the subject referred to and also on the country. Interestingly, in some countries differences among the subjects do not exist, whereas in other there are distinct.

1.2.6 Teacher pre-post comparison

Nearly half of the pre-questionnaires are matched with a post questionnaire. This rate is caused by the number of teachers filling out the post questionnaires and by teachers not filling out the code needed for matching the questionnaires. Therefore, for the following paired-sample t-tests the sample size is 563. As shown in Table 11 the sample is non-uniformly distributed between the countries and the subject. Furthermore, the time difference Δt varies substantially. The minimum of time difference Δt is 8 weeks while the maximum is 88 weeks. This spectrum originates through the different concepts of implementation within the countries of the PRIMAS consortium. Therefore, the mean of the time difference Δt and the standard derivation of the time difference is country dependant (Table 11, Figure 10)

The project PRIMAS has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 244380.

SEVENTH FRAMEWORK PROGRAMME

Table 11

Overview of the paired-samples of the teacher (pre-post study)

	Sample size (proportion)		science	maths
Cyprus	68	(.12)	27	40
Germany	14	(.03)	3	10
Hungary	72	(.13)	40	27
Malta	21	(.04)	8	13
Netherlands	16	(.03)	13	2
Norway	10	(.02)	0	10
Romania	100	(.02)	24	72
Slovakia	83	(.15)	53	30
Spain	49	(.09)	7	33
Switzerland	65	(.12)	14	50
UK	65	(.12)	0	64
Total	563	1.00	189	351

Table 12

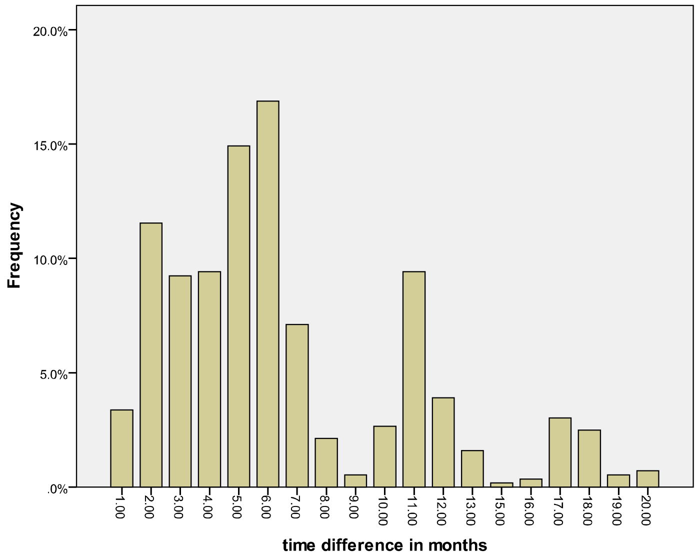
Overview of the time difference Δt

	N	mean Δt in weeks	standard derivation
Cyprus	68	9	1.5
Germany	14	69	19.8
Hungary	72	25	8.1
Malta	21	76	1.8
Netherlands	16	32	4.1
Norway	10	29	4.4
Romania	100	53	9.4
Slovakia	83	21	5.5
Spain	49	23	12.8
Switzerland	65	20	3.4
UK	65	30	7.0
Total	563	31	18.8

The project PRIMAS has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 244380.

SEVENTH FRAMEWORK PROGRAMME

Figure 10
Distribution of time difference Δt in months



A paired-sample t-test shows that the IBL-index of the post sample is significantly higher than the index of the pre-sample. On average teachers having taking part in a PRIMAS intervention report more frequently about elements of IBL being part of their daily teaching practice (M=.06, SD=.31) than before the intervention (M=-.02, SD=.32). This difference, -.08, BCa 95%CI [-.10, -.06] is significant, t(488)=-8.00, p<.001.

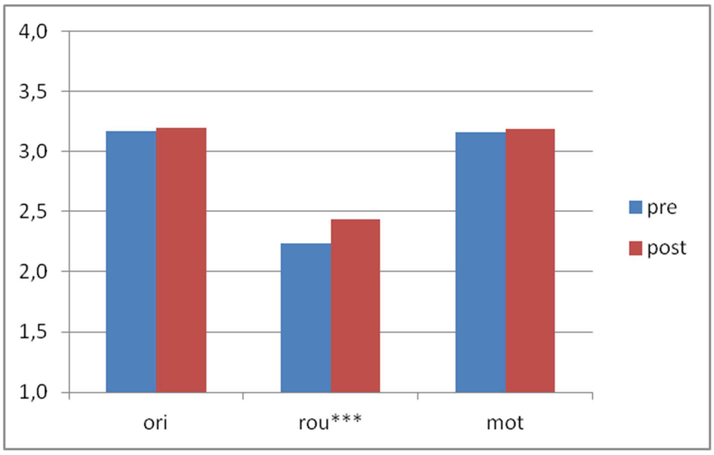
This result is confirmed by the fact that the teachers after the PRIMAS interventions report significantly more about use of IBL (rou). Results indicate significantly more routine use of IBL after the intervention (M = 2.43, SD = .58) than before the different PRIMAS interventions (M =2.23, SD = .63), t(551) =-8.22, p = <001. In both cases the effect is small.

In addition, teachers report being more oriented towards IBL and having a stronger belief that IBL motivates students. These effects are not significant.

The project PRIMAS has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 244380.

Figure 11

Pre-post comparison of orientation towards IBL, routine use of IBL and belief that IBL motivates students (paired samples) (1: strongly disagree, 2: disagree, 3: agree, 4: strongly agree) (*difference is significant at the .01 level)**

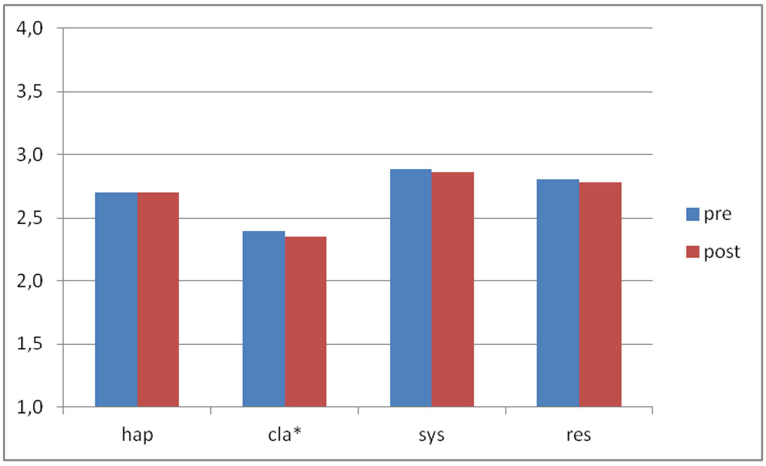


Furthermore, the data indicate that it is easier to raise the status of IBL from a lower level than from a one. The IBL-indexes of the teachers before the intervention are significantly related to the change of the IBL-index, r=-.40, p<.001.

After the PRIMAS interventions teachers see fewer problems when implementing IBL. Problems related to classroom management, to system restrictions and to resources are rated less. The decrease of the relevance of classroom problems is significant, t(554)=1.13, p=.001. No changes relating to contentment with the existing situation are visible.

Figure 12

Changes of happiness with the existing situation and of problems with implementation of IBL: *happiness (hap), classroom management (cla), resources (res)* and *system restrictions (syr)* (1: strongly disagree, 2: disagree, 3: agree, 4: strongly agree) (*difference is significant at the .05 level)



The project PRIMAS has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 244380.

Effects of the PRIMAS interventions are visible. Teachers report a significantly more IBL-oriented teaching practice.

1.2.7 Student sample

The student pre- and the post-questionnaire were distributed in the countries of the PRIMAS consortium. A total of 24649 student questions had been filled out. Altogether 14476 students filled out the pre-questionnaire. As expected there is an equal number of female and male students in the sample. The average age is 13.4 years. There is a difference within the countries. For example the average age of the students in Cyprus is 11.8 while in Romania it is 15.3. This is in coincidence with the teachers referring to different age groups in the countries of the consortium (Figure 2). Furthermore, like the teachers more students refer to mathematics than to science. The variations between the countries are significant. In Romania and the United Kingdom more than 90% of the sample refers to mathematics whereas in the Netherlands and Slovakia it is less than .25 (Table 1). The sample of the post study shows similar characteristics.

