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LABWORK IN SCIENCE EDUCATION

* WORKING PAPER 6 *

Teachers' Objectives For Labwork.
Research Tool And Cross Country Results

Welzel, Manuela; Haller, Kerstin; Bandiera, Milena; Hammelev, Dorte; Koumaras, Panagiotis; Niedderer, Hans; Paulsen, Albert; Robinault, Karine and von Aufschnaiter, Stefan

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Improving Science Education: Issues and Research on Innovative Empirical and Computer-Based Approaches to Labwork in Europe

Short Title: Labwork in Science Education

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Outcomes

A list of the full set of Working Papers from the project can be found at the end of this document. Further results from this work can be found on the Internet via the CORDIS site of the European Commission www.
The abstract of the project provided on this site is given on the next page.

ABSTRACT: *'Labwork in Science Education '*

This project stems from a concern to recognise science education as an important component of a general education, not only for future scientists and engineers, but also for any future citizen in a European society which is increasingly dependent upon science and technology.

Research has focused upon the role of laboratory work ('labwork') in science teaching at the levels of **upper secondary school and the first two years of undergraduate study**, in physics, chemistry, and biology. Various forms of labwork have been identified and investigated, including 'typical' activities in which pairs of students work on activities following precise instructions, open-ended project work in which students design and carry out empirical investigations, and the use of modern technologies for modelling, simulating and data processing.

The main objectives of the project were to clarify and differentiate learning objectives for labwork, and to conduct investigations yielding information that might be used in the design of labwork approaches that are as effective as possible in promoting student learning.

A survey was conducted to allow for better description of existing labwork practices in the countries involved. There are great variations from country to country in the time devoted to labwork, the assessment of students' performance in labwork and the equipment available. However, the forms of labwork activity used between countries are remarkably similar. In each country, the most frequent activity involves students following precise instructions in pairs or threes. A document has been produced describing the place of labwork in science education in each country.

A second survey was conducted to study the learning objectives attributed to labwork by teachers. There are some differences between countries in terms of the relative importance given to the teaching of laboratory skills. Motivation for science learning is not attributed particularly high status as an objective for labwork learning. In each country, the main goal for labwork teaching in the view of teachers surveyed concerns enabling students to form links 'between theory and practice'.

A third piece of survey work was conducted to investigate the images of science drawn upon by students during labwork, and the image of science conveyed to students by teachers during labwork. These surveys were based upon the hypothesis that epistemological and sociological ideas about science are prominent during labwork.

22 case studies were carried out in order to clarify the variety of knowledge, attitudes and competencies that can be promoted through labwork. The case studies focused upon both empirical labwork and labwork involving computer modelling and simulation. The work has resulted in an analysis of the **effectiveness of labwork**, leading to recommendations about policy. It is hoped that teachers and policy makers with responsibilities in science education generally, and labwork in particular, will find these useful in informing future practice with respect to possible objectives for labwork, links between objectives, methods of organisation of labwork and ways of observing and evaluating the effectiveness of labwork in promoting student learning.

* WORKING PAPER 6 *

Teachers' Objectives For Labwork.
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Contents

1. Summary

The study was carried out as a part of the European Research Project "Labwork in Science Education" with members of Denmark, France, Germany, Great Britain, Greece, and Italy. Our team was in charge of surveying teachers' objectives for labwork in science teaching. The aims of this investigation were (1) to gather empirical data on the main objectives for labwork recognised by the teaching staff of upper secondary and first year university level in different European countries and different science subjects and (2) to find out which forms of labwork are useful to reach these objectives. The results of this survey are important as a frame to analyse effectiveness of labwork in European Science Education. Because we intended to gather a spectrum of objectives for labwork as wide as possible, and because of the different languages and cultures in using language in the project we had to use a methodology which allows us to gather data of a rather similar quality in all six countries, at both levels and in three subjects. On the basis of a Delphy technique and intensive discussions within the project we carried out our investigation in three steps: At the first step, we elicited teachers' objectives for labwork, in their own language and their ideas about features for "good" experiments. In the second step, a careful qualitative analysis of these individual teachers' statements, we got categories (main- and sub-categories) of objectives for our next step, the design of a questionnaire by which we asked 60 teachers from each country to judge the importance of the defined categories for labwork in general and in relationship to the type of instruction.

In this working paper we document this investigation step by step. We will show the development of an appropriate tool to gather the intended data in the same way in six different European countries. In addition we will show and discuss the results of our cross country investigation.

2. Theoretical Background

Since the late 70ies labwork in science education keeps staying in a strong research interest. Whether labwork activities are necessary in the processes of teaching and learning at school and university, or wether they are only an assumption made in a period of designing student oriented learning environments is controversially discussed (Toothacker 1983, Woolnough 1983). A reasonable answer to this question lets expect far-reaching national and international political and financial consequences. Thus, in science education a special focus is on the resourses and limits concerning learning sciences through labwork activities. That has been done with the intention to find (develop) innovative forms of labwork which are of particular effectiveness for learning. The results are miscellaneous.

Mainly, the results of these investigations show that experimenting is or can be useful indeed (see e.g. Arons 1993, Bates 1978, Borghi, Brew & Gunstone 1992, De Ambrosis, Mascheretti & Massara 1987, Clough & Clark 1994, Hake 1992, Killermann 1996, 1997, Lunetta 1996, Olsen 1993, Roth 1995, Roth & Duit 1997). Füller (1992) and Killermann (1996) for example find, in a long-term investigation in Biology, a long lasting positive influence of experimenting on memorising abilities of students and in students' motivation for the subject of Biology.

On the contrary, for example investigations of Woolnough (1983) and Hodson (1992) show, that with respect to certain science contents, cognitive abilities not can be improved through experimental activities.

On the other hand Roychoudhury & Roth (1996) and Roth & Duit (1997) describe that and how specific educational effects could be reached using specific experimental learning environments. These authors for example could observe and initiate fostering of social competence and abilities to work in a team, or high quality performances of students.

These mainly contradictory results on the effectiveness of experimental learning environments let think about a close linkage between objectives which can or should be followed when organising labwork, and the type of labwork used to follow certain objectives. In his talk at the 1st ESERA conference 1997 in Rome Woolnough (1997) argued in this sense:

"I would argue that much of this ineffectiveness has been caused by a fundamental, and long lasting, confusion and conflict between aims for doing practical work."

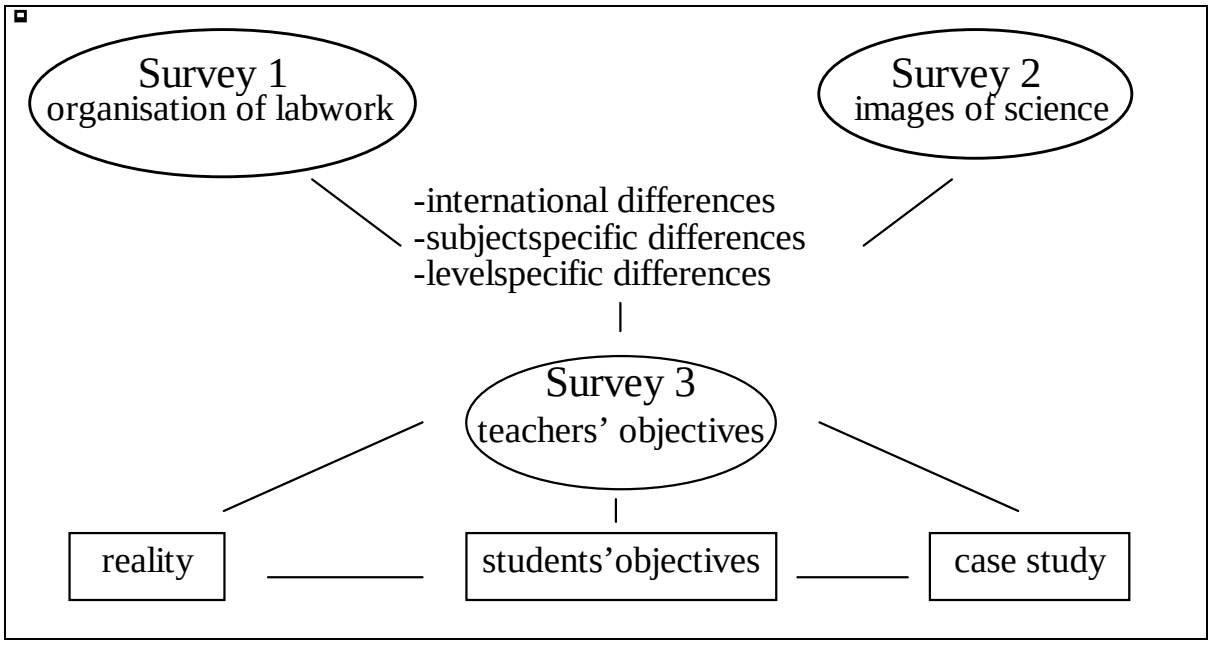
The literature published clearly reflects this situation. Research results in the field of labwork during science instruction show a variety of objectives which can or should be followed when organising labwork at school and at university. These objectives either were formulated on the basis of empirical data gathered by questioning teachers of certain subjects (e.g. Biology - Meyer (1987)) or formulated on the basis of other considerations as pedagogic goals which, for example, occur in curricula (z.B. in Boud 1973, Boud, Dunn & Hegarty-Hazel 1986, Ganiel & Hofstein 1982, Hellingmann 1982, Klainin 1991, Lunetta & Tamir 1979, 1996, Thompson 1975, Woolnough 1983). These objectives are usually justified and weighted. They concern either a specific level or a specific subject to teach or a specific nationality. Also, it is not clear whether and how teachers in fact follow these (mostly given) objectives. Looking at real experimental situations (Boud 1973, Lunetta 1996, Welzel, v. Aufschnaiter & Fischer 1996) it has to be considered that different participants are involved in the teaching-learning process: teachers as well as students. All of them dispose of individual experiences with lab situations and pursue individual objectives. These objectives needn't be the same for all parties.

The reader will find more information on literature in the references attached.

3. Research Questions and Hypotheses

The whole European project was designed to describe the reality of practised labwork in the different countries under specific aspects and to find out in greater detail how to organise labwork in a more effective way with respect to students' learning processes. For that three different surveys and a number of case studies were projected (see WP's of the project).

Survey 3 as part of the European research project "Labwork in Science Education"



Realising this study we wanted to know more about the real situation on what teachers have in mind when organising labwork. Are there any subject-, level- or country specific objectives followed when organising labwork? And, are there any types of labwork more useful than others to reach certain objectives?

Within this two-year research project on labwork in science education researchers tried to answer these questions. Labwork practised in six countries (Denmark, France, Germany, Great Britain, Greece, and Italy), at two levels (upper secondary school and first year university) and in three science subjects (biology, chemistry and physics) was investigated in detail. One main focus was on the objectives teachers have when organising labwork during instruction and on the types of labwork used to follow these objectives.

According to the named central questions of this study - called SURVEY 3 "Teachers' objectives for labwork"- at first we want to have a look at the expectations **teachers** have with respect to the objectives for labwork[1]:

"Given the fact that in effectiveness, the role of teachers is predominant, it appears necessary to study the distance between the main goals recognised by teaching staff, and the main goals

[1] Objectives of students, and the behavior of teachers and students during lab activities with respect to the formulated objectives are investigated in detail with additional quantitative and qualitative studies in the German group of the European project by Kerstin Haller.

they really carry out." (Proposal of "Labwork in Science Education"). On this assumption the work on the present study has been realised.

Thus, the aim of this investigation was **to describe and to compare the main objectives recognised by the teaching staff of upper secondary and first year university level in the different countries and subjects**.

In a second part the types of labwork teachers find useful to reach the named objectives will be described.

4. Methodology

4.1 Introduction

Assumption 1: Similar to Boud (1973) we did not want to give a priori defined categories of objectives to the teachers. They should not be influenced and limited by those formulations. We wanted to get a spectrum of statements (objectives) as wide as possible, to compare it afterwards with those objectives reflected and discussed in the literature.

Assumption 2: One potency of this project is its internationality. Teachers of six different countries had to be investigated at the same time using the same research tool. That, at the same time is definitely problematic for a conversion of the research questions. Because of cultural and linguistic differences between the participants we could not assume a common understanding of items pre-formulated (by a German group).

Thus, we had to find and practise a technique appropriate to the assumptions. One appropriate technique is the Delphy method (Häußler et al. 1988).

4.2 The Delphy-Method

The Delphy-Method is an iterative procedure for questioning larger groups of persons. It grounds usually in the following three elements:

Element 1. One group of persons will be questioned individually and anonymously.

Element 2. The questioning will be repeated within 2 to 4 circles.

Element 3. The repetition will be organised on the basis of the interpretation of the precedent rounds.

This method seems especially suitable to grasp priorities of objectives and for revaluing problems (Kerksiek 1972, Beckerhoff 1971, and Mayer & Bayrhuber 1990). As the only method it produces empirically valuable and valid statements about opinions and views of larger groups of persons.

With attention to the two assumptions stated above we organised the study in three steps adapted to the Delphy-Method.

Each of the steps was discussed and negotiated with respect to the interpretations of items formulated by teachers with the members of the whole European project.

4.3 Research Design

Course of the investigation:

The study was organised in three steps according to the Delphy method:

(1) we "piloted" teachers' objectives using three open questions (element 1 of the Delphy-Method)

(2) we abstracted out of these data categories of objectives and compared these categories with those published in the literature (elements 2 and 3 of the Delphy-Method) and

(3) with a multiple choice questionnaire we let teachers rank and judge the piloted objectives and categories of objectives according to their importance and the usefulness of different types of labwork (elements 2 and 3 of the Delphy-Method).

Ad (1) Using three open questions, we intended to get *empirical* results about possible objectives for labwork in general and according to special types of labwork, and characteristics for "good" labwork. A wide spectrum of objectives formulated by the teachers of the different countries, levels and subjects was expected.

The questions were first formulated by the German group in English language. Then, these formulations were discussed with the international members of the whole project with respect to the meaning of the questions and the intended types of answers. After this procedure a member of each group translated the questions into the national language. The final questionnaires were distributed to 10 teachers of each country covering all levels and subjects). After answering the questions the teachers' statements were translated into English language and sent to Germany.

Ad (2) Out of the teachers' statements translated into English language, we abstracted 5 main categories and 33 sub-categories of objectives. These categories of objectives were compared to objectives formulated in the literature referred above.

Ad (3) A detailed multiple choice questionnaire was designed on the basis of the first step of investigation. With this second questionnaire 10 teachers of each country, level and subject (altogether around 409 teachers)

(1) had to rank five main categories formulated on the basis of the empirical data out of the first step,
(2) had to judge 33 sub-categories of objectives according to their importance with respect to labwork, and
(3) had to judge five different kinds of labwork according to their usefulness to reach the different main categories.

Similar to Boud (1973) we inserted a free line in all categories to allow teachers to fill in missed categories of objectives. This allows us to check (again) the completeness of the list of objectives formulated by us.