Table 13

Overview of the sample of the sample of the student pre-study

	Sample size (proportion)		Male porportion	average age in years (SD)		Proportion referring to maths
Cyprus	1635	(.11)	.52	11.8	(2.8)	.63
Germany	877	(.06)	.51	13.5	(2.5)	.59
Hungary	1700	(.12)	.42	13.2	(2.6)	.35
Malta	2015	(.14)	.51	12.5	(1.2)	.61
Netherlands	770	(.05)	.57	13.8	(1.5)	.22
Norway	1479	(.10)	.51	13.8	(1.2)	.44
Romania	1334	(.09)	.50	15.3	(2.1)	.91
Slovakia	1237	(.09)	.45	14.8	(2.2)	.20
Spain	666	(.05)	.50	13.3	(1.9)	.59
Switzerland	1235	(.09)	.49	13.1	(.8)	.61
UK	1528	(.11)	.51	13.1	(1.4)	.95
all	14476	(1.00)	.50	13.4	(2.2)	.58

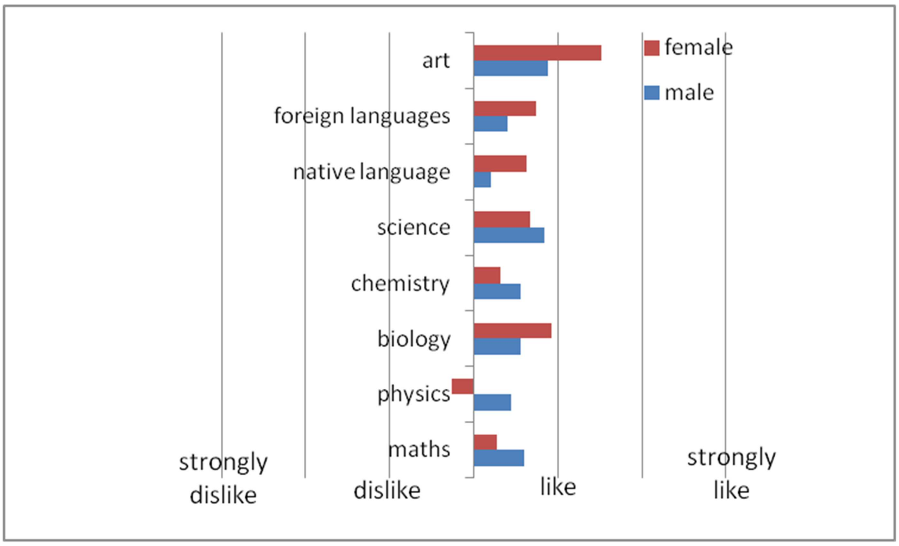
A total of 14,476 students filled out the pre-questionnaire. The post questionnaire was filled out by 10,134 students. With respect to the age of the students and the subject referred meaningful differences exist between the countries.

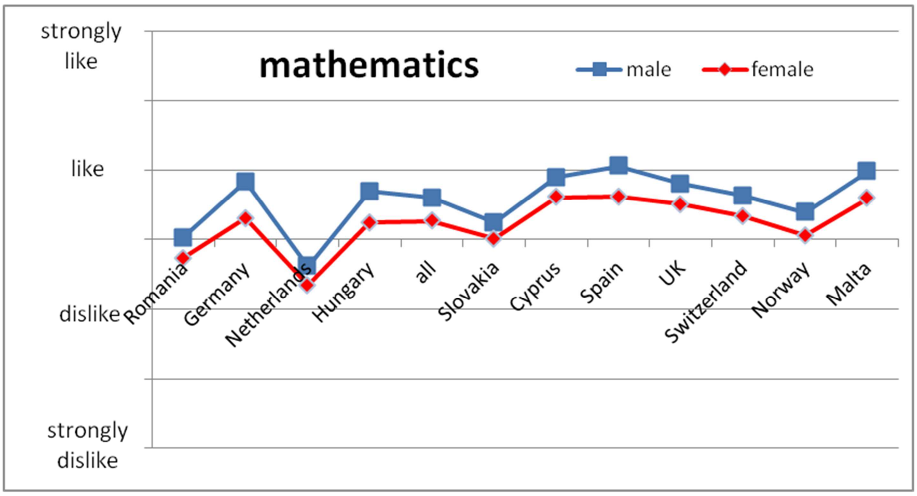
The project PRIMAS has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 244380.

1.2.8 Subject preferences

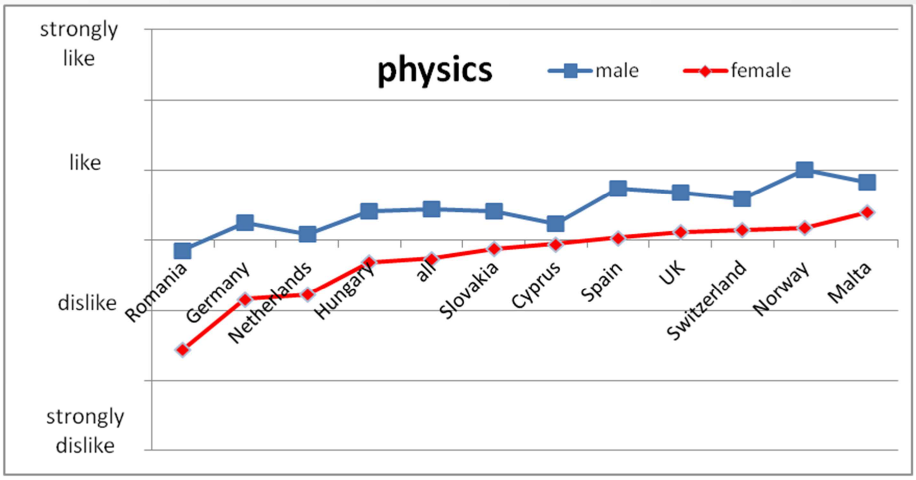
Students were asked how much the disliked respectively liked certain subjects. Figure 13 shows a typical pattern across the countries. Out of the subjects in question physics is the most unpopular subject whereas art is the most popular. Gender-specific differences exist. Female students are more positive oriented towards art, foreign languages and biology than male students. Accordingly, male students like science, chemistry, physics and mathematics more than female students. All these gender differences are significant (t-test). Except for art and physics the effects are small. Country specific-differences also exist (Figure 13, Appendix 5: Country-specific subject preferences).

Figure 13: Subject preferences of the students of the pre-sample (N between 7310 (chemisty) and 14054 (mathematics))





The project PRIMAS has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 244380.



Looking at all subjects students from the Maltese and Hungarian sample enjoy the subjects more than students from the other countries. Physics is liked most by students in Malta and Norway. Students in these two countries like the subject significantly more than students in Romania, Germany, the Netherlands, Hungary, Cyprus and Slovakia.Mathematics in our sample is liked most by students in Spain, Malta and Cyprus. Students from these three countries differ significantly from students the Netherlands, Romania, Slovakia, Norway, Hungary and Switzerland.

Students' preferences of school subjects significantly depends on the gender and the country the live in. Out of the subjects in question Physics is liked the least.

1.2.9 Interest and IBL

Items measuring students' reports on their interest in the subject of question are included in the students' questionnaire. Therefore, three scales are included in the questionnaire. One scale (*fun*) measures the enjoyment of the students. The scale value (*val*) takes account of the value the subject has for the student. The third scale measures the desire of the student to get more involved with the subject, their epistemic interest (*epi*). Based on the interest theory of Krapp (Krapp 2005), we specified a second-order factor model to calculate the interest-index of the student based on the introduced three first order factors. Second-order models are potentially applicable when the lower order factors are substantially correlated with each other and there is a higher order factor that is hypothesized to account for the relations among the lower order factors.