Also this questionnaire was designed by the German group in English language. After intensive discussion with members of each group, it was revised and afterwards translated into each native language. Because of the multiple choice design, only comments and additional categories of objectives free formulated by teachers had to be translated into English.

So far, following these three steps adapted to the Delphy-Method, we are able to work with items coming from teachers of all countries, levels and subjects, and thus we are able to look for level-specific, subject-specific and country-sample-specific characteristics.

Labwork in Science Education

European Research Project 1996-1998

Dear colleague,

all students of primary and secondary schools and in natural science branches of education are learning by experiments - ranging from teacher demonstration experiments to student-labwork and projects. This process is being organised in different ways in European schools and universities. Within a project on labwork in science education in six European countries we want to find out how labwork should be organised and supervised in order to achieve an optimum of learning effectiveness. In this context we ask you as teacher at school or at university and thus as an expert in natural science education to answer three questions (in a few words) for a specific subject (physics, biology, or chemistry). Your answer will be the basis for an elaboration of a more differentiated questionnaire. In order to categorise your answers we also ask you to also fill in the lines on the bottom of this page.

Thank you very much for your co-operation.

Name:
Country:
Type of school:
Subject that your answers refer to: (Phy, Bio, Che)
Are you personally engaged in instructing students in labwork or in carrying out experiments? (please circle) yes / no

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Question 1:
What should in your opinion be achieved by labwork in science education? (objectives)

Question 2:
What do you think are the most important characteristics of a "good" labwork?

Question 3:
What kind of labwork did you have in mind when you answered questions 1 and 2? (e.g. demonstration experiment, student-labwork, hands-on experiment, ...)

5. Data Analysis 1

Data analysis—open questions and abstraction of categories of objectives

As expected we got a wide spectrum of objectives formulated by the 60 teachers (each country, level and subject) asked and translated into English language. On average we got 4 to 6 statements of each teacher, that means 4 to 6 different objectives (altogether 317 statements).

Out of this amount of data we could abstract categories (main- and sub-categories) of objectives on the basis of a qualitative content analysis (Berelson 1952, Huber 1989). For that purpose we checked the answers and searched for common characteristics to sort them into groups with similar features. These features were described and distinguished from each other. On this basis names for main categories were formulated.

In a second step we looked at the items within each category. All statements within each category again were sorted by new features. So, we got sub-groups within each category. For each of these sub-groups again names for sub-categories were formulated trying to use the teachers' formulations.

In a further step, in our research group we tested the inter-subjectivity of the assignment to the categories. An accordance of around 90% was reached. The English language categories of objectives were presented and tested again according to their inter-subjectivity during the second international meeting in Bremen.

The following *main categories* of objectives and *sub-categories* of objectives for labwork developed therefore on the basis of individual statements of teachers of six different European countries, two levels, and three science subjects.

The *main categories* of objectives of labwork we could formulate are:

Objectives for labwork are

(A) for the student to link theory to practice,

(B) for the student to learn experimental skills,

(C) for the student to get to know the methods of scientific thinking,

(D) for the student to foster motivation, personal development, social competence[2] and

(E) for the teacher to evaluate the knowledge of the students.

The four main categories of objectives (A-D) contain a number of sub-categories. For category A there are 12, for B 6, for C 8, for D again 6. These 33 sub-categories found describe in more detail different aspects of the main categories and the background for

[2] This category contains three very different aspects - motivation, personal development and social competence. However, we put them into one category because they all represent a social dimension. Dividing this category into three single items could overestimate the social aspect within the whole set of categories.

formulation of the main categories - e.g. what teachers mean saying "to link theory and practice is an objective for labwork".

The answers on the second and third questions (features of a "good" labwork and examples of types of labwork the teachers took into account giving the answers) gave us background information about the understanding of the formulated objectives. As said before, also the formulation of the categories was discussed during a meeting of the whole research project. There were negotiated formulations understandable (hopefully) in a rather similar way by all participants. Finally we could formulate the following sub-categories:

A for the student to link theory and practice

A_1	to facilitate the understanding of the theory
A_2	to verify scientific laws
A_3	to produce (certain) phenomena
A_4	to make the understanding of theory better through practice
A_5	to illustrate phenomena for the students
A_6	to make explicit specific experimental methods for specific topics (content)
A_7	to observe and experiment for future use in theory development
A_8	to deepen by example a subject systematic approach
A_9	to introduce notation and technical terms
A_{10}	to solve problems which arise from an experiment
A_{11}	to demonstrate technical applications
A_{12}	to help remember facts and principles

B for the student to learn experimental skills

B_1	to get experience in standard techniques and procedures
B_2	to learn a method using an example
B_3	to learn and to practice how to write a lab report
B_4	to learn how to make careful observations
B_5	to learn working in a proper and safe way
B_6	to handle experimental errors

C for the student to get to know the methods of scientific thinking

C_1	get to know the scientific approach
C_2	to learn scientific thinking
C_3	to develop skills of planning and experimenting in general in sciences
C_4	to develop a critical approach to interpreting data
C_5	to learn and to handle science as complex networks
C_6	get to know epistemological methods
C_7	get to know how scientists work professionally
C_8	learn to deal with equipment difficulties in general

D for the student to foster motivation, personal development, social competency

D_1	to develop interest
D_2	to enjoy subject and activity
D_3	to develop general skills of communication and interaction
D_4	for the teacher to give and for the student to get motivation

D5	to learn how to work in teams
D6	to develop awareness of natural environment, responsibility, tolerance (ethics in science)

E **for the teacher to evaluate the knowledge of the students**

E1	for the teacher to evaluate the knowledge of the students

The categories of objectives formulated by us on the basis of teachers' statements were compared with the categories of objectives found in the referred literature (e.g. Boud, 1973; Hellingmann, 1982; Klainin, 1991; Lunetta, 1996; Thompson, 1975; Toothacker, 1983). We found similarities: The different sets of objectives used in the literature are formulated usually in a rather similar way and fit into our categories of objectives. But, in each of the articles analysed, we only found a partial quantity of those we did formulate. Thus, our spectrum of objectives for labwork should represent the relevant categories available in the community of science educators. The items of the reported literature were helpful to check the formulations of "our" categories.

For the next step of our study, we worked in the categories of objectives into a questionnaire. In addition we planned to investigate, which types of labwork the teachers think are useful to reach these objectives. For that purpose, we analysed the types of labwork the teachers had in mind while answering the "pilot-questionnaire", and we used the map of types of labwork elaborated through the project (mainly on the data of survey 1 and discussions within the project) and written by Robin Millar. They should be types of labwork relatively easy to differentiate and practised by teachers in all countries.

Finally, we decided to take the following five types of labwork:

- demonstration experiments
- experiments carried out by the students
- open ended labwork
- strongly guided experiments
- using modern technologies

6. The Second Questionnaire

Labwork in Science Education

European Research Project 1996-1998

Questionnaire on "teachers' objectives"

Dear colleague,

all students of primary and secondary schools and in the natural science branches learn by experiments - ranging from teacher demonstration experiments to student-labwork and projects. This process is organised in different ways in European schools and universities. As part of a project on labwork in science education in six European countries, we want to find out how labwork should be organised and supervised in order to achieve optimum learning effectiveness.

In this context we ask you, as a teacher at school or university, and thus as an expert in science education, to answer the following questions. This questionnaire consists of three parts: In the first one you are asked to rank general objectives of labwork. In the second part we give you many different sub-categories of objectives. You are asked to answer the importance each of them has in labwork. In the third part we provide you with different labwork contexts. There you are asked to think about their usefulness for achieving different aims.

In order to categorise your answers we also ask you to complete the questions at the bottom of this page.

Thank you very much for your co-operation!

Manuela Welzel and Kerstin Haller
(Questionnaire co-ordinators)

Name: _____

Country:_____

School (please circle):_____ **upper secondary** **university**

Subject that your answers refer to: **Biology** **Chemistry** **Physics**

Are you personally engaged in instructing students
in labwork or in carrying out experiments? (please circle) **yes / no**

A pilot study carried out in six European countries has led to a **spectrum of different** categories (main- and sub-categories) about the **objectives of labwork**. These categories are based on individual statements and responses from different teachers. The categories of objectives might be important to different degrees for labwork.

Please tell us, what **importance** in your opinion the following objectives have. Please ensure, that in each case the student is the focus of your response.
Please answer each question independently.

1. Objectives for labwork in general

Please rank the following 5 objectives in the order of 1 - highest rank- to 5 - lowest rank - using each number only once.

	Objectives for labwork are	**rank**
A	for the student to link theory to practice	
B	for the student to learn experimental skills	
C	for the student get to know the methods of scientific thinking	
D	for the student to foster motivation, personal development, social competency	
E	for the teacher to evaluate the knowledge of the students	

2. Special sub-categories of objectives for labwork

Now we give to you special objectives formulated as statements. These are sub-categories of each of the main objectives. They are different possibilities or descriptions of interpretations of the main objectives. Please think about **their importance for labwork** and tick the appropriate field!

Judge each statement independently even if it seems similar to another statement.

If we missed a category, feel free in using the extra line at the end of each table. Suggest anything else if you wish.

A	**for the student to link theory and practice**	very im-portant	impor-tant	can't decide	less im-portant	not im-portant	I don't understand this item
A_1	to facilitate the understanding of the theory						
A_2	to verify scientific laws						
A_3	to produce (certain) phenomena						
A_4	to make the understanding of theory better through practice						
A_5	to illustrate phenomena for the students						
A_6	to make explicit specific experimental methods for specific topics (content)						
A_7	to observe and experiment for future use in theory development						
A_8	to deepen by example a subject systematic approach						
A_9	to introduce notation and technical terms						
A_{10}	to solve problems which arise from an experiment						
A_{11}	to demonstrate technical applications						
A_{12}	to help remember facts and principles						

B	**for the student to learn experimental skills**	very important	important	can't decide	less important	not important	I don't understand this item
B_1	to get experience in standard techniques and procedures						
B_2	to learn a method using an example						
B_3	to learn and to practice how to write a lab report						
B_4	to learn how to make careful observations						
B_5	to learn working in a proper and safe way						
B_6	to handle with experimental errors						

C	**for the student to get to know the methods of scientific thinking**	very important	important	can't decide	less important	not important	I don't understand this item
C_1	get to know the scientific approach						
C_2	to learn scientific thinking						
C_3	to develop skills of planning and experimenting in general in sciences						
C_4	to develop a critical approach to interpreting data						
C_5	to learn and to handle science as complex networks						
C_6	get to know epistemological methods						
C_7	get to know how scientists work professionally						
C_8	learn to deal with equipment difficulties in general						

D	**for the student to foster motivation, personal development, social competency**	very important	important	can't decide	less important	not important	I don't understand this item
D_1	to develop interest						
D_2	to enjoy subject and activity						
D_3	to develop general skills of communication and interaction						
D_4	for the teacher to give and for the student to get motivation						
D_5	to learn how to work in teams						
D_6	to develop awareness of natural environment, responsibility, tolerance (ethics in science)						

E	**for the teacher** to evaluate the knowledge of the students	very important	important	can't decide	less important	not important	I don't understand the item
E_1	for the teacher to evaluate the knowledge of the students						

3. Special forms of labwork

Different forms of labwork may have special advantages and disadvantages to achieve certain objectives.
So we give you for each main objective 5 different forms of labwork. Please judge them according to **their usefulness**.
We know that the different forms of labwork listed below are often mixed or combined during lessons. Nevertheless try to imagine a main focus on the described situations.

Please tick the appropriate box.

AIM 1: For the students to become better able to link theory and practice

		1 very useful	2 useful	3 can't decide	4 less useful	5 not useful
1	demonstration experiments are					
2	experiments carried out by the students are					
3	an open ended labwork session is					
4	a (strongly) guided labwork session is					
5	experiments using modern technologies are					

AIM 2: For the students to learn experimental skills

		1 very useful	2 useful	3 can't decide	4 less useful	5 not useful
1	demonstration experiments are					
2	experiments carried out by the students are					
3	an open ended labwork session is					
4	a (strongly) guided labwork session is					
5	experiments using modern technologies are					

AIM 3: That the students become able to get to know the methods of scientific thinking

		1 very useful	2 useful	3 can't decide	4 less useful	5 not useful
1	demonstration experiments are					
2	experiments carried out by the students are					
3	an open ended labwork session is					
4	a (strongly) guided labwork session is					
5	experiments using modern technologies are					

AIM 4: For motivation of students

		1 very useful	2 useful	3 can't decide	4 less useful	5 not useful
1	demonstration experiments are					
2	experiments carried out by the students are					
3	an open ended labwork session is					
4	a (strongly) guided labwork session is					
5	experiments using modern technologies are					

AIM 5: For supporting the personal development of students

		1 very useful	2 useful	3 can't decide	4 less useful	5 not useful
1	demonstration experiments are					
2	experiments carried out by the students are					
3	an open ended labwork session is					
4	a (strongly) guided labwork session is					
5	experiments using modern technologies are					

AIM 6: For improving the social skills of students (i.e. ability of working in a team)

		1 very useful	2 useful	3 can't decide	4 less useful	5 not useful
1	demonstration experiments are					
2	experiments carried out by the students are					
3	an open ended labwork session is					
4	a (strongly) guided labwork session is					
5	experiments using modern technologies are					

AIM 7: To evaluate students' knowledge

		1 very useful	2 useful	3 can't decide	4 less useful	5 not useful
1	demonstration experiments are					
2	experiments carried out by the students are					
3	an open ended labwork session is					
4	a (strongly) guided labwork session is					
5	experiments using modern technologies are					

7. Data Analysis 2

In the third part of our study, using the presented questionnaire, we asked 60 teachers of each participating country to rank the main categories, to judge the importance of the defined sub-categories for labwork in general and in relationship to the type of labwork. With this we expected results about country-sample-related, level-related and subject-related differences in planning and practising labwork.

We got back the following sample of data:

Level-Country-Sample:

Count

		level		
		Secondary school	University	Total
country	Denmark	32	27	59
	France	76	52	128
	Germany	37	35	72
	Great Britain	23	24	47
	Greece	30	30	60
	Italy	28	15	43
Total		226	183	409

Subject-Country-Sample[3]:

Count

		subject			
		biology	chemistry	physics	Total
country	Denmark	20	15	22	57
	France	50	48	29	127
	Germany	19	21	32	72
	Great Britain	16	12	16	44
	Greece	16	16	28	60
	Italy	13	11	19	43
Total		134	123	146	403

All these data were analysed quantitatively using SPSS. The data analysis was proceeded according to the three parts of the final questionnaire:

(1) Ranking of given main categories of objectives,

(2) Judgement of given sub-categories,

(3) Judgement of the usefulness of given types of labwork for reaching the different main objectives.

It has to be taken into consideration that (1) and (2) are different situations for the teachers. For answering the first question, objectives for labwork in general had to be ranked. That generality of the given main categories allows to be far away from any concrete labwork situation. For part (2) *special sub-categories* of objectives for labwork were given to judge the importance—for example: A4 "It is an objective for labwork to illustrate for the students phenomena", or B4 "... to encourage careful observation". This task leads a teacher to think about specific labwork situations and actions. Hence, that will change the perspective during answering the questionnaire.

[3] Six teachers did not give the information about the subject in the questionnaire. Thus, we have 6 answers less for the subject-country-sample.

8. Results

Because of the limited samples in each country, subject and level, we decided to be careful with the formulations of "results" with respect to objectives followed by teachers when organising labwork. We exclusively can show tendencies found in the data set, or formulate hypotheses to go further in the research within this field, or ask questions. Nevertheless, we now are able to present interesting tendencies.

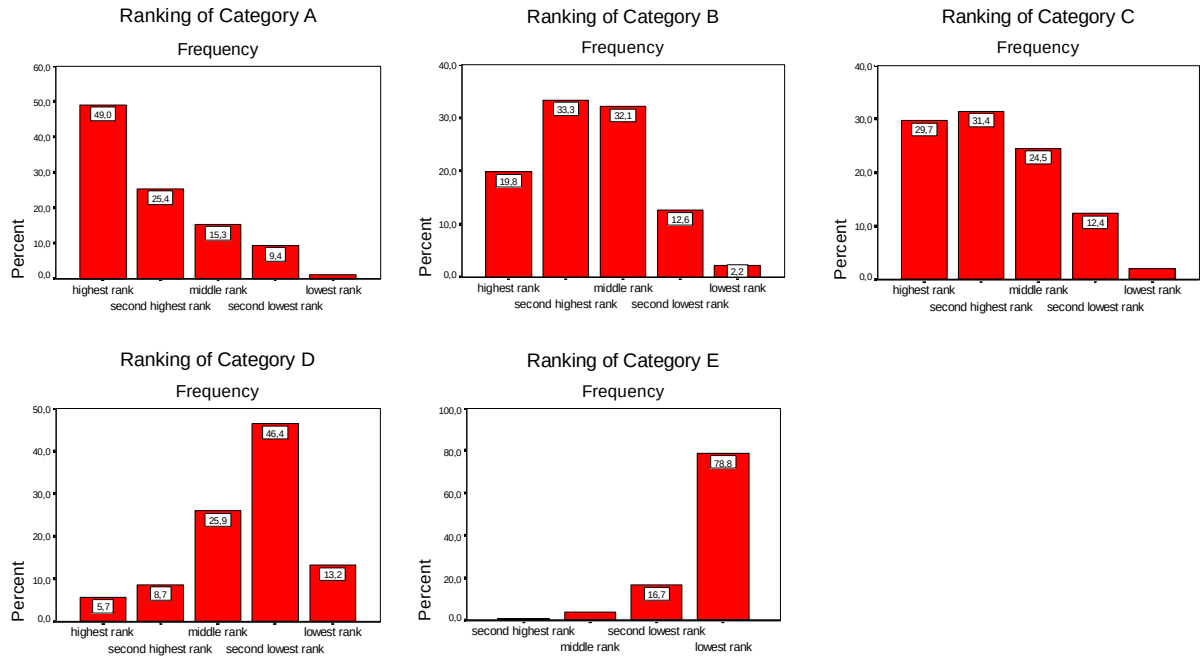
8.1 Main Objectives for Labwork

The teachers had to answer the following task:

Please rank the objectives in the order of 1 - highest rank- to 5 - lowest rank using each number only once.

	Objectives for labwork are	**rank**
A	for the student to link theory to practice	
B	for the student to learn experimental skills	
C	for the student get to know the methods of scientific thinking	
D	for the student to foster motivation, personal development, social competency	
E	for the teacher to evaluate the knowledge of the students	

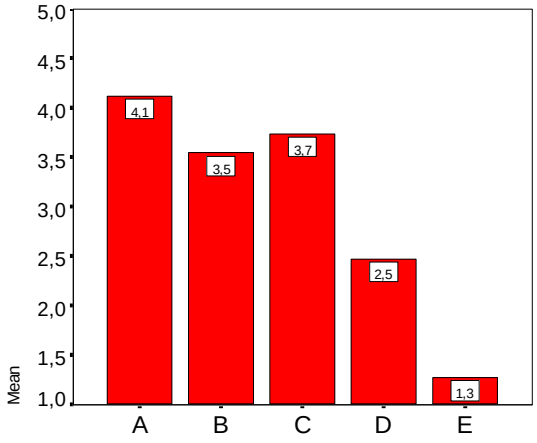
Looking at the frequencies of the ranking of each single category we got the following results (n_{total}=409):



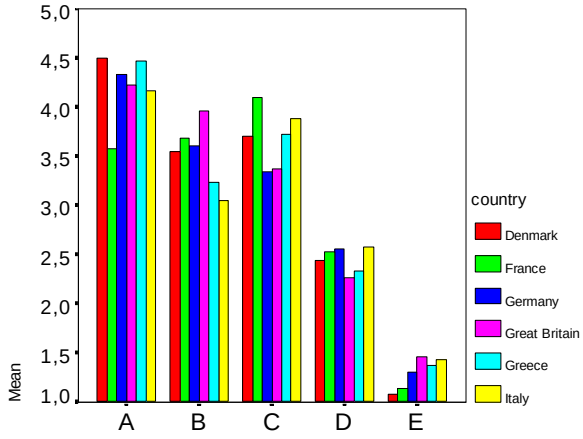
More than 40% of the teachers asked ranked category A (to link theory to practice) as the most important one. Categories B and C got both the most weight for the second rank, but C (for the student get to know the methods of scientific thinking) got more often than B the highest rank. Category D (to foster motivation, personal development, social competency) is mainly ranked lower than the first three categories, but 14% of the teachers put it at the first or second position.

Calculating the mean value of the rank of all categories across all countries and country sample specific we get the following results[4]:

Mean value of main categories (all countries)



Mean value of main categories (country sample specific)



mean-value main-categories - statistics

	N				
	Valid	Missing	Mean	Mode	Variance
A: link theo. and prac.	406	3	4,12	5,00	1,09
B:exp. skills	405	4	3,55	4,00	1,03
C: scien.think	404	5	3,74	4,00	1,17
D: motivation	401	8	2,47	2,00	1,03
E: eva. knowledge	401	8	1,27	1,00	,35

The data show a rather coherent rank of the main categories A, B and C.

! (A) to link theory and practice, (B) to develop scientific thinking, and (C) to develop experimental skills, were ranked as the most important categories of objectives for labwork.

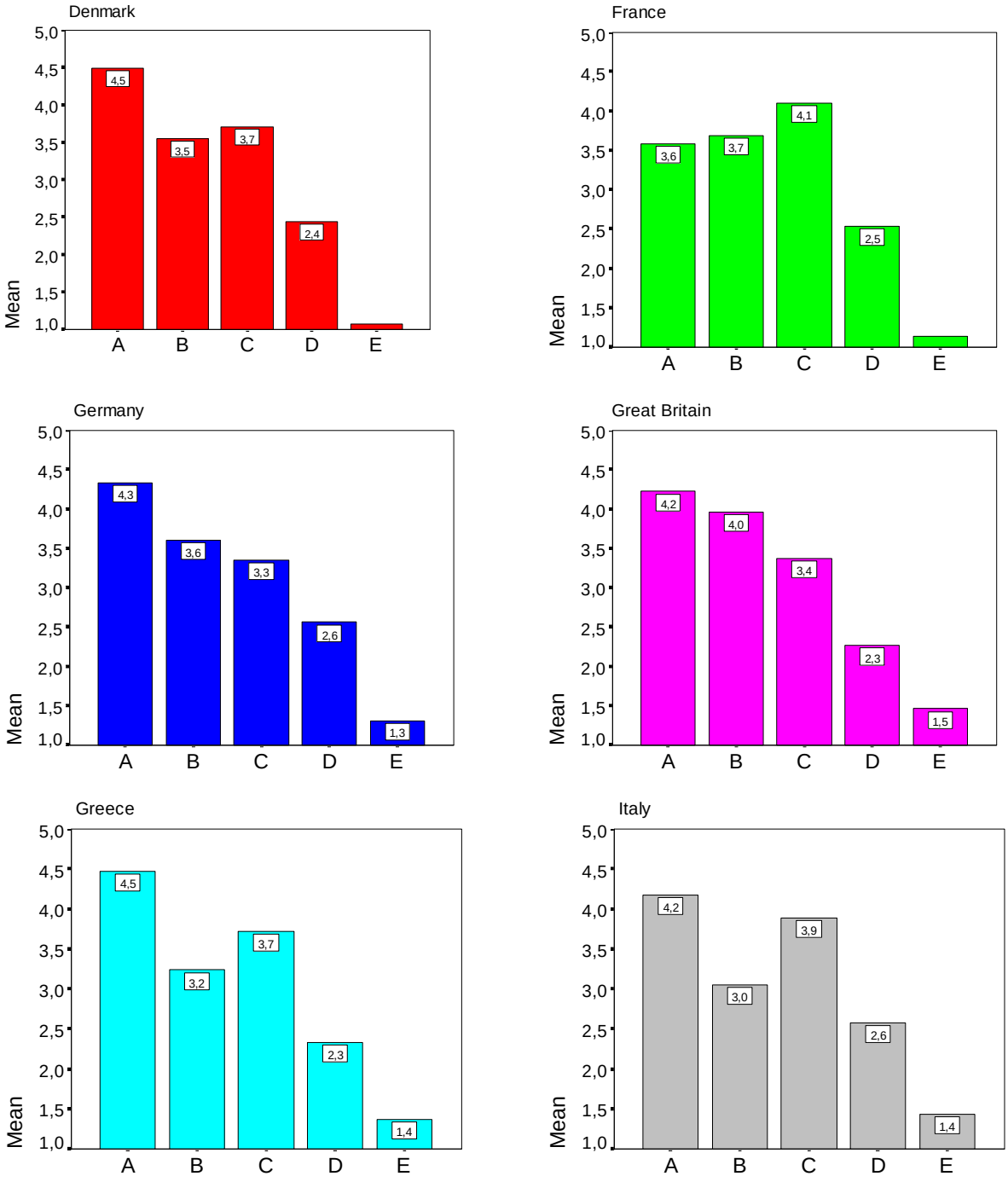
The differences between the country samples[5], between the level specific and subject specific answers are rather small (see next graphs and tables). But there are some interesting phenomena:

[4] Every time we will speak about similarities or differences we will have checked the significance of the predication by mathematical means.

[5] We use the term "country samples" because the data set is limited according to its number. In addition, the questionnaires were differently distributed in the different countries, thus representativity with respect to a country is not given.

COUNTRY SAMPLE SPECIFICS

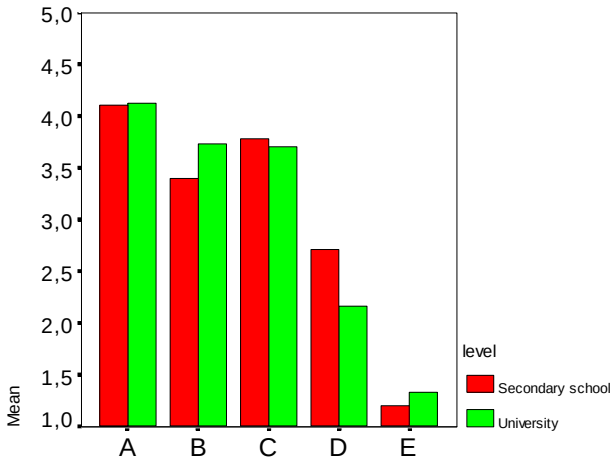
Mean Value of Main Categories for All Country Samples



The French sample as the only one shows the highest value of "to develop scientific thinking" - whatever is meant by this - through labwork.

LEVEL SPECIFICS **mean value of main categories (all levels)**

There are some significant differences between the answers of the different levels:



secondary school

	N				
	Valid	Missing	Mean	Mode	Variance
A: link theo. and prac.	223	3	4,10	5	1,1560
B:exp. skills	223	3	3,41	3[a]	1,0272
C: scien.think	221	5	3,79	5	1,3019
D: motivation	221	5	2,72	2	,9826
E: eva. knowledge	220	6	1,20	1	,3004

a. Multiple modes exist. The smallest value is shown

university

	N				
	Valid	Missing	Mean	Mode	Variance
A: link theo. and prac.	183	0	4,14	5	1,0237
B:exp. skills	182	1	3,74	4	,9798
C: scien.think	183	0	3,69	3[a]	,9739
D: motivation	180	3	2,17	2	,9330
E: eva. knowledge	181	2	1,34	1	,3247

a. Multiple modes exist. The smallest value is shown

! The objective **"to learn experimental skills"** seems to be **more** important for labwork at university than for labwork at secondary school. The same tendency we can find in the data on the sub-categories.

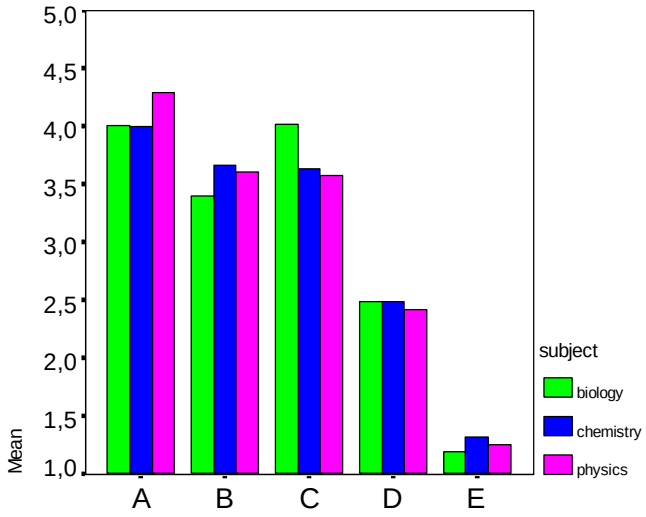
! **"To foster motivation, personal development and social competence"** by doing labwork were ranked **higher at school level** than at university level. The same tendency we can find in the data on the sub-categories.

1. Apparently, the objective **"to learn experimental skills"** is ranked as **more** important for labwork at university than for labwork at secondary school. This result might show that at the university level vocational training moves into the focus of instruction in general. That means professional skills and practises should be developed. Furthermore, the university level teachers asked to answer the questionnaire are usually scientists who have had a strong scientific professional training. That could implicit patterns of behavior for their own teaching.
2. „**To foster motivation, personal development and social competence"** by doing labwork were ranked **higher at school level** than at university level. This result is not surprising, if we take into account that at upper secondary school level a *general education* is claimed in

all Europe (see European Commission 1997) also for science education. To pursue this objective leads to a wide flexibility of the young people for their future orientations and professional development.

SUBJECT SPECIFICS **mean value of main categories (all subjects)**

The answers of biology and physics teachers show two specific features:



! Category C ("**to get to know the methods of scientific thinking**") is **ranked higher by the Biology teachers** than by the others and, it is higher ranked by them than "to develop experimental skills". This effect becomes evident throughout the whole data set[6].

! "**To link theory to practice**" through labwork is ranked **highest by physics teachers**.