In consistence with the teacher questionnaire four scales giving insight into the frequency of different aspect of IBL are included in the student questionnaire. The interaction scale (*int)* measures the frequency of students interacting with each other. The application scale (*app*) *gives* insight into the frequencies of references to students' daily life. The following two scales measure the frequency of practical activity. While the first one focuses on having

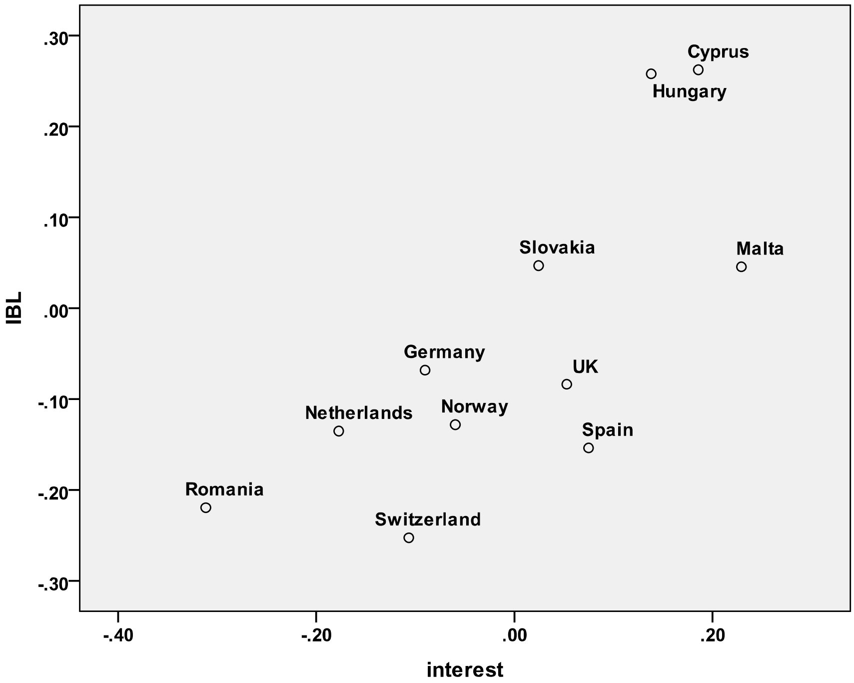
The project PRIMAS has received funding from the European Union Seventh Framework Programme

(FP7/2007-2013) under grant agreement n° 244380.

practical “hands-on experiences” (*hon*), the second one captures the frequency of more investigative activities (*inv*). Based on these four scales a second-order factor model to calculate the so-called IBL-index is specified. This model is identical with the model specified for the teachers (1.2.5)[2]. Again, the model fits the data. It still has to be tested, if the two models are invariant – showing that student and teacher have a similar understanding of IBL This index gives insight into the frequency of IBL in daily teaching practice. An increase of this indicates a successful implantation of IBL into teaching practice.

Remarkably, the correlation between the IBL-index and the interest index is significant. r=.42, p<.001. This indicates that implementation of IBL has the potential to increase students' interest in the subject.

Figure 14: Scatterplot of the IBL-index versus the interest-index (students in the different countries of the consortium)



The IBL-index of the subject is significantly correlated with the interest the student has in the subject

[2] The same items were part of the teachers questionnaire and the student questionnaire.

The project PRIMAS has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 244380.

1.2.10 Student pre-post comparison

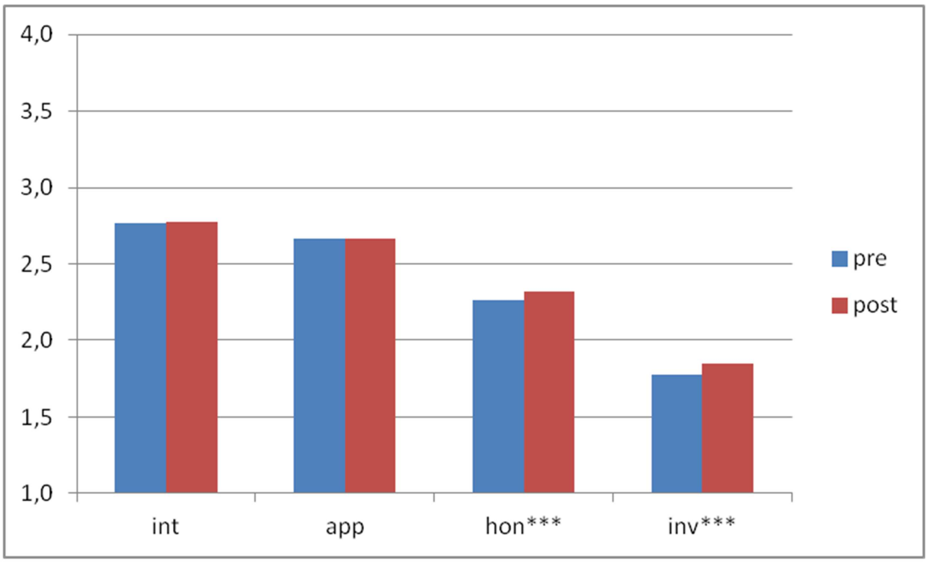
Out of all student questionnaires 6341 are paired. The ratio is comparable with the teacher sample. We also assume similar reason, the overall post sample is smaller and some student not fill out the codes needed for matching the data. Additionally, not all teachers distributed the pre and the post questionnaire in the same classes.

As the teacher sample the paired student sample also indicates a significant change in teaching practice. The student report a significant higher frequency of investigations and hand-on experiences in daily teaching practice. The effect size is small (Figure 159.

In accordance with the change of the factors the IBL- index also increases significantly.

Related to the scales measuring the interest no relevant differences exist.

Figure 15: Changes in teaching practice related to IBL from the viewpoint of the students



Analysing the student questionnaires shows clearly, that PRIMAS CPDs were successful. The students report more frequently IBL-related teaching pattern.

The project PRIMAS has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 244380.

2. Conclusions and Recommendations

The review of the literature has shown that the acronym IBL is used in various contexts. Within the project PRIMAS a multi-faceted approach has been elaborated. Beside the process of inquiry there also is a focus on having a meaningful context and on students being activated. We were able to show that this definition is sustainable. Based on the first order factors describing teaching practice focusing on IBL we specified a second-order factor model to calculate the so-called IBL-index. This second-order factor model was empirical affirmed. It enables us to calculate an IBL-index. Through this index we are able to report the status of IBL and also changes in the implementation of IBL.

The project PRIMAS gave valuable insight into the teaching situation with respect to the implementation of IBL in the different countries of the consortium. The pre- and also the post questionnaires got from students and teachers reflect the considerable diversity in the rich cultural settings in which education is developing. Nevertheless, all over Europe there are teachers who had at least initial experience with IBL and who are keen to learn more about IBL. Teachers are convinced that IBL has the potential to overcome learning problems and to motivate students. The problems teacher have with the implementing of IBL can be assigned to three categories: Classroom management, resources and system restrictions. All of them have to be taken seriously, even though classroom management is seen as the smallest barrier in all participating countries. However, in some countries teachers perceive more obstacles to a successful implementation of IBL than in others.

We were able to show that the implementation of IBL is greatly influenced by cultural backgrounds and school subject. As expected, science teacher implement IBL more frequently than mathematics teacher. Most interestingly, there is a significant interaction effect between the country and subject. In some countries mathematics lesson have teaching patterns that differ significantly from those of science lessons. In those countries the implementation of IBL in mathematic lessons is strikingly low.

The analysis of the student data showed clearly that there is a need for projects like PRIMAS. Students, especially girls show a low interest in the school subjects chemistry, mathematics and physics. We were able to show that frequency of IBL is significantly correlated with the interest of the students. Therefore, we are eligible to believe that the implantation of IBL will have a positive effect on the interest of the students in the medium term. Projects like PRIMAS which offer effective professional development programs for teacher should be supported. They are a mean to ensure that a greater number of students develop more positive dispositions towards these subjects and that they attain important competences, such as problem-solving skills, self-directed learning and exploring new knowledge areas.

Finally, the pre-post study showed that the professional development courses within PRIMAS were held successfully. Teachers as well as students reported a significant higher frequency of IBL in their daily practice. This affirms that the project PRIMAS met its goal to closely link

The project PRIMAS has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 244380.