The second result seems to reflect one central problem of physics teaching:

Investigations of conceptual change and misconceptions (Pfundt & Duit 1996) did show in great detail the difficulties of students to use individual experiences for the explanation of physics phenomena and for mathematic modeling or description of physics phenomena. Experiments are mainly done to overcome these problems.

[6] Looking at the mean value of the main categories it seems to be an effect produced by the French sample answers. Checking this according to the other samples and the levels, we must say that category C is higher ranked by all Biology teachers.

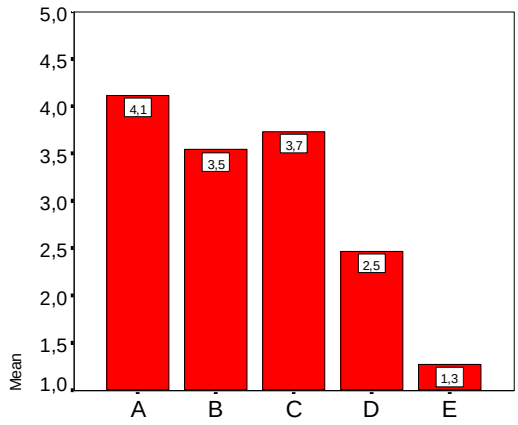
8.2 Sub-Categories of Objectives for Labwork

In the second part of the questionnaire, the teachers had to judge the importance of all sub-categories of objectives.

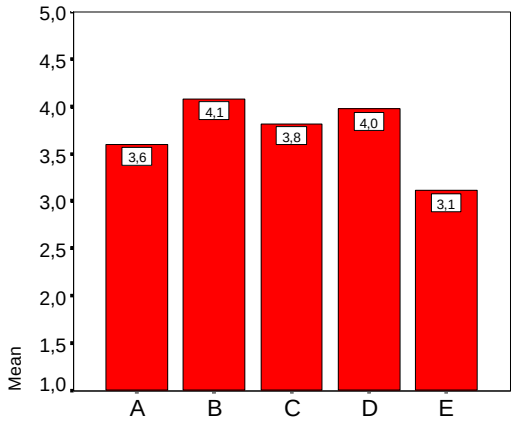
First, we calculated the mean value of the importance of the sub-categories (within each main category) to compare it with the values of the ranking results.

Except for the sum of the mean value in category A, all other categories are judged higher in importance. As expected, we got no ranking effect in the second part of the questionnaire. The items were judged independently from the first part.

Main Categories (mean value)



Sum of Sub-Categories (mean value)



Especially the sub-categories of B (to learn experimental skills) and of D (to foster motivation, personal development, social competency) were judged coherently as very important by all. Within category B item B4: "to learn to make careful observations" gets the highest marks. In D there are items like: "to develop interest through labwork", or "to enjoy subject and activity", or "to develop general skills of interaction and communication".

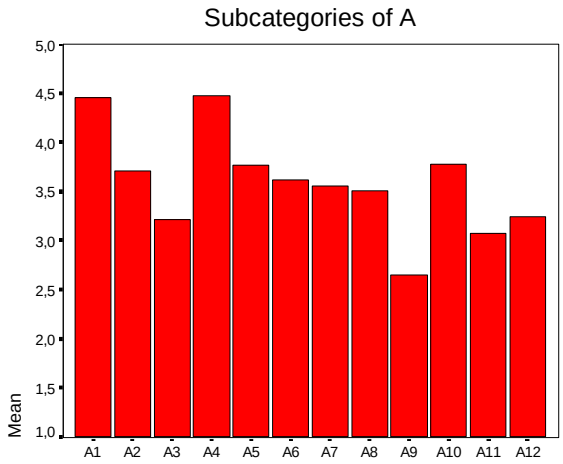
For E we only had one category which was judged now high for its importance, and in addition it was intensively discussed by the teachers. There we could see the problem of how to assess or evaluate students' knowledge during labwork. The teachers normally have to evaluate, but they do not really know how to do this in a fair and reasonable way.

The sub-categories of A "to link theory to practice" and C "to learn the methods of scientific thinking" generally were judged differently and inhomogeneously with respect to their importance. This result and the discussions within the international research group let us think about different understandings of single items or misunderstandings according to the use of language.

This phenomenon we now want to analyse in more detail. With the following tables and graphs we want to drive the attention to the distribution of valuation. We will begin with the sub-categories of A and C - because in both we found inhomogeneousness -, and then, describe the results for D and E.

The sub-categories of A - to link theory to practice

	N		Mean	Mode	Variance
	Valid	Missing			
A1: improve understanding of theory	391	18	4,40	5,00	,55
A2: verify scientific laws	391	18	3,65	4,00	1,30
A3: make phenomena occur	321	88	3,19	4,00	1,25
A4: understanding of theory through practice	390	19	4,47	5,00	,48
A5: illustrate phenomena	374	35	3,69	4,00	1,19
A6: make specific experimental methods explicit	370	39	3,61	4,00	1,39
A7: experiments which will be used in discussions	373	36	3,54	4,00	1,41
A8: improve systematic approach	371	38	3,50	4,00	1,23
A9: introduce notation and technical terms	382	27	2,53	2,00	1,37
A10: solve problems which arise from an experiment	371	38	3,75	4,00	1,21
A11: to demonstrate technical applications	390	19	2,98	2,00	1,45
A12: help remember facts and principles	389	20	3,22	4,00	1,47



The data show a relatively incoherent profile. There are sub-categories which are seen as very important objectives and some are seen as less important:

important	less important
A4 understanding of theory through practice	A9 - introduce notation and technical terms
A1 improve understanding of theory	A3 - make phenomena occur
A10 solve problems which arise from an experiment	

This result could reflect differences between the teachers according to the importance of single objectives, or cultural and lingual differences and problems of understanding the items.

Deeper analyses show, according to the ranking in the first part of the questionnaire, the common view of the teachers asked that the main objective within A is to develop and improve the understanding of theory through practice (A4 and A1). The experiment has to be understood as a tool to learn theoretical descriptions of theory. The weight is on theory. Another argument is that only a small percentage of missing values occur in these categories.

Sub-category A3 - to make phenomena occur - is judged as less important, but there is also a high number (88 = 23% of the population) of missed answers (see table). The reason of missing in this case is for 14.5% of the missed answers that the teachers did not understand the item. They ticked the appropriate box. The teachers ticking this box came mainly from Denmark, France, Great Britain and Greece. In the case of A6 (to make specific experimental methods explicit) almost 10% of answers (mainly by French teachers) were missed.

Looking for country sample specifics, subject specifics and level specifics we found:

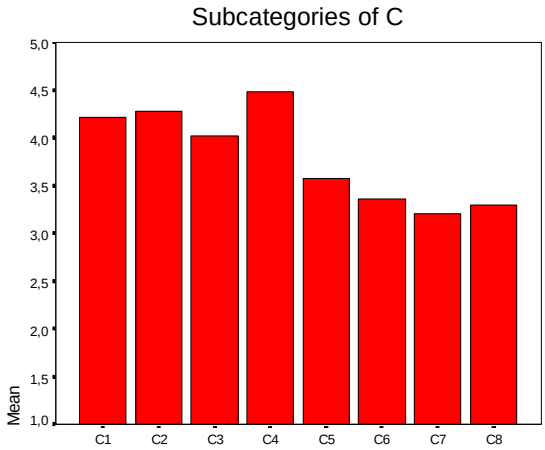
- There are very **high values** (higher than 4.2) for A2 (to verify scientific laws) and A8 (to improve a systematic approach) given by **Greek teachers**.
- There are very **low values** (lower than 2.5) given by **Danish teachers** for A6 (make specific experimental methods explicit) and given by **German teachers** for A9 (to introduce notation...).
- There are **no subject specifics** for the answers in category A.
- Only for A3 (to make phenomena occur) and A10 (to solve problems which arise from an experiment) the **university teachers give higher values** to the sub-categories of A than the school level teachers.

We propose to change the description of the item A3 into "to demonstrate specific physics phenomena (like friction, buoyancy etc.)"

Sub-categories of C to develop scientific thinking

Also for C the data show a relatively incoherent profile. There are sub-categories which are seen as very important objectives and some are seen as less important:

	N		Mean	Mode	Variance
	Valid	Missing			
C1: get to know the scientific approach	384	25	4,19	5,00	,87
C2: to learn how to think scientifically	387	22	4,26	4,00	,71
C3: develop scientifin skills of planning and experimenting in general	388	21	4,02	4,00	,96
C4: develop a critical approach to interpreting data	400	9	4,46	5,00	,42
C5: learn and handle science as complex networks	367	42	3,52	4,00	1,34
C6: get to know epistemological methods	355	54	3,32	4,00	1,22
C7: get to know how scientists work	390	19	3,14	4,00	1,26
C8: learn to deal with equipment difficulties	392	17	3,24	4,00	1,50



very important		less important	
C4	develop a critical approach to interpreting data	C7	get to know how scientists work
C2	to learn how to think scientifically		
C1	get to know the scientific approach		

The mostly missing category (more than 10%) here is C6 (to get to know epistemological methods) (13.5%). The reason for these missing ticks is for 8% of them the answer "I do not understand this item". The teachers mainly came from France and Great Britain. This sub-category gets also a low value of importance.

Looking for country sample specifics, subject specifics and level specifics we found:

- The **Italian teachers** judge **all items higher** than the others.
- C6 (to get to know epistemological methods), C7 (to get to know how scientists work) and C8 (learn to deal with equipment difficulties) are judged **significantly lower** by the **teachers of France and Great Britain** than by the others.
- For C1 (get to know the scientific approach), C2 (to learn how to think scientifically), C5 (learn and handle science as complex networks) and C6 (to get to know epistemological methods) the **Biology teachers** give the highest values.
- All categories are judged higher by the **university teachers**.

Because of misunderstandings with this item we propose to add to the description of item C6 "e.g. inductive, deductive".

The sub-categories of B - to learn experimental skills - and D - to foster motivation, personal development and social competence

By all teachers the sub-categories of B and D are homogeneously judged as very important. It seems to be negotiated relatively good what is meant by "experimental skills" and by social demands.

Looking for country sample specifics, subject specifics and level specifics we found:

- There are no country sample specifics.
- Chemistry teachers give in B the highest values for all items.
- The sub-categories of D are judged in the same way (very high) by the teachers of all the three subjects.
- University teachers judge the importance of experimental skills to learn higher than school teachers.
- Secondary school teachers give higher importance to the objectives of D than university teachers. They feel more responsible for the development of students' social competencies.

8.3 Types of Labwork and their Usefulness to Reach the Objectives

Types of Labwork

In the third part of the questionnaire the teachers were asked to judge the usefulness of different given types of labwork — 1 demonstration experiments, 2 experiments carried out by the students, 3 open ended labwork, 4 (strongly) guided labwork, 5 experiments using modern technologies — for reaching the main objectives[7]. (It could be ticked the items "very useful", "useful", "can't decide", "less useful", "not useful".) These types of labwork we got from the "pilot" study where we asked the teachers to name the types of lab-situations they thought of.

In the questionnaire we formulated:

"Different forms of labwork may have special advantages and disadvantages to achieve certain objectives. Thus, we give you for each main objective 5 different forms of labwork. Please judge them according to their usefulness. We know, that the different forms of labwork listed below are often mixed or combined during lessons. Nevertheless, try to imagine a main focus on the described situations."

The objectives are:

- For the students to become better able to link theory and practice
- For the students to learn experimental skills
- That the students become able to get to know the methods of scientific thinking
- For motivation of students
- For supporting the personal development of students
- For improving the social skills of students (i.e. ability of working in a team)
- To evaluate students' knowledge

Usefulness of specific types of labwork for reaching the objectives

The answers on the usefulness of different types of labwork to reach certain objectives were analysed in the same quantitative way as used in the first two parts of this questionnaire — through calculation of mean values. The results show different usefulness for different objectives:

For the usefulness of the different types of labwork for reaching *all main objectives in general* we got the following rank

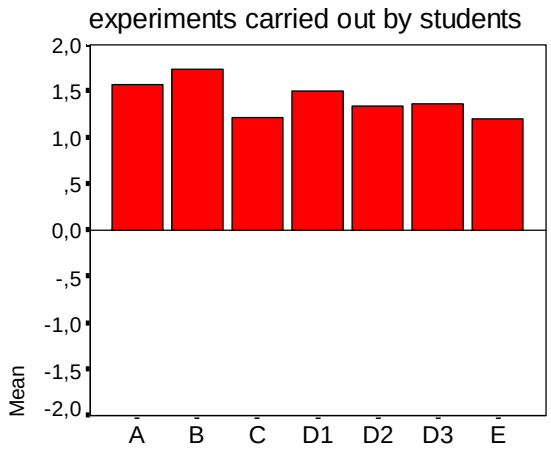
1. experiments carried out by the students
2. open ended labwork
3. using modern technologies
4. strongly guided experiments
5. demonstration experiments

[7] At this point we divided the main category D into three single items (motivation of students, support personal development of students and improving the social skills of students). This division became necessary because of the concreteness of the described types of labwork. Thus we now have 7 main objectives. But now, 3/7 of all objectives have a social dimension.

In general the "normal" labwork practice, usually organised (experiments carried out by the students) were judged as very useful to reach the named objectives. Demonstration experiments were seen as less useful to reach the given main objectives. See the following graphs:

Rank of different Labwork Situations

1



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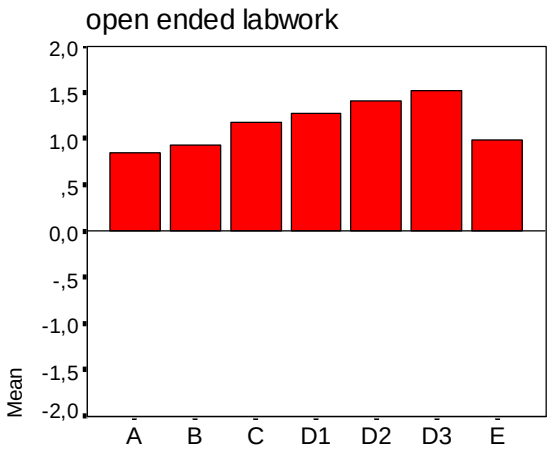

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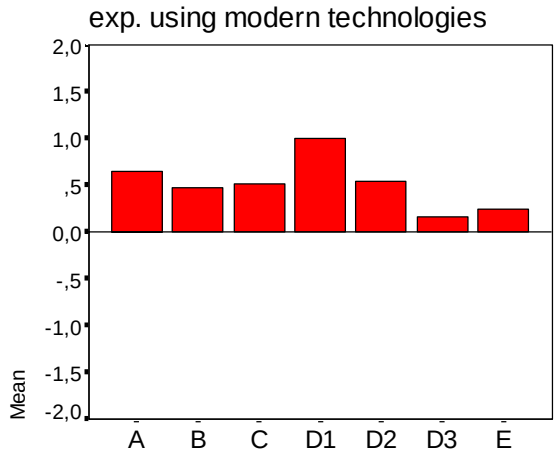

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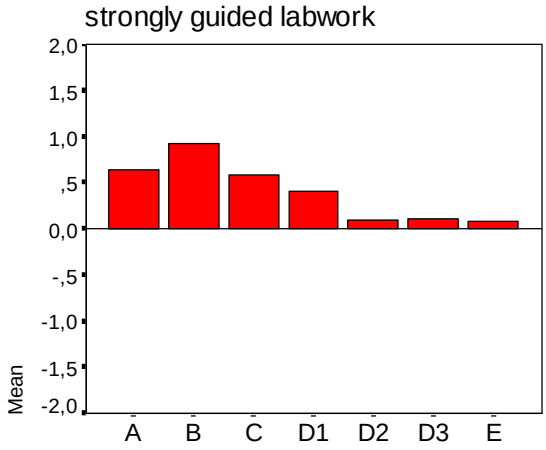
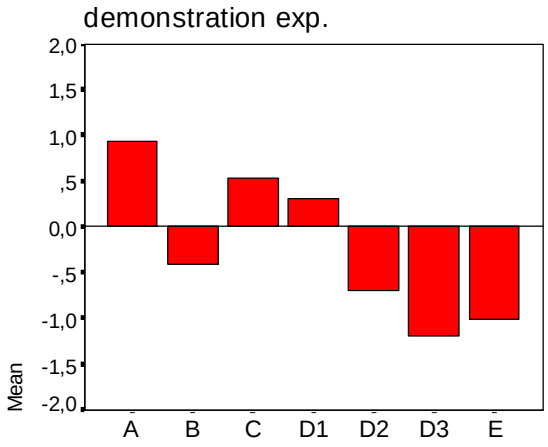


5



The value **2** is "very useful",
1 is "useful",
0 is "can't decide",
-1 is "less useful",
-2 is "not useful"

Tendencies, following these graphs are first presented in the following overview:

Type of Labwork and Objectives

experiments carried out by students	→	useful to reach all objectives
open ended labwork	→	useful to develop social skills
modern technologies	→	useful to foster students' motivation
strongly guided labwork	→	useful to develop experimental skills
demonstrations	→	useful to link theory and practice

modern technologies	→	*less useful* to improve social skills, to evaluate students' knowledge
strongly guided labwork	→	*less useful* to improve social skills, to support the personal development, to evaluate students' knowledge
demonstrations	→	*less useful* to learn scientific thinking, to foster students' motivation, to improve social skills, to support the personal development, to evaluate students' knowledge, to learn experimental skills

It has to be taken into account that usually different forms of labwork are mixed and combined during lessons and practicing labwork. Thus, the advantages and disadvantages can be linked together, too. However, the following overview shows the teachers' answers on the usefulness of pure forms of labwork.

- **Experiments carried out by the students** are judged very useful to reach *all* objectives. This we find at both levels as well as for all subjects and country samples.
- **Open ended labwork** generally is judged very useful, too. But here can be seen a weight on the objectives concerning social competencies.
- **Experiments using modern technologies** is judged positively, but not at both levels and for all country samples. The answers seem to be related to the specific population and/or to the equipment facilities in each country and at each level. The opportunities there are really different.
- **Strongly guided experiments** are mainly seen as useful to learn experimental skills and to link theory and practice (except by Danish teachers). Strongly guided experiments are usually valuated as less useful to develop social competencies.
- **Demonstration experiments** is the only type of labwork judged partly negatively—for supporting personal development and for improving social competencies. A positive effect of demonstration experiments seems to be for the linkage of theory to practice as well as for motivation of students. But there are level specific differences.

Some level-, subject- and country sample specific differences get visible looking deeper into the data set.

- **Experiments using modern technologies** are judged as **less useful for the university level** than for the school level. Especially the usefulness for improving social competencies and for evaluation of students' knowledge is seen negatively. With focus on the country

samples the data show that the teachers asked in Germany and in Denmark judge the use of modern technologies for reaching the main objectives as less useful.

- **Strongly guided experiments** are judged as **more useful at the school level**, especially for reaching aims with a social dimension. With this result it has to bee seen that for instruction at school level the development of experimental skills mainly concerns basic skills of handling material than creative experimenting in the framework of natural sciences.

Demonstration experiments are judged less useful than the other types of labwork. However, they are seen as **useful for reaching the first three objectives at school level** - to link theory and practice, to learn experimental skills and to learn methods of scientific thinking.

9. Discussion and Conclusions

This study is a part of a larger European research project. Its aims were (1) to find out teachers' objectives for labwork in different European countries, different levels and subjects, and (2) to find out which types of labwork are considered as useful by the teachers asked to reach the objectives.

For these purposes, a new survey was developed. The data were collected and analysed country sample specific, level specific and subject specific. Consequently the perspective of teachers of different countries, levels and science subjects was kept. The formulation of categories was oriented as close as possible at teachers' formulations. During the study, an intensive process of discussion and negotiation was installed between the participating scientists. That was especially important to find and to check interpretations of data coming from teachers of different countries, levels and subjects. While discussing interpretations again and again, different possibilities of usage and interpretation of descriptions and meanings were to be seen. According to the problems of multi-culturality , multi-linguality, and data gathered within limited samples, the results are formulated as empiricaly hypotheses, which can give a rough overview and special tendencies. In further research, the generalisability of these results has to be tested.

The objectives formulated, ranked and judged by teachers and categories abstracted by us for labwork instruction could be described. For being able to abstract hypotheses about the achievement of these objectives further investigations are necessary. The first step into this direction is a special case study running in the German group of the project. With this also students' objectives for labwork are investigated using the developed questionnaire and videodata analyses during labwork activities. A close link between questionnaire data and process data will be realised. First results are expected for next year.

We see the main results of this study in the following three aspects:

a) A tool to gather empirical data about teachers' objectives for labwork was developed according to the Delphy technique. Thus, the development of this tool could be discussed critically for its improvement.

b) With the formulations of the questionnaire we found a list of possible main objectives for labwork and possible subcategories for these objectives, which are usefull beyond the empirical results for planning innovations of labwork in the future.

c) The empirical data show teachers' preferences among these objectives - teachers of different European countries, different levels and different science subjects in a limited sample. These data were analysed and shall give an overview about the situation "around" the organisation of labwork in some European countries.

For a) The method used for this investigation generally seems to be appropriate to gather data about teachers' objectives of different European countries doing labwork with students at school and at university level. However, there were some problems in translating the items into the different languages. In some cases an oral instruction by a participating researcher on how to understand the tasks and questions was necessary. Especially in the case of "the use of modern technologies" misunderstandings became visible. Modern technologies are more than only the use of computers. For a future use of the questionnaire some sub-categories differently understood by different teachers have to be re-formulated. Such improvements have been suggested in section 8.2 and 8.3.

For b) The formulations of objectives have a common core with possible objectives of labwork formulated in the "MAP" (Working Paper WP 1). The formulations here are more detailed. They have been used in a German project with university physicists to enhance the formulation of participants' own objectives for labwork.

For c) Analysing teachers' answers on objectives for labwork level-, subject- and country-sample-specific similarities and differences about objectives arise. The main result is that three objectives are seen by teachers as highly and equally important: **to link theory to practice, to learn experimenting skills and to learn the methods of scientific thinking**. These objectives seem to be the "main" objectives for labwork throughout the whole sample. Other results show the importance of fostering motivation, personal development and social competence through experimental activity.

Differences between levels and subjects could be identified within the two first parts of the questionnaire. The objective "to learn experimental skills" seems to be more important at university level than at school level. The objective "to foster motivation, personal development and social competence" seems to be more important at school level than at university level. The subject of Biology in the opinion of teachers contributes more than the other subjects to an objective "to develop scientific thinking". More details are shown in section 8.1 and 8.2.

Different types of labwork are seen to be useful to reach certain objectives in different degrees.

For the usefulness of the different types of labwork for reaching *all main objectives in general* we got the following rank **1.** experiments carried out by the students, **2.** open ended labwork, **3.** using modern technologies, **4.** strongly guided experiments, and **5.** demonstration experiments.

It has to be taken into account that usually different forms of labwork are mixed and combined during lessons and practising labwork. Thus, the advantages and disadvantages of each of them can be linked together. However, with our investigation we got the teachers' answers on the usefulness of pure forms of labwork.

Experiments carried out by the students are judged very useful to reach *all* objectives. This we find at both levels as well as for all subjects and country samples.

Open ended labwork generally is judged very useful, too. But here can be seen a weight on the objectives concerning social competencies.

Experiments using modern technologies is judged positively, but not at both levels and for all country samples. The answers seem to be related to the specific population and/or to the equipment facilities in each country and at each level.

Strongly guided experiments are mainly seen as useful to learn experimental skills and to link theory and practice. Strongly guided experiments are usually valuated as less useful to develop social competencies.

Demonstration experiments is the only type of labwork judged partly negatively—for supporting personal development and for improving social competencies. A positive effect of demonstration experiments seems to be for the linkage of theory to practice as well as for motivation of students. But there are level specific differences.

10. The revised Questionnaire on Teachers' Objectives for Labwork

Labwork in Science Education

European Research Project 1996-1998

Questionnaire on "teachers' objectives"

Dear colleague,

All students of science learn through experiments - ranging from teacher demonstration experiments to student- labwork and projects. This labwork is organised in different ways in European schools and universities. As part of a project on labwork in science education in six European countries, we want to find out how labwork should be organised and supervised in order to optimise students' learning. As a result we are asking you, as a teacher at school or university, and thus as an expert in science education, to answer the following questions. This questionnaire consists of three parts: In the first part you are asked to rank general objectives of labwork. In the second part you are presented with different subcategories of objectives. You are asked to indicate the extent to which you feel each of these is an important objective of labwork. In the third part we provide you with different labwork contexts. There you are asked to think about their usefulness of each context in achieving different labwork objectives.

In order to categorise your answers it would be helpful if you could complete the questions at the bottom of this page.

Thank you very much for your co-operation!

Manuela Welzel and Kerstin Haller
(Questionnaire coordinators)

Name: _____
Country:_____

School (please circle):_____ **upper secondary** **university**

Subject that your answers refer to: **Biology** **Chemistry** **Physics**

Are you personally engaged in instructing students

in labwork or in carrying out experiments? (please circle) **yes / no**

A pilot study carried out in six European countries has led to a **variety of different** categories describing the **objectives of labwork**. These categories are based on individual statements and responses from different teachers. We have arranged these categories under five main headings (main-categories). These main headings are described in section 1. Section 2 then presents the sub-categories under each heading.

Please tell us in your opinion what **importance** these objectives have.

Ensure that in each case the student is the focus of your response. Please answer each question independently.

1. Objectives for labwork in general

Please rank the following 5 objectives in the order of 1 = highest rank and 5 = lowest rank.

Please use each number only once.

	Objectives for labwork are	**rank**
A	for the student to link theory and practice	
B	for the student to learn experimental skills	
C	for the student get to know the methods of scientific thinking	
D	for the student to increase their motivation, personal development, social competency	
E	for the teacher to evaluate the knowledge of the students	

2. Special subcategories of objectives for labwork

In this section we present a number of sub-categories within each of the five main objectives.

Please think about **their importance for labwork** and tick the appropriate box.

Judge each statement independently even if it seems similar to another statement.

If you feel that there is an additional sub-category, then please write in the extra line at the end of each table.

A	**For the student to link theory and practice**	very impor-tant	impor-tant	can't decide	less impor-tant	not impor-tant	I don't understand this item
A1	to facilitate the understanding of the theory						
A2	to verify scientific laws						
A3	to demonstrate specific physics phenomena (like friction, buoyancy)						
A4	to make the understanding of theory better through practice						
A5	to illustrate phenomena to the students						
A6	to make specific experimental methods explicit						
A7	to make observations and perform experiments which will be used in future discussions about specific scientific theories						
A8	to deepen by example the student's systematic approach to their subject						
A9	to introduce notation and technical terms						
A10	to solve problems which arise from an experiment						
A11	to demonstrate technical applications						
A12	to help remember facts and principles						

B	**For the student to learn experimental skills**	very impor-tant	impor-tant	can't decide	less impor-tant	not impor-tant	I don't understand this item
B1	to get experience in standard techniques and procedures						
B2	to learn an experimental procedure by performing it						
B3	to learn and to practice how to write a laboratory report						
B4	to learn how to make careful observations						
B5	to learn how to work properly and safely						
B6	to learn how to handle experimental errors						

C	**For the student to get to know the methods of scientific thinking**	very impor-tant	impor-tant	can't decide	less impor-tant	not impor-tant	I don't understand this item
C1	get to know the scientific approach						
C2	to learn to think scientifically						
C3	to develop the scientific skills of planning and experimenting in general						
C4	to develop a critical approach to interpreting data						
C5	to learn and to handle science as complex networks						
C6	get to know epistemological methods (e.g. inductive, deductive)						
C7	get to know how scientists work professionally						
C8	learn to deal with equipment difficulties in general						

D	**For the student to increase their motivation, personal development, social competency**	very impor-tant	impor-tant	can't decide	less impor-tant	not impor-tant	I don't understand this item
D1	to develop interest						
D2	to enjoy subject and activity						
D3	to develop general skills of communication and interaction						
D4	for the teacher to give and for the student to get motivation						
D5	to learn how to work in teams						
D6	to develop awareness of natural environment, responsibility, tolerance (ethics in science)						

E	**For the teacher to evaluate the knowledge of the students**	very impor-tant	impor-tant	can't decide	less impor-tant	not impor-tant	I don't understand the item
E1	for the teacher to evaluate the knowledge of the students						

3. Special forms of labwork

Different forms of labwork may have special advantages and disadvantages for achieve certain aims.

In this section we present 5 different forms of labwork which could be used to achieve each labwork aim.

Please judge each form of labwork according to **its usefulness** in achieving the specific aim.

We know, that the different forms of labwork listed below are often mixed or combined during lessons. Nevertheless try to imagine a main focus on the described situations.

Please tick the appropriate box.

AIM 1: For the students to become better able to link theory and practice

		1 very useful	2 useful	3 can't decide	4 less useful	5 not useful
1	demonstration experiments are					
2	experiments carried out by the students are					
3	an open ended labwork session is					
4	a (strongly) guided labwork session is					
5	experiments using modern technologies (e.g. for data capture or modelling) are					

AIM 2: For the students to learn experimental skills

		1 very useful	2 useful	3 can't decide	4 less useful	5 not useful
1	demonstration experiments are					
2	experiments carried out by the students are					
3	an open ended labwork session is					
4	a (strongly) guided labwork session is					
5	experiments using modern technologies (e.g. for data capture or modelling) are					

AIM 3: For students to get to know the methods of scientific thinking

		1 very useful	2 useful	3 can't decide	4 less useful	5 not useful
1	demonstration experiments are					
2	experiments carried out by the students are					
3	an open ended labwork session is					
4	a (strongly) guided labwork session is					
5	experiments using modern technologies (e.g. for data capture or modelling) are					

AIM 4: For the motivation of students

		1 very useful	2 useful	3 can't decide	4 less useful	5 not useful
1	demonstration experiments are					
2	experiments carried out by the students are					
3	an open ended labwork session is					
4	a (strongly) guided labwork session is					
5	experiments using modern technologies (e.g. for data capture or modelling) are					

AIM 5: For supporting the personal development of students

		1 very useful	2 useful	3 can't decide	4 less useful	5 not useful
1	demonstration experiments are					
2	experiments carried out by the students are					
3	an open ended labwork session is					
4	a (strongly) guided labwork session is					
5	experiments using modern technologies (e.g. for data capture or modelling) are					

AIM 6: For improving the social skills of students (i.e. ability of working in a team)

		1 very useful	2 useful	3 can't decide	4 less useful	5 not useful
1	demonstration experiments are					
2	experiments carried out by the students are					
3	an open ended labwork session is					
4	a (strongly) guided labwork session is					
5	experiments using modern technologies (e.g. for data capture or modelling) are					

AIM 7: To evaluate students' knowledge

		1 very useful	2 useful	3 can't decide	4 less useful	5 not useful
1	demonstration experiments are					
2	experiments carried out by the students are					
3	an open ended labwork session is					
4	a (strongly) guided labwork session is					
5	experiments using modern technologies (e.g. for data capture or modelling) are					

11. References

Barbera; Valdes 1996: El trabajo practico en la ensenanza de las ciencias: una revision. Ensenanza de las Ciencias.14 (3).