SEVENTH FRAMEWORK PROGRAMME

practice and theory. The model for professional development based on phases of analysis, implementation and reflection has proven to be successful. It is reasonable and advisable to continue with the work of the projects on a national and an international level. We would recommend paying even more attention analysing the functioning of the professional development courses. This will give valuable insights to the crucial elements of the courses and help to enhance the effectiveness and the acceptance of these courses.

During the projects' lifetime (2010-2013) professional development courses have been offered for teachers among other resources and support measures. The impact of these professional development courses was evaluated within a pre-post survey using questionnaires. We were able to confirm that through the professional development courses the project PRIMAS improved mathematics and science education. Our analysis of the data of the pre-post survey showed that teaching practices changed significantly. After the professional development courses the IBL-index indicating the frequency of IBL in classroom practice increased significantly. Therefore, we were able to prove that our efforts not only reached the teachers, even students were aware of these changes, which shows the high impact of the courses. This is a great success.

The project PRIMAS used the great opportunity to work internationally and especially with people from different professional backgrounds and also on a national level with experienced and motivated teachers and teacher educators as multipliers. Having developed a common understanding of IBL and a common model for professional development there still was enough room for national adapted courses to meet the needs within a specific teaching- and learning culture, which ensured the success of the project.

The project PRIMAS has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 244380.

3. References

Anderson R. D. (2002) Reforming science teaching: What research says about inquiry. *Journal of Science Teacher Education, 13*(1), 1-12.

Barrow L. H. (2006) A Brief History of Inquiry: From Dewey to Standards. *Journal of Science Teacher Education, 2006*(17), 265-278.

Chinn C. A., Malhotra B. A. (2002a) Epistemologically Authentic Inquiry in Schools: A Theoretical Framework for Evaluating Inquiry Tasks. *Science Education, 86*(2), 175-218.

Chinn C. A., Malhotra B. A. (2002b) Epistemologically Authentic Science in Schools: A Theoretical Framework for Evaluation Inquiry Tasks. *Science Education, 86*(2), 175-218.

Colburn A. (2000) An Inquiry Primer. *Science Scope*.

Colburn A. (2006). *What teacher educators need to know about inquiry-based instruction*. Paper presented at the Annual meeting of the Association for the Education of Teachers in Science

Cunningham C. M., Helms J. V. (1998) Sociologgy of Science as a Means to a More Authentic, Inclusive Science Education. *Journal of Research in Science Teaching, 35*(5), 483-499.

Dorier J.-L. (2010) WP2 Analysis. *PRIMAS – Promoting inquiry in mathematics and science education across Europe (www.primasproject.eu)*.

Duit R., Treagust D. (1998) Learning in science: From behaviourism towards social constuctivism and beyond. In B. J. Fraser & K. G. Tobin (Eds.), *International Handbook of Science Education* (pp. 3-25). Dordrecht: Kluwer Academic Publisher.

Euler M. (2011) WP9: Report about the survey on inquiry-based learning and teaching in the European partner countries. *PRIMAS: Promoting inquiry-based learning in mathematics and science education across Europe*.

Hmelo-Silver C. E. (2004) Problem-Based Learning: What and How do Students Learn? *Educational Psychology Review, 16*(3), 235-266.

Hmelo-Silver C. E., Duncan R. G., Chinn C. A. (2006) Scaffolding and Achievement in Problem-Based and Inquiry Learning: A Response to Kirschner, Sweller and Clark. *Educational Psychologist, 42*(2), 99-107.

Hodson D. (1996) Laboratory work as scientifc method: three decades of confusion and distortion. *Curriculum Studies, 28*(2), 115-135.

Hodson D., Brencze L. (1998) Becoming critical about practical work: changing views and changing practice through action research. *International Journal of Science Education, 20*(6), 683-694.

Hofstein A., Lunetta V. N. (2004) The laboratory in science education: Foundations for the twenty-first century. *Science Education, 88*(1), 28-54.

Kirschner P. A. (1992) Epistemology, Practical Work and Academic Skills in Science Education. *Science and Education, 1*, 273-299.

The project PRIMAS has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 244380.

SEVENTH FRAMEWORK PROGRAMME

Kirschner P. A., Sweller J., Clark R. E. (2006) Why Minimal Guidance During Instruction Does Not Work: An Analysis of the Failure of Constructivist, Discovery, Problem-Based, Experiential, and Inquiry-Based Teaching. *Educational Psychologist, 41*(2), 75-86.

Krapp A. (2005) Basic needs and the development of interest and intrinsic motivational orientations. *Learning and Instruction, 15*(5), 381-395.

Lunetta V. N. (1998) The School Science Laboratory: Historical Perspectives and Contexts for Contemporary Teaching. In B. J. Fraser & K. G. Tobin (Eds.), *International Handbook of Science Education Pt.1* (pp. 249-262): Kluwer Academic Publishers.

Maaß K., Doorman M. (2013) A model for a widespread implementation of inquiry-based learning. *ZDM 45*(6).

Mortimer E., Scott P. (2003) *Meaning making in secondary science classrooms*. Philadelphia: Open University Press.

OECD. (2009) *Technical Report- PISA 2006*. Paris: OECD Publishing.

Prince M., Felder R. (2007) The many faces of inductive teaching and learning. *Journal of College Science Teaching*.

Stodolsky S. S., Grossman P. L. (1995) The Impact of Subject Matter on Curricular Activity: An Analysis of Five Academic Subjects. *American Educational Research Journal, 32*(2), 227-249.

Walker M. D. (2007) *Teaching inquiry-based science - A guide for middle and high school teachers*. LaVergne, TN: Lightning Source.

The project PRIMAS has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 244380.

4. Appendices

4.1 Appendix 1: Teacher questionnaire

Dear teacher,

You are being asked to complete this questionnaire because you are taking part in a professional development programme that promotes inquiry-based learning. The information collected here is to help us evaluate the impact of a range of professional development initiatives across Europe.

All your responses will be kept confidential and will only be reported and used in an aggregated form.

At the end of the professional development programme we ask you to fill in another questionnaire. In order to be able to match the questionnaires you are asked to fill in the following code:

- first two letters of your mother's first name (e.g. Ch for Christina) and
- the date of your birthday, without the year (e.g. 0112 for 01.12.1967)

Thank you for your cooperation. If you don't feel able to help at this time, then that is perfectly OK.

Many thanks

The project PRIMAS has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 244380.

SEVENTH FRAMEWORK PROGRAMME

Your Code

1.

Please enter the first two letters of your mother's first name (e.g. Ch for Christina)		

2.

	day		month	
Please enter the date of your birthday				

Today's date

3.

Day		month		Year			

Personal Data

4. I am working as a teacher in

Cyprus	Denmark	Germany	Hungary	Malta	Netherlands	Norway	Romania	Slovakia	Spain	Switzerland	UK

5. I am

Male	Female

6. Which subjects do you teach? (you may tick more than one if appropriate)

a. Maths	
b. Physics	
c. Biology	
d. Chemistry	
e. Combined, balanced or general Science	

The project PRIMAS has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 244380.

Description of your current practice

Now we would like you to think of **one** class you teach (or have taught).

7. Subject

Maths	Physics	Biology	Chemistry	Combined, balanced or general Science

8. Age Group

a.	Years 1, 2	(8 years and younger)	
b.	Years 3, 4	(8 to 10 years)	
c.	Years 5, 6	(10 to 12 years)	
d.	Years 7, 8	(12 to 14 years)	
e.	Years 9,10	(14 to16 years)	
f.	Years 11, 12, 13	(16 years and older)	

The project PRIMAS has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 244380.