Arons, A. B. (1993). Guiding Insight and Inquiry in the Introductory Physics Laboratory. In: The Physics Teacher, 31. 278-282.

Bates, G. R. (1978). The role of the laboratory in secondary school science programs. In: M. B. Rowe (Ed.). What research says to the science teacher, Washington DC: National Science Teachers Association, ED 166057, 55-82.

Beckerhoff, D. (1971). Methoden der Prioritätsbestimmung I, Teil II. Abschlußbericht für das Bundesministerium für Bildung und Wissenschaft. In: Methoden der Prioritätsbestimmung Band 1-3. Bonn. 61-91.

Berelson, B. (1952). Content Analysis in Communication Research. Glencoe: Free Press.

Borghi, L., De Ambrosis, A., Mascheretti, P., & Massara, C.I. (1987). Computer simulation and laboratory work in the teaching of mechanics. In: Physics Education, 22. 117-121.

Boud, D. J. (1973). The laboratory aims questionnaire a new method for course improvement? In: Higher Education.Vol.2. 81-94.

Boud, D. J., Dunn, J.; Kennedy, T. & Thorley, R. (1980). The aims of science laboratory courses: A survey of students, graduates and practising scientists. In: Research Reports. Taylor & Francis Ltd.

Brew, C. R., & Gunstone, R. F. (1992). Students' perceptions of an innovative university laboratory program. In: Research in Science Education 22, 55-62.

Clough, M. P. & Clark, R. (1994). Cookbooks and constructivism - a better approach to laboratory activities. In: The Science Teacher 61(2). 34-37.

Europäische Kommission (1997). Sozio-ökonomische Schwerpunktforschung (TSER), Informationspaket, Ausgabe 1997.

Füller, F. (1992). Biologische Unterrichtsexperimente - Bedeutung und Effektivität. In: Killermann (Hg.). Münchner Schriften zur Didaktik der Biologie. Universität München.

Ganiel, U. & Hofstein, A. (1982). Objective and continous assessmant of student performance in the physics laboratory. In: Science Education 66, 581-591.

Hake, R. R. (1992). Socratic Pedagogy in the Introductory Physics Laboratory. *The Physics Teacher*, *19*, 546-552.

Häußler, P. (1988): Physikalische Bildung für heute und morgen: Ergebnisse e. curricularen Delphi-Studie. Institut für Pädagogik der Naturwissenschaften an der Universität Kiel.

Hellingmann, C. (1982). A trial list of objectives of experimental work in science education. In: European Journal of Science Education 4, 29-43.

Huber, G. L. (1989). Qualität versus Quantität in der Inhaltsanalyse: In. Bos, W. und Tarnai, C. (Hrsg.) Angewandte Inhaltsanalyse in Empirischer Pädagogik und Psychologie. New York: Waxmann. 32-47.

Kerksiek, H.-J. (1972). Methoden der technischen Vorausschau im Dienst der Forschungsplanung industrieller Unternehmungen unter besonderer Berücksichtigung der Delphi-Methode. Diss. Mannheim.

Killermann, W. (1996). Biology Education in Germany: research into the effectiveness of different teaching methods. In: International Journal of Science Education 18(3). 333-346.

Klainin, S. (1991). Practical Work and Science Education 1. In: Peter Fensham (Ed.) Development and Dilemmas in Science Education. The Falmer Press. 169-217.

Lunetta, V. N. & Tamir, P. (1979). Matching lab activities with teaching goals. In: The Science Teacher 46(5). 22-24.

Lunetta, V. N. (in press). The School Science Laboratory: Historical Perspectives and Contexts for Contemporary Teaching. In: Kenneth Tobin & Barry Fraser (Eds.), International Handbook of Science Education. The Netherlands: Kluwer.

Mayer, J. & Bayrhuber, H. (1990). Formenkundliche Inhalte des Biologieunterrichtes - Ergebnisse einer Delphi-Studie. In: Killermann & Staeck (Hrsg.) Methoden des Biologieunterrichts. Köln: Aulis Verlag. 279-290.

Olsen, T. P. (1993). The nature of the laboratory task in science classrooms: Diverse examples from project DISTIL. In: Nowak, J. (ED.) Proceedings of the Third International Seminar on Misconceptions and Educational Strategies in Science and Mathematics. Ithaca, New York: Cornell University (distributed electronically).

Pfundt, H. & Duit, R. (1996). Bibliography. Students' Alternative Frameworks and Science Education. Kiel: IPN

Roth, W. M. (1995). Authentic school science: knowing and learning in open-inquiry science laboratories. Dordrecht, The Netherlands: Kluwer Academic Publishers.

Roth, W.-M. & Duit, R. (1997). Learning in real time: How understandings emerge from physics students' laboratory activities. In: M. G. Shafto, & P. Langley (Eds.), Proceedings of the Ninth Anual Conference of the Cognitive Science Society (p. 1028). Mahwah, NJ: Lawrence Erlbaum Associates.

Roychoudhury, A. & Roth, W. M. (1996). Interactions in an open-inquiry physics laboratory. In: International Journal of Science Education, 18(4). 423-445.

Thompson, J.J. (1975). Practical work in sixth form Science. Science Centre, Oxford University, Department of Educational Studies

Toothacker, W.S. (1983). A critical look at introductory laboratory instruction. In: American Journal of Physics 51 (6), 516-520.

Welzel, M.; Aufschnaiter, S.v. & Fischer, H.E. (1996). Lernprozesse im Physikstudium und Physikalisches Praktikum. In: Didaktik der Physik. 60. Physikertagung. DPG: Jena. 579-584.

Woolnough, B.E. (1983). Exercises, investigations and experiences. Physics Education. Vol. 18. 60-63.

Woolnough, B.E. (1997). School Science - Real Science? Paper presented at ESERA-Conference, Rome, 02.09.-06.09.1997.

12. Overview on the Literature Included in this Study

In this section we give to the reader some additional information on the literature used in this project. Working with it and looking for work done in this field of research before, we found different types of articles touching different aspects of objectives for labwork. These articles or books are only a part of all what ia done worldwide, but it can give a good overview on the topic.

First we will give you an overview about the literature included more or less in our study in alphabetical order. Second we categorise these articles using the following headlines

- Literature with focus on effectiveness of lab-activities
- Literature on surveys about objectives of labwork
- Literature on objectives of labwork
- Reviews

There is number of articles which got additional statements about the main content from our point of interest. This is a subjective interpretation and shall only give a first information or idea to the reader according to our focus of research.

Literature on labwork included in this study in alphabetical order

Arons, A. B. (1993). Guiding Insight and Inquiry in the Introductory Physics Laboratory. The Physics Teacher 31, 278-282.

Bates, G. R. (1978). The role of the laboratory in secondary school science programs. In M. B. Rowe (Ed.), What research says to the science teacher, Washington DC: National Science Teachers Association, ED 166057, 55-82.

Borghi, L., De Ambrosis, A., Mascheretti, P., & Massara, C.I. (1987). Computer simulation and laboratory work in the teaching of mechanics. Physics Education 22, 117-121.

Boud, D. J. (1973). The laboratory aims questionnaire a new method for course improvement? Higher Education Vol.2, 81-94.

Boud, D. J. (1986). Aims, Objectives and Course Planning in Boud, D. J.; Dunn, J.; Hegarty-Hazel, E.(eds.). Teaching in Laboratories. Guildford: Wheaton & Co, 13-35

Boud, D. J., Dunn, J., Kennedy, T. & Thorley, R. (1980). The aims of science laboratory courses: A survey of students, graduates and practising scientists. European Journal of Science Education 2, 415-428.

Brew, C. R., & Gunstone, R. F. (1992). Students' perceptions of an innovative university laboratory program. Research in Science Education 22, 55-62.

Chambers,R.G. (1963). What use are practical physics classes ? Bulletin of the Institute of Physics 14, 181-183.

Clackson, S. P. & Wright, D. K. (1992). An appraisal of practical work in science education. School Science Review 74 (266), 39-42.

Clough, M. P. & Clark, R. (1994). Cookbooks and constructivism - a better approach to laboratory activities. The Science Teacher 61(2), 34-37.

Devenport, J.; Lazonby, J. N. & Waddington, D. J. (1979). Attitudes to Practicals. Education in Chemistry,16, 188-190

Füller, F. (1992). Biologische Unterrichtsexperimente - Bedeutung und Effektivität. W. Killermann (Hrsg.), Münchner Schriften zur Didaktik der Biologie. Universität München.

Ganiel, U. & Hofstein, A. (1982). Objective and continuous assessment of student performance in the physics laboratory. Science Education 66, 581-591.

Hake, R. R. (1992). Socratic Pedagogy in the Introductory Physics Laboratory. The Physics Teacher, 19, 546-552.

Hedewig, R. (1990). Bericht der Arbeitsgruppe "Experimentieren im Biologieunterricht" Killermann (Hrsg.), Methoden des Bilogieunterrichts. Aulis Verlag.

Hellingmann, C. (1982). A trial list of objectives of experimental work in science education. European Journal of Science Education 4, 29-43.

Hodson, D. (1992). Redefining and reorientating practical work in school science. School Science Review 73(264), 65-78.

Hofstein, A. (1991). Practical Work and Science Education II. In: Fensham, P. (Ed.). Development and Dilemmas in Science Education. London: The Falmer Press, 189-217

Hofstein, A., & Lunetta, V.N. (1982). The role of the laboratory in science teaching: Neglected aspects of research. Review of Educational Research, Vol. 52, pp. 201-217

Kay, S. M.; O'Connell, S. & Cryer, P. (1981). Higher Level Aims in a Physics Laboratory: a first-year course at Royal Holloway College. Studies in Higher Education, 6(2), 177-184

Kern, W. (1997). Verbesserung der Lehre - Analysen und Anregungen. Physikalische Blätter, 53(1), 47-48

Kerr, J.F.(1964) Practical Work in School Science. Leicester, Leicester University Press.

Killermann, W. (1996). Biology Education in Germany: Research into the effectiveness of different teaching methods. International Journal of Science Education 18(3), 333-346.

Klainin, S. (1991). Practical Work and Science Education I. In P. Fensham (Ed.), Development and Dilemmas in Science Education. The Falmer Press, 169-217.

Kyle, W. C.; Penick, J. E. & Shymansky, J. A. (1979). Assessing and Analyzing the Performance of Students in College Science Laboratories. Journal of Research in Science Teaching, 16(6), 545-551.

Lazarowitz, R. & Tamir, P. (1994) Research on using Laboratory Instruction in Science. In D. Gabel (Ed.) Handbook of Research on Science Teaching and Learning. New York Macmillan. 94-128

Lunetta, V. N. & Tamir, P. (1979). Matching lab activities with teaching goals. The Science Teacher 46(5), 22-24.

Lunetta, V. N. (1997). The School Science Laboratory: Historical Perspectives and Contexts for Contemporary Teaching. In: K. Tobin & B. Fraser (Eds.), International Handbook of Science Education. Dordrecht: Kluwer.

Lynch, P.P. & Gerrans, G.C. (1977). The aims of first year chemistry courses, the expectations of new students and subsequent course influences Research in Science Education 7, 173-180.

Okebukola, P. A. (1986). An Investigation of Some Factors Affecting Students' Toward Laboratory Chemistry. Journal of Chemical Education, 63(6), 531-532

Olsen, T. P. (1993). The nature of the laboratory task in science classrooms: Diverse examples from project DISTIL. In J. Nowak (Ed.), Proceedings of the Third International Seminar on Misconceptions and Educational Strategies in Science and Mathematics. Ithaca, New York: Cornell University (distributed electronically).

Pickering, M. (1980). Are lab courses a waste of time? Chronicle of Higher Education, Vol. 19, pp. 44-50.

Roth, W. M. (1995). Authentic school science: knowing and learning in open-inquiry science laboratories. Dordrecht, The Netherlands: Kluwer Academic Publishers.

Roth, W.-M. & Duit, R. (1997). Learning in Real Time: How understandings emerge from physics students' laboratory activities. In M. G. Shafto, & P. Langley (Eds.), Proceedings of the Ninth Anual Conference of the Cognitive Science Society (p. 1028). Mahwah, NJ: Lawrence Erlbaum Associates.

Roth, W.-M.; McRobbie, C. J.; Lucas, K. B. & Boutonné, S. (1997). The Local Production of Order in Science Laboratories: a Phenomenological Analysis. Learning and Instruction, 7(2), 107-136.

Roychoudhury, A. & Roth, W. M. (1996). Interactions in an open-inquiry physics laboratory. International Journal of Science Education 18(4), 423-445.

Ruickoldt, G. (1996). Ergebnisse einer Umfrage zum physikalischen Praktikum. Physikalische Blätter, Vol. 52(10), pp. 1022-1024.

Séré M.G., Journeaux R. and Winther J; (1997) Enquête sur les objectifs des travaux pratiques . Bulletin de l'union des Physiciens. Vol 91 pp.1377-1389.

Sutman, F.; Schmukler, J. & Hilosky, A. (1995). The Laboratory Experience. Chemistry and Industry, 6(3), 18

Thompson, J. J. (1975). Practical work in sixth form Science. Science Centre, Oxford University, Department of Educational Studies

Toothacker, W. S. (1983). A critical look at introductory laboratory instruction. American Journal of Physics 51 (6), 516-520.

Welzel, M., Aufschnaiter, S.v. & Fischer, H.E. (1996). Lernprozesse im Physikstudium und Physikalisches Praktikum. In Didaktik der Physik. 60. Physikertagung. DPG: Jena, 579-584.

Woolnough, B.E. (1983). Exercises, investigations and experiences. Physics Education Vol. 18, 60-63.

Woolnough, B.E. (1997). School Science - Real Science? Paper presented at ESERA-Conference, Rome, 02.09.-06.09.1997.