9. When teaching this subject to this class, how often do the following activities occur in your lessons?

	The students...	never or hardly ever	in some lessons	in most lessons	in almost all lessons
a.	…are given opportunities to explain their ideas.				
b.	...spend time doing practical experiments/investigations.				
c.	...have the possibility to try out their own ideas.				
d.	...do experiments/investigations by following my instructions.				
e.	... repeatedly practice the same method on many questions.				
f.	...have discussions about the topics.				
g.	...learn through doing exercises.				
h.	...draw conclusions from experiments/investigations they have conducted.				
i.	...listen to what I say.				
j.	...design their own experiments/investigations.				
k.	...have the possibility to decide how things are done during the lesson.				
l.	… have no problems in following the lesson.				
m.	...do experiments/investigations to test out their own ideas.				
n.	…know enough to understand the lessons.				
o.	…are involved in class debate or discussion.				
p.	...have the chance to choose their own experiments/investigations.				
q.	…behave noisily and cause disorder.				
r.	…work on problems that are related to their real life experience.				
s.	...start with easy questions and move on to harder questions.				
t.	... have an influence on what is done in the lesson.				
u.	…choose which questions to do or which ideas to discuss.				
v.	…are informed about the aim of the lesson.				
w.	... take a long time to settle down after the lesson begins.				
x.	… do experiments/investigations that can be done/answered using more than one method.				

The project PRIMAS has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 244380.

SEVENTH FRAMEWORK PROGRAMME

10. When taking this class in this particular subject how often do you do the following things?

		never or hardly ever	in some lessons	in most lessons	in almost all lessons
a.	I use this subject to help the students understand the world outside school.				
b.	I give my students precise instructions.				
c.	I enjoy teaching the subject.				
d.	I show interest in every student's learning.				
e.	I show how this subject is relevant to society.				
f.	I give students extra help, when they need it.				
g.	I continue teaching until the students understand.				
h.	I explain the relevance of this subject to students' daily lives.				
i.	I summarise content and results.				
j.	I help students with their learning.				
k.	I really like the subject.				
l.	I outline the most important points of a lesson.				
m.	I treat the subject as important.				
n.	I give a lecture.				

11. What are the problems you face when teaching the subject?

____

____

____

The project PRIMAS has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 244380.

SEVENTH FRAMEWORK PROGRAMME

Inquiry Based Learning (IBL)

This PRIMAS CPD is related to "Inquiry-based learning" (IBL). This term may be described as follows:

> **Inquiry-based learning** aims to develop the inquiring minds and attitudes that are required to cope with an uncertain future. Fundamentally, IBL is based on students adopting an active, questioning approach. Students inquire and pose questions, explore and evaluate, and the problems they address are relevant to them. Learning is driven by open questions and multiple solution strategies. Teachers are proactive, supporting struggling students and extending those that are succeeding through the use of carefully chosen strategic questions. They value students' contributions, including their mistakes, and scaffold learning using students' reasoning and experience. In the classroom there is a shared sense of purpose and ownership.

12. To what extent do you agree with the following statements concerning this particular PRIMAS programme you are attending?

	strongly disagree	disagree	agree	strongly agree
a. This programme is only necessary for those new to the profession				
b. This programme is necessary in order to update subject knowledge.				
c. Teachers with a great deal of professional experience don't need a programme like this one.				
d. This programme is necessary to update my repertoire of teaching methods.				
e. This programme can help me to become a better teacher.				
f. Through this programme I can attain greater professional satisfaction as a teacher.				
g. It is difficult for me to see the value of this programme.				
h. This programme is necessary to update pedagogical skills.				
i. I am participating in this programme because it is compulsory.				
j. This programme is only important for those seeking higher levels of responsibility.				
k. I am really glad that I have the opportunity to take part in this programme.				
l. Engaging in this programme can make me more confident in performing my role.				

The project PRIMAS has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 244380.

SEVENTH FRAMEWORK PROGRAMME

13. Please indicate to what extent you agree with the following statements.

	strongly disagree	disagree	agree	strongly agree
a. I would like to implement more IBL practices in my lessons.				
b. IBL is well suited to overcome problems with students' motivation.				
c. I already use IBL a great deal.				
d. I would like to have more support to integrate IBL in my lessons.				
e. I regularly do projects with my students using IBL.				
f. I would like to do more IBL to enrich my teaching practice.				
g. IBL is part of my daily teaching.				
h. IBL is well suited to approach students' learning problems.				
i. Students benefit from IBL.				

The project PRIMAS has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 244380.

SEVENTH FRAMEWORK PROGRAMME

14. Please indicate to what extent you agree with the following statements.

I have difficulties in implementing IBL, because…	strongly disagree	disagree	agree	strongly agree
a. ...the curriculum does not encourage IBL.				
b. ...I have a lack of adequate teaching materials.				
c. ...IBL is not included in textbooks I use.				
d. ...I don’t know how to assess IBL.				
e. ...I enjoy the way teaching works right now.				
f. ...I don’t have access to any adequate CPD programs involving IBL.				
g. ...I worry about students’ discipline being more difficult in IBL lessons.				
h. ...I don’t feel confident with IBL.				
i. ...I worry about my students getting lost and frustrated in their learning.				
j. ...I think students are happy with the way I teach.				
k. ...I think that group work is difficult to manage.				
l. ...there is not enough time in the curriculum.				
m. ...I don’t have sufficient resources such as computers, laboratory,…				
n. ....my students have to take assessments that don’t reward IBL.				
o. ...I am happy with the way things are in my classrooms.				
p. ...the school system does not encourage changes.				

The project PRIMAS has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 244380.

SEVENTH FRAMEWORK PROGRAMME

15. Please indicate to what extent you agree with the following.

		strongly disagree	disagree	agree	strongly agree
a.	I have spent some time thinking about inquiry-based learning (IBL).				
b.	Other priorities prevent me from considering the use of IBL pedagogies.				
c.	I know about the principles of IBL.				
d.	I know about the immediate requirements of using IBL.				
e.	I am concerned about criticism of my work when I try to implement IBL.				
f.	I am concerned about the time and energy required to implement IBL.				
g.	I am concerned about my new teacher's role when using IBL pedagogies.				
h.	I am concerned that I cannot manage all that IBL pedagogies require of me as a teacher.				
i.	I am concerned about the tension between IBL and effectively preparing students for exams.				
j.	I am concerned that preparing IBL lessons takes extra time.				
k.	I am concerned about students' attitudes towards IBL oriented lessons.				
l.	I am concerned about the effects of IBL teaching on students' performance overall.				
m.	I want my students to be motivated by IBL.				
n.	I am concerned that classroom management of IBL is difficult.				
o.	I would like to work more closely with other colleagues who use IBL.				
p.	I am keen to help colleagues to use IBL more effectively.				
q.	I want to be part of a more coordinated and effective approach to IBL.				

Thank you !!!

The project PRIMAS has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 244380.

SEVENTH FRAMEWORK PROGRAMME

4.2 Appendix 2: Student questionnaire

Dear student,

We would like you to take part in this survey as part of a European project.

This questionnaire is anonymous. This means that nobody will be able to identify you from what you have written.

In a few months we will ask you to fill in another questionnaire. To match the questionnaires you are asked to fill in a personal code and a class code.

Your personal code:

- first two letters of your mother's first name (e.g. Ch for Christine) and
- the date of your birthday, (e.g. 06071999 for 06.07.1999)

Your class code:

- first two letters of the first name of your teacher's mother and
- the date of your teacher's birthday, without the year (e.g. 2112 for 21.12.1967)

The aim of this survey is to find out about the European situation regarding learning and teaching across different countries and school subjects.

Thank you so much for your help.

The project PRIMAS has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 244380.

Your Code

1.

Please enter the first two letters of your mother's first name (e.g. Ch for Christine)		

2.

	day		month		year			
Please enter the date of your birthday								

Class code

3.

Please enter the first two letters of the first name of your teacher's mother		

4.

	day		month	
Please enter the date of your teacher's birthday –without the year				

Today's date

5.

Day		Month		Year			

Personal Data

6. I am a student in

Cyprus	Denmark	Germany	Hungary	Malta	Netherlands	Norway	Romania	Slovakia	Spain	Switzerland	UK

7. I am

male	female

The project PRIMAS has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 244380.

8. How much do you like or dislike the lessons in the given subjects?

	No lessons	strongly dislike	dislike	like	strongly like
a. Maths					
b. Physics					
c. Biology					
d. Chemistry					
e. Combined, balanced or general Science					
f. English					
g. Foreign Languages					
h. Art					

Description of current lessons

For the rest of the questionnaire please refer to the subject the teacher who gave you this questionnaire is teaching you.

9. Subject

Maths	Physics	Biology	Chemistry	Combined, balanced or general Science

10. In this subject, how often do the following things happen in class?

		never or hardly ever	in some lessons	in most lessons	in almost all lessons
a.	We are given opportunities to explain our ideas.				
b.	We spend time doing practical experiments / investigations.				
c.	We have the possibility to try out our own ideas.				
d.	When we do experiments / investigations by following the instructions of the teacher.				
e.	We practice the same method repeatedly on many questions.				
f.	We have discussions about the topics.				

SEVENTH FRAMEWORK PROGRAMME
The project PRIMAS has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 244380.

	never or hardly ever	in some lessons	in most lessons	in almost all lessons
g. We learn through doing exercises.				
h. We draw conclusions from experiments or investigations we have conducted.				
i. We listen to what the teacher says.				
j. We design our own experiments or investigations.				
k. We have the possibility to decide how things are done during the lesson.				
l. We have no problems in following the lesson.				
m. We do experiments / investigations to test out our own ideas.				
n. We know enough to understand the lessons.				
o. We are involved in class debate or discussion.				
p. We have the chance to choose our own experiments/investigations.				
q. We are noisy and disruptive.				
r. We work on problems that are related to our real life experience.				
s. We start with easy questions and then move on to harder questions.				
t. We have an influence on what is done in the lesson.				
u. We choose which questions to do or which ideas to discuss.				
v. We are informed about the aim of the lesson.				
w. We take long to settle down after the lesson begins.				
x. We do experiments/investigations that can be done/answered using more than one method.				

11. When having lessons in the chosen subject how often does your teacher do the following things?

		never or hardly ever	in some lessons	in most lessons	in almost all lessons
a.	Our teacher uses this subject to help us understand the world outside our school.				
b.	Our teacher gives us precise instructions.				
c.	Our teacher seems to enjoy teaching the subject.				
d.	Our teacher shows interest in every student's learning.				
e.	Our teacher shows us how this subject is relevant to society.				
f.	Our teacher gives students extra help, if they need it.				
g.	Our teacher continues teaching until we understand.				
h.	Our teacher explains the relevance of this subject to our daily lives.				
i.	Our teacher summarises content and results.				
j.	Our teacher helps us with our learning.				
k.	Our teacher really likes the subject.				
l.	Our teacher outlines the most important points of a lesson.				
m.	Our teacher treats the subject as important.				
n.	Our teacher stands at the front and explains the work.				

SEVENTH FRAMEWORK PROGRAMME

The project PRIMAS has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 244380.

12. Please indicate to what extent you agree or disagree with the following statements about the chosen subject.

		strongly disagree	disagree	agree	strongly agree
a.	I enjoy this subject at school.				
b.	I am talented in this subject.				
c.	I talk with my family or my friends about things I experienced in this subject at school.				
d.	I look forward to lessons in this subject.				
e.	I find that this subject helps me to understand the things around me.				
f.	I have fun when I am learning this subject.				
g.	I am pleased that we learn this subject at school.				
h.	As an adult I would like to work on projects involving this subject.				
i.	I like to study this subject in my free time.				
j.	This subject is very relevant to me.				
k.	I like this subject.				
l.	I learn this subject quickly.				
m.	I will use this subject in my daily life when I am an adult.				
n.	I would like to have even more of this subject at school.				
o.	I would like to spend my life doing more advanced work in this subject.				
p.	I think it is useful to have this subject at school.				
q.	Learning advanced topics would be easy for me.				
r.	I think about this subject outside school.				
s.	When I leave school there will be many opportunities for me to use this subject.				
t.	I would like to work in a career involving this subject.				
u.	I can easily understand new ideas in this subject.				

Thank you for your help!!

SEVENTH FRAMEWORK PROGRAMME
The project PRIMAS has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 244380.

4.3 Appendix 3: Teacher questionnaire: Item scale documentation

The following value will be reported for each scale used in the analysis.

$\bar{x}$	s	r_{it}	a	Cronbachs α	N
Mean of item	Standard derivation	Correlation of item with scale	Cronbachs α, if item is deleted		Size of sample

When teaching this subject to this class, how often do the following activities occur in your lessons?

rou: routine use

	Item	$\bar{x}$	s	r_{it}	a
13c	I already use IBL a great deal.	2,37	0,731	0,717	0,790
13e	I regularly do projects with my students using IBL.	2,24	0,758	0,688	0,817
13g	IBL is part of my daily teaching.	2,21	0,760	0,748	0,759
		Cronbachs α=0,849 N=1127			

ori: orientation

	Item	$\bar{x}$	s	r_{it}	a
13a	I would like to implement more IBL practices in my lessons.	3,24	0,591	0,483	0,615
13d	I would like to have more support to integrate IBL in my lessons.	3,10	0,630	0,442	0,668
13f	I would like to do more IBL to enrich my teaching practice.	3,19	0,618	0,581	0,484
		Cronbachs α=0,686 N=1128			

SEVENTH FRAMEWORK PROGRAMME
The project PRIMAS has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 244380.

mot: motivation

	Item	$\bar{x}$	s	r_{it}	a
13b	IBL is well suited to overcome problems with students' motivation.	3,20	0,566	0,533	0,658
13h	IBL is well suited to approach students' learning problems.	3,05	0,601	0,542	0,649
13i	Students benefit from IBL.	3,29	0,566	0,572	0,612
		Cronbachs α= 0,727 N=1092			

cla: classroom management

	Item	$\bar{x}$	s	r_{it}	a
14g	I have difficulties in implementing IBL, because I worry about students' discipline being more difficult in IBL lessons.	2,35	0,798	0,526	0,658
14h	I have difficulties in implementing IBL, because I don't feel confident with IBL.	2,34	0,751	0,465	0,693
14i	I have difficulties in implementing IBL, because I worry about my students getting lost and frustrated in their learning.	2,32	0,754	0,551	0,643
14k	I have difficulties in implementing IBL, because I think that group work is difficult to manage.	2,33	0,739	0,518	0,663
		Cronbachs α= 0,725 N=1151			

res: resources

	Item	$\bar{x}$	s	r_{it}	a
14b	I have difficulties in implementing IBL, because I have a lack of adequate teaching materials.	2,79	0,769	0,433	
14c	I have difficulties in implementing IBL, because IBL is not included in textbooks I use.	2,70	0,767	0,433	
		Cronbachs α= 0,604 N=1160			

SEVENTH FRAMEWORK PROGRAMME

The project PRIMAS has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 244380.

sys: system restrictions

	Item	$\bar{x}$	s	r_{it}	a
14l	I have difficulties in implementing IBL, because there is not enough time in the curriculum.	3.02	0.801	0.445	0.664
14n	I have difficulties in implementing IBL, because my students have to take assessments that don't reward IBL.	2.80	0.804	0.500	0.630
14a	I have difficulties in implementing IBL, because the curriculum does not encourage IBL.	2.67	0.801	0.523	0.616
14p	I have difficulties in implementing IBL, because the school system does not encourage changes.	2.56	0.797	0.480	0.643
		Cronbachs α= 0,702 N=1121			

int: interaction

	Item	$\bar{x}$	s	r_{it}	a
9a	The students are given opportunities to explain their ideas.	2,90	0,774	0,380	0,576
9f	The students have discussions about the topics.	2,69	0,857	0,458	0,465
9o	The students are involved in class debate or discussion.	2,82	0,809	0,437	0,498
		Cronbachs α=0,616 N=1167			

app: application

	Item	$\bar{x}$	s	r_{it}	a
10a	I use this subject to help the students understand the world outside school.	2,77	0,826	0,508	0,538
10e	I show how this subject is relevant to society.	2,92	1,445	0,428	0,744
10h	I explain the relevance of this subject to students' daily lives.	2,87	0,848	0,581	0,454
		Cronbachs α=0,651 N=1159			

SEVENTH FRAMEWORK PROGRAMME

The project PRIMAS has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 244380.

hon: hands-on

	Item	$\bar{x}$	s	r_{it}	a
9b	The students spend time doing practical experiments/ investigations.	2,01	0,741	0,606	0,622
9d	The students do experiments/investigations by following my instructions.	2,33	0,783	0,527	0,710
9h	The students draw conclusions from experiments/investigations they have conducted.	2,34	0,812	0,582	0,647
		Cronbachs α=0,744 N=1163			

inv: investigation

	Item	$\bar{x}$	s	r_{it}	a
9j	The students design their own experiments/investigations.	1,66	0,714	0,650	0,729
9m	The students do experiments/investigations to test out their own ideas.	1,78	0,741	0,658	0,720
9p	The students have the chance to choose their own experiments/investigations.	1,67	0,763	0,638	0,742
		Cronbachs α=0,802 N=1153			

exe: exercise

	Item	$\bar{x}$	s	r_{it}	a
9g	The students learn to doing exercises.	3,01	0,738	0,450	0,440
9s	The students start with easy questions and move on to harder questions.	3,09	0,725	0,369	0,560
9e	The students repeatedly practice the same method on many questions.	2,56	0,719	0,412	0,499
		Cronbachs α=0,601 N=1165			

SEVENTH FRAMEWORK PROGRAMME
The project PRIMAS has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 244380.