Literature with focus on effectiveness of lab-activities

Füller, F. (1992). Biologische Unterrichtsexperimente - Bedeutung und Effektivität. W. Killermann (Hrsg.), Münchner Schriften zur Didaktik der Biologie. Universität München.

(labwork activities contribute to an increase of interest by the students)

Hake, R. R. (1992). Socratic Pedagogy in the Introductory Physics Laboratory. The Physics Teacher, 19, 546-552.

(a special designed interactive lab can have a positive effect in attaining an understanding of basic physics concepts)

Hodson, D. (1992). Redefining and reorientating practical work in school science. School Science Review 73(264), 65-78.

(practical work is unsuccessful in giving pupils an understanding of the ideas of science)

Killermann, W. (1996). Biology Education in Germany: Research into the effectiveness of different teaching methods. International Journal of Science Education 18(3), 333-346.

(labwork completed by students is compared with labwork demonstrated by teacher and pen and pencil lessons: students who participate in lessons wich allow contact with real plants and animal demonstrated a higher level of learning)

Okebukola, P. A. (1986). An Investigation of Some Factors Affecting Students' Toward Laboratory Chemistry. Journal of Chemical Education, 63(6), 531-532

(labwork has a positive effect on the attitudes toward chemistry)

Toothacker, W. S. (1983). A critical look at introductory laboratory instruction. American Journal of Physics 51 (6), 516-520.

(laboratory work has no statistically significant effect upon student's performance on lecture theory)

Literature on surveys about objectives of labwork

Boud, D. J. (1973). The laboratory aims questionnaire a new method for course improvement? Higher Education Vol.2, 81-94.

Boud, D. J. (1986). Aims, Objectives and Course Planning in Boud, D. J.; Dunn, J.; Hegarty-Hazel, E.(eds.). Teaching in Laboratories. Guildford: Wheaton & Co, 13-35

Boud, D. J., Dunn, J., Kennedy, T. & Thorley, R. (1980). The aims of science laboratory courses: A survey of students, graduates and practising scientists. European Journal of Science Education 2, 415-428.

Devenport, J.; Lazonby, J. N. & Waddington, D. J. (1979). Attitudes to Practicals. Education in Chemistry,16, 188-190

Kerr, J.F.(1964) Practical Work in School Science. Leicester, Leicester University Press.

Ruickoldt, G. (1996). Ergebnisse einer Umfrage zum physikalischen Praktikum. Physikalische Blätter, Vol. 52(10), pp. 1022-1024.

Séré M.G., Journeaux R. and Winther J; (1997) Enquête sur les objectifs des travaux pratiques . Bulletin de l'union des Physiciens. Vol 91 pp.1377-1389.

Thompson, J. J. (1975). Practical work in sixth form Science. Science Centre, Oxford University, Department of Educational Studies

Welzel, M., Aufschnaiter, S.v. & Fischer, H.E. (1996). Lernprozesse im Physikstudium und Physikalisches Praktikum. In Didaktik der Physik. 60. Physikertagung. DPG: Jena, 579-584.

Literature on objectives of labwork

Clough, M. P. & Clark, R. (1994). Cookbooks and constructivism - a better approach to laboratory activities. The Science Teacher 61(2), 34-37.

(teachers goal are important: "What we do with activities is far more important than the activities themselves")

Chambers, R.G. (1963). What use are practical physics classes ? Bulletin of the Institute of Physics 14, 181-183.

(list of objectives for labwork, which the questionnaire of Boud is based on)

Devenport, J.; Lazonby, J. N. & Waddington, D. J. (1979). Attitudes to Practicals. Education in Chemistry,16, 188-190

(survey of observed and achieved aims of labwork in first year university in chemistry)

Hedewig, R. (1990). Bericht der Arbeitsgruppe "Experimentieren im Biologieunterricht" Killermann (Hrsg.), Methoden des Bilogieunterrichts. Aulis Verlag.

(differences between explicit and implicit objectives of teachers)

Hellingmann, C. (1982). A trial list of objectives of experimental work in science education. European Journal of Science Education 4, 29-43.

(list of objectives in terms of observable behaviour of pupils engaged in practical work)

Hofstein, A. (1991). Practical Work and Science Education II. In: Fensham, P. (Ed.). Development and Dilemmas in Science Education. London: The Falmer Press, 189-217

(review and redefinition of the goals for teaching and learning in the science laboratory and review of the teaching practices)

Hofstein, A., & Lunetta, V.N. (1982). The role of the laboratory in science teaching: Neglected aspects of research. Review of Educational Research, Vol. 52, pp. 201-217

(review of laboratory goals)

Kay, S. M.; O'Connell, S. & Cryer, P. (1981). Higher Level Aims in a Physics Laboratory: a first-year course at Royal Holloway College. Studies in Higher Education, 6(2), 177-184

(description and evaluation of a lab course designed for reaching higher level aims)

Kyle, W. C.; Penick, J. E. & Shymansky, J. A. (1979). Assessing and Analyzing the Performance of Students in College Science Laboratories. Journal of Research in Science Teaching, 16(6), 545-551.

(relationship between type of labwork and behaviour of students)

Lunetta, V. N. & Tamir, P. (1979). Matching lab activities with teaching goals. The Science Teacher 46(5), 22-24.

(list of goals formulated in terms of expected students' behaviour)

Lunetta, V. N. (1997). The School Science Laboratory: Historical Perspectives and Contexts for Contemporary Teaching. In: K. Tobin & B. Fraser (Eds.), International Handbook of Science Education. Dordrecht: Kluwer.

(differences between the teachers' objectives and the students' activities)

Lynch, P.P. & Gerrans, G.C. (1977). The aims of first year chemistry courses, the expectations of new students and subsequent course influences Research in Science Education 7, 173-180.

(list on goals)

Pickering, M. (1980). Are lab courses a waste of time? Chronicle of Higher Education, Vol. 19, pp. 44-50.

(The goal of lab courses is to provide the experience in doing science)

Sutman, F.; Schmukler, J. & Hilosky, A. (1995). The Laboratory Experience. Chemistry and Industry, 6(3), 18

(comparison of German and American lab organisation with respect of higher goals)

Woolnough, B.E. (1997). School Science - Real Science? Paper presented at ESERA-Conference, Rome, 02.09.-06.09.1997.

(practical work in science should be largely decoupled from theory)

Reviews:

Clackson, S. P. & Wright, D. K. (1992). An appraisal of practical work in science education. School Science Review 74 (266), 39-42.

Hofstein, A., & Lunetta, V.N. (1982). The role of the laboratory in science teaching: Neglected aspects of research. Review of Educational Research, Vol. 52, pp. 201-217

Klainin, S. (1991). Practical Work and Science Education I. In P. Fensham (Ed.), Development and Dilemmas in Science Education. The Falmer Press, 169-217.

Lazarowitz, R. & Tamir, P. (1994) Research on using Laboratory Instruction in Science. In D. Gabel (Ed.) Handbook of Research on Science Teaching and Learning. New York Macmillan. 94-128

Woolnough, B.E. (1997). School Science - Real Science? Paper presented at ESERA-Conference, Rome, 02.09.-06.09.1997.

Appendix

The second questionnaire used in the study by the participating countries in each national language

In the following order:

France

Denmark

Great Britain

Germany

Greece

Italy

Activités expérimentales dans l'enseignement scientifique

Projet de recherche européen 1996-1998

Questionnaire sur les objectifs des enseignants

Cher collègue,

Tous les élèves de nos pays acquièrent des connaissances en sciences expérimentales (biologie, chimie, physique) par le moyen d'expériences - depuis les expériences de démonstration réalisées par l'enseignant jusqu'aux travaux de laboratoire et aux projets que les étudiants réalisent eux-mêmes. Ce processus est organisé de façons différentes dans les écoles et universités européennes. Nous souhaitons savoir comment les activités expérimentales devraient être organisées pour conduire à une efficacité optimale dans l'apprentissage : c'est une partie d'un projet sur les activités expérimentales dans l'éducation scientifique dans six pays européens.
Dans ce cadre nous vous demandons, en tant qu'enseignant dans un lycée ou une université, c'est à dire en tant que praticien de l'éducation scientifique, de répondre aux questions suivantes. Ce questionnaire comprend trois parties : dans la première nous vous demandons de classer par ordre d'importance différents objectifs généraux de l'activité expérimentale ; dans la seconde nous vous donnons beaucoup de sous-catégories différentes de ces objectifs généraux, et nous vous demandons de dire quelle est à votre avis l'importance de chacune d'entre elles pour l'activité expérimentale ; dans la troisième partie, nous vous donnons différentes situations d'activités expérimentales, et nous vous demandons de réfléchir sur l'utilité de chacun pour atteindre différents objectifs.
Pour pouvoir traiter vos réponses, nous vous demandons également de bien vouloir répondre aux questions situées en bas de cette page.

Merci beaucoup pour votre coopération !

Manuela Welzel et Kerstin Haller

(Coordinatrices du questionnaire)

Nom: _____

Pays: _____

Niveau d'enseignement (entourez la bonne réponse s.v.p.): **lycée** **université**

Discipline à laquelle vos réponses se réfèrent : **Biologie** **Chimie** **Physique**

Assurez vous personnellement un enseignement comprenant des activités expérimentales ?
(entourez la bonne réponse s.v.p.) **oui / non**

Une étude pilote menée dans six pays européens a conduit à dégager **différentes catégories** (et de sous-catégories) sur **les objectifs des activités expérimentales**. Ces catégories sont basées sur les affirmations et réponses individuelles de différents enseignants. Les catégories d'objectifs peuvent être importantes à des degrés variés. Dites nous s.v.p. quelle est, à votre avis, l'importance des objectifs suivants, **du point de vue de l'étudiant**.
Veuillez répondre à chaque question indépendamment des autres.

1. Objectifs pour l'activité expérimentale en général

Veuillez classer les cinq objectifs suivants par ordre d'importance, de 1 (le plus important) à 5 (le moins important), en n'utilisant chaque nombre qu'une seule fois.

	Objectifs pour l'activité expérimentale	**ordre**
A	permettre à l'étudiant de lier la théorie et la pratique	
B	permettre à l'étudiant d'acquérir des savoir-faire expérimentaux *	
C	permettre à l'étudiant d'acquérir des méthodes de raisonnement scientifiques	
D	permettre à l'étudiant de développer sa motivation, sa personnalité, ses compétences relationnelles	
E	permettre à l'enseignant d'évaluer les connaissances de l'étudiant	

* Pourriez vous préciser ce que vous entendez par "savoir-faire expérimentaux" ? Donnez des exemples dans votre discipline.

2. Sous-catégories particulières d'objectifs

Ci dessous nous vous donnons des objectifs particuliers formulés comme des affirmations. Ce sont des sous-catégories de chacun des objectifs principaux. Ils constituent des possibilités ou interprétations différentes des objectifs principaux. Indiquez s.v.p. en cochant la case **appropriée leur importance pour l'activité expérimentale** !

Evaluez chaque affirmation indépendamment, même si elle semble proche d'une autre affirmation.

Si vous trouvez que nous avons oublié une catégorie, utilisez la ligne vide en bas de chaque tableau pour la donner. Toute suggestion de votre part nous intéresse.

A	**permettre à l'étudiant** de lier théorie et pratique	très impor-tant	impor-tant	je ne sais pas	moins import ant	pas du tout impor-tant	je ne comprends pas cette affirmation
A_1	faciliter la compréhension de la théorie						
A_2	vérifier les lois scientifiques						
A_3	produire (certains) phénomènes						
A_4	améliorer la compréhension de la théorie par la pratique						
A_5	illustrer les phénomènes pour les étudiants						
A_6	rendre explicites des méthodes expérimentales spécifiques pour des sujets (ou des contenus) spécifiques						
A_7	observer et expérimenter pour une utilisation ultérieure dans le développement d'une théorie						
A_8	approfondir par l'exemple l'approche systématique d'un sujet						
A_9	introduire une notation et des termes techniques						
A_{10}	résoudre des problèmes soulevés par une expérience						
A_{11}	montrer des applications techniques						
A_{12}	aider à se souvenir de faits et de principes						
A_{13}	vérifier des prédictions						

B	**permettre à l'étudiant** d'acquérir des savoir-faire expérimentaux	très impor-tant	impor-tant	je ne sais pas	moins impor-tant	pas du tout impor-tant	je ne comprends pas cette affirmation
B1	acquérir une expérience dans des techniques et des procédures standards						
B2	apprendre une méthode en utilisant un exemple						
B3	apprendre et pratiquer la rédaction d'un compte-rendu						
B4	apprendre à travailler avec soin et sécurité						
B5	gérer les erreurs expérimentales						

C	**permettre à l'étudiant** d'acquérir des méthodes de raisonnement scientifiques	très impor-tant	impor-tant	je ne sais pas	moins impor tant	pas du tout impor-tant	je ne comprends pas cette affirmation
C1	acquérir une méthode scientifique *						
C2	apprendre à raisonner de façon scientifique						
C3	développer des capacités de planification et d'expérimentation en général en sciences **(à décomposer)**						
C4	développer une approche critique dans l'interprétation des données						
C5	comprendre et manipuler la complexité des connaissances scientifiques						
C6	acquérir des méthodes épistémologiques *						
C7	connaître comment travaillent les scientifiques professionnels						
C8	apprendre à gérer les problèmes d'équipement en général						

* Si vous avez choisi "important" ou "très important" pourriez vous donner des exemples de la façon dont vous le mettez en œuvre dans votre enseignement :

D	**permettre à l'étudiant** de développer sa motivation, sa personnalité, ses compétences relationnelles	très impor-tant	impor-tant	je ne sais pas	moins impor tant	pas du tout impor-tant	je ne comprends pas cette affirmation
D1	développer son intérêt						
D2	apprécier le sujet et l'activité						
D3	développer des capacités générales de communication et d'interaction avec les autres						
D4	faciliter la motivation de l'étudiant par l'enseignant						
D5	apprendre à travailler en équipe						
D6	développer l'attention portée à l' environnement naturel, la responsabilité, la tolérance (éthique scientifique)						

E	**permettre à l'enseignant** d'évaluer l'activité de l'étudiant	très impor-tant	impor-tant	je ne sais pas	moins impor tant	pas du tout impor-tant	je ne comprends pas cette affirmation
E1	permettre à l'enseignant d'évaluer l'activité de l'étudiant						

Pourriez vous dire ci-dessous ce que vous pensez qu'il est important d'évaluer ?

3. Formes particulières d'activités expérimentales

Des formes différentes d'activités expérimentales peuvent avoir des avantages et des désavantages les unes par rapport aux autres pour parvenir à certains objectifs.
C'est pourquoi nous vous donnons pour chacun des cinq objectifs principaux cinq formes différentes d'activités expérimentales. Evaluez les s'il vous plaît suivant leur utilité pour atteindre chacun des objectifs.
Nous sommes conscients que les différentes formes d'activités expérimentales citées ci-dessous sont souvent mélangées ou combinées dans un cours. Cependant, essayez de vous focaliser sur une des situations décrites.

Cochez la case appropriée, s.v.p.