4.4 Appendix 4: Student questionnaire: Item scale documentation

Fun

	Item	$\bar{x}$	s	r_{it}	a
12a	I enjoy this subject at school.	2.84	0.875	0.805	0.888
12d	I look forward to lessons in this subject.	2.58	0.934	0.785	0.894
12f	I have fun when I am learning this subject.	2.68	0.922	0.805	0.887
12k	I like this subject.	2.78	0.948	0.818	0.883
		Cronbachs α= 0.914 N=13784			

val: value

	Item	$\bar{x}$	s	r_{it}	a
12e	I find that this subject helps me to understand the things around me.	2.77	0.894	0.585	0.813
12g	I am pleased that we learn this subject at school.	3.20	0.862	0.623	0.802
12p	I think it is useful to have this subject at school.	3.12	0.847	0.684	0.786
12i	I like to study this subject in my free time.	2.66	0.916	0.646	0.796
12s	When I leave school there will be many opportunities for me to use this subject.	2.70	0.928	0.628	0.801
		Cronbachs α= 0.833 N=13566			

The project PRIMAS has received funding from the European Union
Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 244380.

sco: self-concept

	Item	$\bar{x}$	s	r_{it}	a
12b	I am talented in this subject.	2.64	0.881	0.707	0.842
12l	I learn this subject quickly.	2.64	0.932	0.764	0.819
12q	Learning advanced topics would be easy for me.	2.43	0.914	0.695	0.847
12u	I can easily understand new ideas in this subject.	2.70	0.913	0.733	0.832
		Cronbachs α= 0.871 N=13565			

epi: epistemic interest

	Item	$\bar{x}$	s	r_{it}	a
12c	I talk with my family or my friends about things I experienced in this subject at school.	2.55	0.928	0.462	0.799
12i	I like to study this subject in my free time.	2.10	0.908	0.665	0.699
12n	I would like to have even more of this subject at school.	2.28	0.976	0.608	0.728
12r	I think about this subject outside school.	2.29	0.921	0.653	0.705
		Cronbachs α= 0.787 N=13727			

int: interaction

	Item	$\bar{x}$	s	r_{it}	a
10a	We are given opportunities to explain our ideas.	2.86	0.880	0.369	0.552
10f	We have discussions about the topics.	2.90	0.957	0.424	0.473
10o	We are involved in class debate or discussion.	2.59	0.976	0.431	0.462
		Cronbachs α= 0.599 N=14087			

SEVENTH FRAMEWORK PROGRAMME

The project PRIMAS has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 244380.

app: application

	Item	$\bar{x}$	s	r_{it}	a
11a	Our teacher uses this subject to help us understand the world outside our school.	2.57	0.958	0.578	0.740
11e	Our teacher shows us how this subject is relevant to society.	2.74	0.930	0.630	0.683
11h	Our teacher explains the relevance of this subject to our daily lives.	2.66	0.933	0.635	0.677
		Cronbachs α= 0.778 N=14057			

hon: hands-on

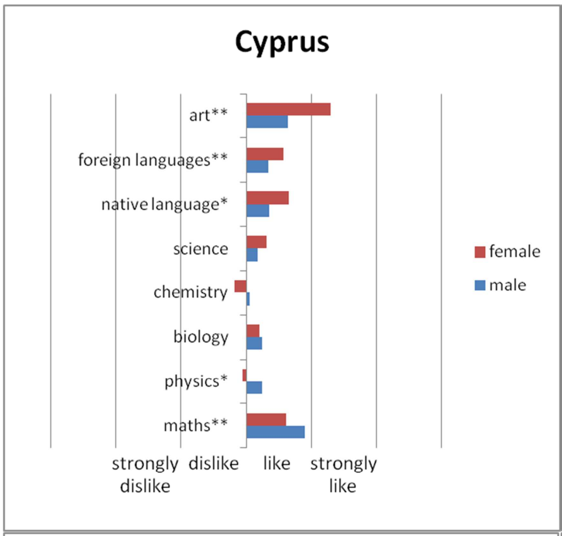
	Item	$\bar{x}$	s	r_{it}	a
10b	We spend time doing practical experiments/ investigations.	2.08	0.871	0.582	0.693
10d	When we do experiments/investigations by following the instructions of the teacher.	2.48	1.025	0.605	0.661
10h	We draw conclusions from experiments/investigations we have conducted.	2.41	1.025	0.592	0.676
		Cronbachs α= 0.759 N=14018			

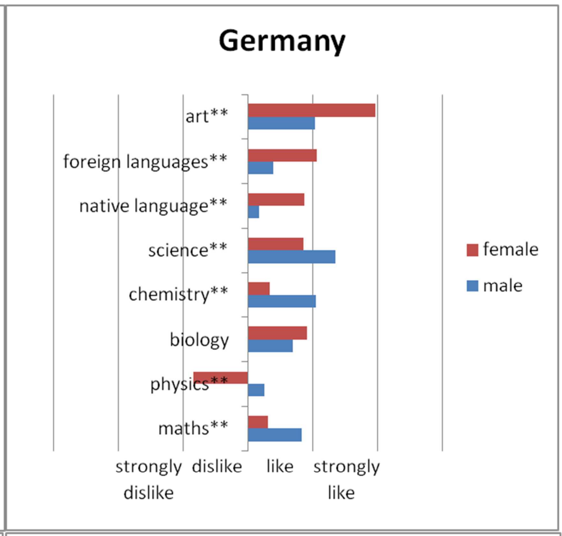
inv: investigation

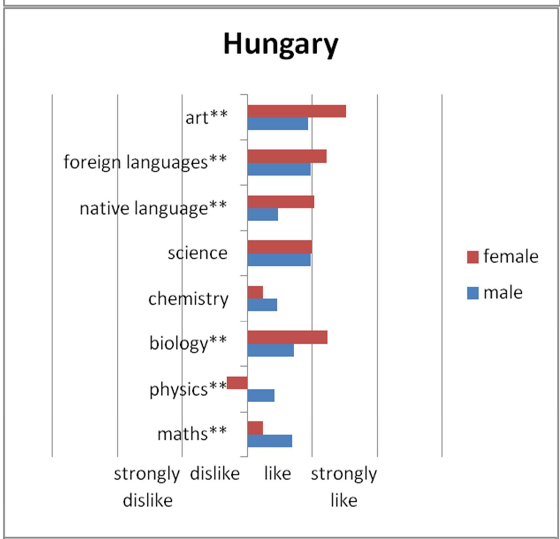
	Item	$\bar{x}$	s	r_{it}	a
10j	We design our own experiments/investigations.	1.67	0.832	0.588	0.628
10m	We do experiments/investigations to test out our own ideas.	1.92	0.923	0.596	0.675
10p	We have the chance to choose our own experiments/investigations.	1.67	0.831	0.591	0.678
		Cronbachs α= 0.760 N=13930			

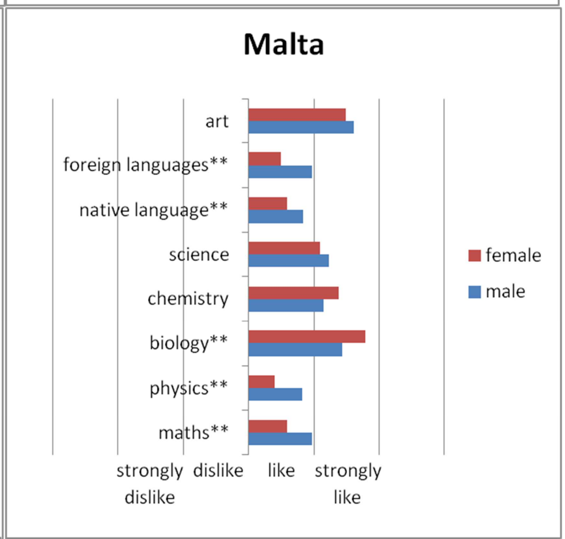
The project PRIMAS has received funding from the European Union
Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 244380.

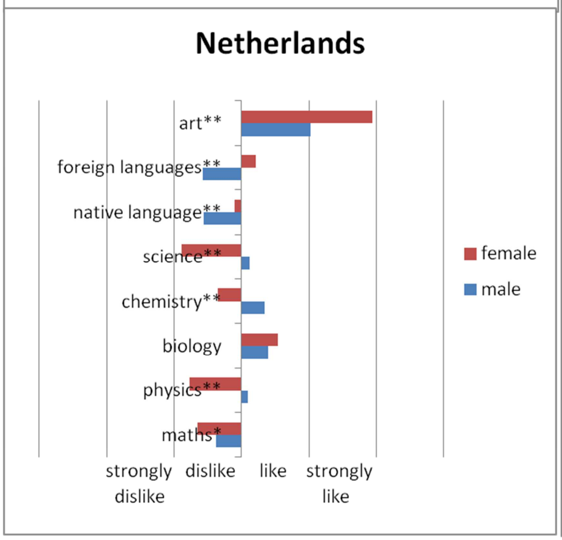
4.5 Appendix 5: Country-specific subject preferences

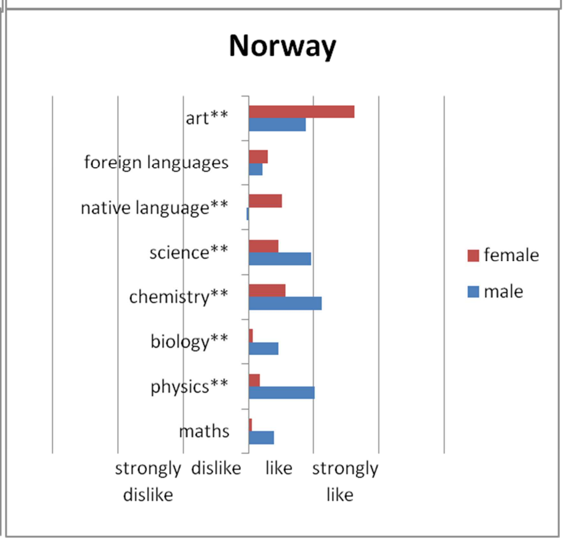




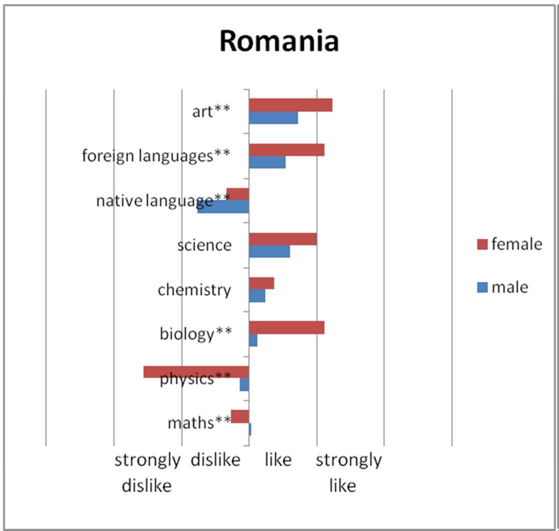


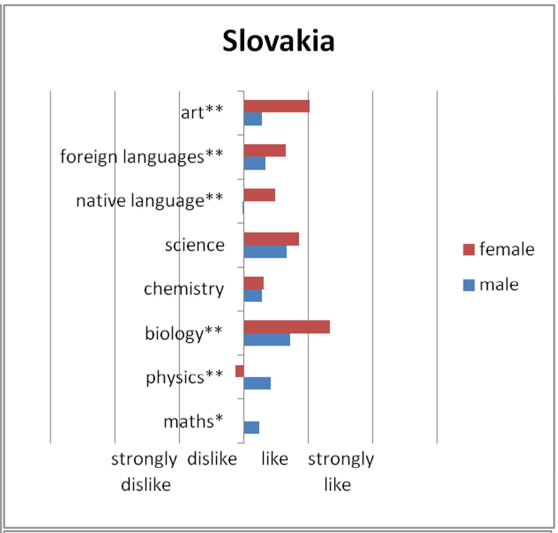


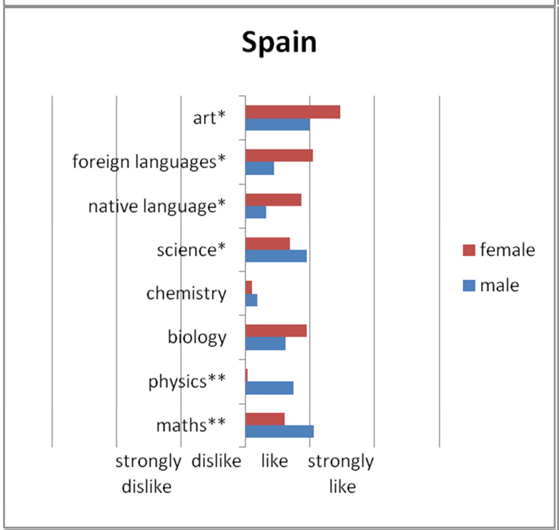


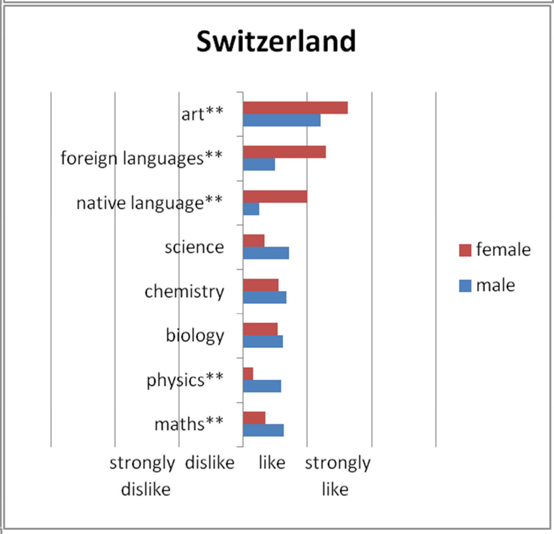


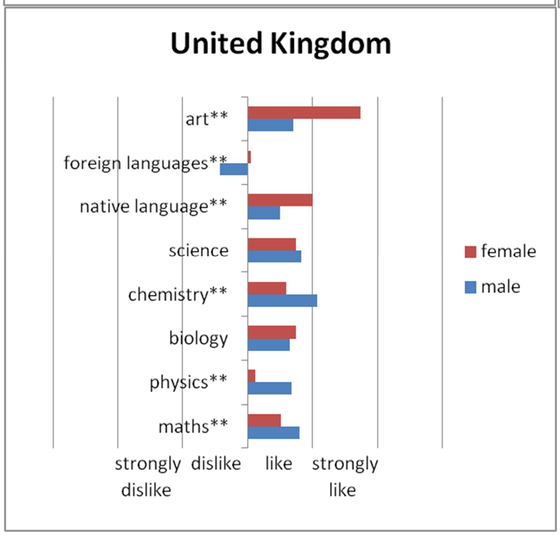
The project PRIMAS has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 244380.











The project PRIMAS has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 244380.