OBJECTIF 1: Pour permettre aux étudiants de faire le lien entre la théorie et la pratique

		1 très utile(s)	2 utile(s)	3 je ne sais pas	4 peu utile(s)	5 inutile(s)
1	les expériences de démonstration sont					
2	les expériences réalisées par les élèves sont					
3	une activité expérimentale ouverte (de type projet) est					
4	une activité expérimentale (plus ou moins fortement) guidée est					
5	des expériences utilisant les technologies modernes sont					

OBJECTIF 2: Pour faire apprendre aux étudiants des savoir-faire expérimentaux

		1 très utile(s)	2 utile(s)	3 je ne sais pas	4 peu utile(s)	5 inutile(s)
1	les expériences de démonstration sont					
2	les expériences réalisées par les élèves sont					
3	une activité expérimentale ouverte (de type projet) est					
4	une activité expérimentale (plus ou moins fortement) guidée est					
5	des expériences utilisant les technologies modernes sont					

OBJECTIF 3: Pour permettre aux étudiants d'acquérir les méthodes de raisonnement scientifique

		1 très utile(s)	2 utile(s)	3 je ne sais pas	4 peu utile(s)	5 inutile(s)
1	les expériences de démonstration sont					
2	les expériences réalisées par les élèves sont					
3	une activité expérimentale ouverte (de type projet) est					
4	une activité expérimentale (plus ou moins fortement) guidée est					
5	des expériences utilisant les technologies modernes sont					

OBJECTIF 4: Pour la motivation des étudiants

		1 très utile(s)	2 utile(s)	3 je ne sais pas	4 peu utile(s)	5 inutile(s)
1	les expériences de démonstration sont					
2	les expériences réalisées par les élèves sont					
3	une activité expérimentale ouverte (de type projet) est					
4	une activité expérimentale (plus ou moins fortement) guidée est					
5	des expériences utilisant les technologies modernes sont					

OBJECTIF 5: Pour aider le développement personnel des étudiants

		1 très utile(s)	2 utile(s)	3 je ne sais pas	4 peu utile(s)	5 inutile(s)
1	les expériences de démonstration sont					
2	les expériences réalisées par les élèves sont					
3	une activité expérimentale ouverte (de type projet) est					
4	une activité expérimentale (plus ou moins fortement) guidée est					
5	des expériences utilisant les technologies modernes sont					

OBJECTIF 6: Pour améliorer les aptitudes sociales des étudiants (i.e. capacité de travailler en équipe)

		1 très utile(s)	2 utile(s)	3 je ne sais pas	4 peu utile(s)	5 inutile(s)
1	les expériences de démonstration sont					
2	les expériences réalisées par les élèves sont					
3	une activité expérimentale ouverte (de type projet) est					
4	une activité expérimentale (plus ou moins fortement) guidée est					
5	des expériences utilisant les technologies modernes sont					

OBJECTIF 7: Pour évaluer les connaissances des étudiants

		1 très utile(s)	2 utile(s)	3 je ne sais pas	4 peu utile(s)	5 inutile(s)
1	les expériences de démonstration sont					
2	les expériences réalisées par les élèves sont					
3	une activité expérimentale ouverte (de type projet) est					
4	une activité expérimentale (plus ou moins fortement) guidée est					
5	des expériences utilisant les technologies modernes sont					

Labwork in Science Education

European Research Project 1996-1998

Eksperimentet i undervisningen i biologi, kemi og fysik

3. Del: Spørgeskema om „lærernes formål“

Kære kollega,
alle, der studerer naturvidenskab, i folkeskolen, i gymnasiet eller på universitetet, lærer det bl.a. ved at se eller udføre eksperimenter, fra simple demonstrationer til længerevarende projekter. Denne læreproces er organiseret på forskellig vis i de europæiske skoler og universiteter. Som del af et projekt om laboratoriearbejdet i den naturfaglige undervisning ønsker vi at finde ud af, hvordan laboratoriearbejdet bedst kan organiseres, når man (selvfølgelig) ønsker det optimale udbytte.
I denne sammenhæng beder vi dig, som underviser i gymnasiet eller på universitetet, og derfor er fortrolig med naturfaglig undervisning, om at besvare de følgende spørgsmål.

Dette spørgeskema består af tre dele:
I den første del beder vi dig om at prioritere fem formål med laboratoriearbejdet.
I den anden del er disse fem formål opdelt i underkatagorier. Vi beder dig om at vægte disse underkategoriers betydning i laboratoriearbejdet.
I den tredie del har vi udvalgt fem typer laboratoriearbejde. Vi beder dig overveje hvilke formål, der bedst opfyldes ved hver af de fem typer.

Af hensyn til kategoriseringen i den europæiske undersøgelse beder vi dig angive navn, niveau og fag nederst på denne side.

På forhånd tak for din hjælp !

Manuela Welzel og Kerstin Haller, Institut für Didaktik der Physik, Universität Bremen.

Navn:

DANMARK

Niveau (sæt kryds) **Gymnasium**:_____ **Universitet**:

Hvilket fag gælder dine svar (sæt kryds) **Biologi**:_____ **Kemi:** _____ **Fysik**:

Er du personlig ansvarlig for at instruere de studerende
i laboratoriearbejde eller udføre eksperimenter ? **Ja**: _____ **Nej**:

En foreløbig undersøgelse, udført i seks europæiske lande, har ført til et **spektrum af forskellige** kategorier (hoved- og underkatagorier) om **formål med laboratoriearbejde**. Disse kategorier er baseret på individuelle udsagn og svar fra forskellige lærere, og de kan have forskellig grad af betydning for laboratoriearbejde.

Vi beder dig fortælle os, hvad du mener om **vigtigheden** af de følgende formål,
Vi beder dig om at tænke på den studerende ved besvarelsen af hvert enkelt spørgsmål, og
Vi beder dig besvare spørgsmålene uafhængigt af hinanden.

1. Generelle formål med laboratoriearbejdet

Vi beder dig prioritere de følgende 5 formål, marker det vigtigste med „1" og det mindst vigtige med „5", hvert tal må kun bruges én gang.

	Formål med laboratoriearbejde	**Prioritering**
A	at den studerende forbinder teori og praksis	
B	at den studerende lærer eksperimentelle færdigheder	
C	at den studerende lærer de naturvidenskabelige metoder at kende	
D	at den studerende bliver motiveret, udvikler sig personligt og socialt	
E	at læreren kan evaluere den studerendes viden	

2. Specielle underkategorier af formål med laboratoriearbejde

Vi giver nu nogle udsagn om specielle delformål, som er underkategorier af de generelle formål. Der er tale om forskellige muligheder eller fortolkninger af de generelle formål. Vi beder dig overveje deres betydning for laboratoriearbejdet og krydse af i det relevante felt !

Vurder hvert udsagn uafhængigt, selv om det måske ligner et andet udsagn.

Hvis du synes, at vi mangler en kategori, beder vi dig bruge de sidste blanke linier i hver tabel til yderligere forslag til formål.

A	**at den studerende** forbinder teori og praksis	meget vigtigt	vig tigt	kan ikke afgøre vigtig-heden	mindre vigtigt	ikke vig-tigt	jeg for-står ikke dette spørgs-mål
A1	at lette forståelsen af teori						
A2	at eftervise videnskabelige love						
A3	at frembringe (visse) fænomener						
A4	at uddybe forståelsen af teori v.hj.a. praksis						
A5	at illustrere fænomener for de studerende						
A6	at vise, at der til hvert emne hører særlige eksperimentelle metoder						
A7	at observere og eksperimentere med henblik på kommende teorigennemgang						
A8	at uddybe behandlingen af et emne med et eksempel						
A9	at introducere notation og tekniske begreber						
A10	at løse en problemstilling, der opstår i forbindelse med et eksperiment						
A11	at demonstrere tekniske anvendelser						
A12	at hjælpe til at huske fakta og principper						
A13	at efterprøve forudsigelser						

B	**at den studerende** lærer eksperimentelle færdigheder	meget vigtigt	vig tigt	kan ikke afgøre vigtig-heden	mindre vigtigt	ikke vig-tigt	jeg for-står ikke dette spørgs-mål
B1	at få erfaringer med almindelig laboratorieteknik og procedure						
B2	at bruge et eksempel til at lære en metode						
B3	at lære og at praktisere rapportskrivning						
B4	at lære at foretage omhyggelige observationer						
B5	at lære at arbejde omhyggeligt og sikkert i laboratoriet						
B6	at tage stilling til eksperimentelle fejl						

C	**at den studerende** lærer naturvidenskabelige arbejdsmetoder at kende	meget vigtigt	vig tigt	kan ikke afgøre vigtig-heden	mindre vigtigt	ikke vig-tigt	jeg for-står ikke dette spørgs-mål
C1	at lære naturvidenskabelige tilgange at kende						
C2	at lære den naturvidenskabelige måde at tænke på						
C3	at udvikle en generel evne til at planlægge og eksperimentere						
C4	at udvikle en kritisk holdning til fortolkning af data						
C5	at lære og at omgås naturvidenskab som et komplekst system						
C6	at lære forskellige erkendelsesmåder at kende						
C7	at lære hvordan forskere i naturvidenskab arbejder						
C8	at lære at håndtere eksperimentelle opstillinger						

D	**at den studerende** bliver motiveret, udvikler sig personligt og socialt	meget vigtigt	vig tigt	kan ikke afgøre vigtig-heden	mindre vigtigt	ikke vig-tigt	jeg for-står ikke dette spørgs-mål
D1	at udvikle/fremme interessen						
D2	at være glad for faget og aktiviteten						
D3	at udvikle en generel evne til kommunikation og samvær						
D4	at læreren motiverer de studerende						
D5	at lære at arbejde i grupper						
D6	at udvikle hensyntagen overfor den omgivende natur, dvs. ansvarlighed, tolerance (etik i naturvidenskab)						

E	**at læreren** kan evaluere den studerendes viden	meget vigtigt	vig tigt	kan ikke afgøre vigtig-heden	mindre vigtigt	ikke vig-tigt	jeg forstår ikke dette spørgs-mål
E1	Kan du angive, hvad efter din mening er vigtigt at evaluere ?						

3. Forskellige former for laboratoriearbejde

De **forskellige former for laboratoriearbejde** kan have hver deres fordele og ulemper med hensyn til at fremme de forskellige formål. Vi beder jer om at **vurdere, hvor hensigtsmæssige** følgende 5 slags laboratoriearbejde er med henblik på disse 7 formål.
Vi ved, at disse 5 former for laboratoriearbejde ofte er blandet sammen i timerne, men prøv at vurdere dem særskilt.

Marker med kryds i den relevante boks

Formål 1: at den studerende skal blive bedre til at forbinde teori og praksis

		1. Meget egnede	2. Eg-nede	3. Jeg kan ikke afgøre om de er egnede	4. Mindre egnede	5. Ikke egnede
1	Demonstrationsforsøg er					
2	Elevøvelser er					
3	Mere åbne aktiviteter (f.x. projekter) er					
4	Stærkt styrede laboratoriearbejder er					
5	Eksperimenter, der bruger moderne teknologi, er					

Formål 2: at den studerende skal lære eksperimentelle færdigheder

		1. Meget egnede	2. Eg-nede	3. Jeg kan ikke afgøre om de er egnede	4. Mindre egnede	5. Ikke egnede
1	Demonstrationsforsøg er					
2	Elevøvelser er					
3	Mere åbne aktiviteter (f.x. projekter) er					
4	Stærkt styrede laboratoriearbejder er					
5	Eksperimenter, der bruger moderne teknologi, er					

Formål 3: at den studerende skal lære videnskabelige metoder

		1. Meget egnede	2. Eg-nede	3. Jeg kan ikke afgøre om de er egnede	4. Mindre egnede	5. Ikke egnede
1	Demonstrationsforsøg er					
2	Elevøvelser er					
3	Mere åbne aktiviteter (f.x. projekter) er					
4	Stærkt styrede laboratoriearbejder er					
5	Eksperimenter, der bruger moderne teknologi, er					

Formål 4: at motivere de studerende

		1. Meget egnede	2. Eg-nede	3. Jeg kan ikke afgøre om de er egnede	4. Mindre egnede	5. Ikke egnede
1	Demonstrationsforsøg er					
2	Elevøvelser er					
3	Mere åbne aktiviteter (f.x. projekter) er					
4	Stærkt styrede laboratoriearbejder er					
5	Eksperimenter, der bruger moderne teknologi, er					

Formål 5: at støtte de studerendes personlige udvikling

		1. Meget egnede	2. Eg-nede	3. Jeg kan ikke afgøre om de er egnede	4. Mindre egnede	5. Ikke egnede
1	Demonstrationsforsøg er					
2	Elevøvelser er					
3	Mere åbne aktiviteter (f.x. projekter) er					
4	Stærkt styrede laboratoriearbejder er					
5	Eksperimenter, der bruger moderne teknologi, er					

Formål 6: at udvikle de studerendes sociale adfærd (f.eks. arbejde i grupper)

		1. Meget egnede	2. Eg-nede	3. Jeg kan ikke afgøre om de er egnede	4. Mindre egnede	5. Ikke egnede
1	Demonstrationsforsøg er					
2	Elevøvelser er					
3	Mere åbne aktiviteter (f.x. projekter) er					
4	Stærkt styrede laboratoriearbejder er					
5	Eksperimenter, der bruger moderne teknologi, er					

Formål 7: at evaluere de studerendes viden

		1. Meget egnede	2. Eg-nede	3. Jeg kan ikke afgøre om de er egnede	4. Mindre egnede	5. Ikke egnede
1	Demonstrationsforsøg er					
2	Elevøvelser er					
3	Mere åbne aktiviteter (f.x. projekter) er					
4	Stærkt styrede laboratoriearbejder er					
5	Eksperimenter, der bruger moderne teknologi, er					

Labwork in Science Education

European Research Project 1996-1998

Questionnaire on "teachers' objectives"

Dear colleague,

All students of science learn through experiments - ranging from teacher demonstration experiments to student-labwork and projects. This labwork is organised in different ways in European schools and universities. As part of a project on labwork in science education in six European countries, we want to find out how labwork should be organised and supervised in order to optimise students learning. As a result we are asking you, as a teacher at school or university, and thus as an expert in science education, to answer the following questions.
This questionnaire consists of three parts: In the first part you are asked to rank general objectives of labwork. In the second part you are presented with different subcategories of objectives. You are asked to indicate the extent to which you feel each of these is an important objective of labwork. In the third part we provide you with different labwork contexts. There you are asked to think about their usefulness of each context in achieving different labwork objectives.

In order to categorise your answers it would be helpful if you could complete the questions at the bottom of this page.

Thank you very much for your cooperation!

Manuela Welzel and Kerstin Haller
(Questionnaire coordinators)

Name: _____

Country:_____

School (please circle):_____ **upper secondary** **university**

Subject that your answers refer to: **Biology** **Chemistry** **Physics**

Are you personally engaged in instructing students
in labwork or in carrying out experiments? (please circle) **yes / no**

A pilot study carried out in six European countries has led to a **variety of different** categories describing the **objectives of labwork**. These categories are based on individual statements and responses from different teachers. We have arranged these categories under five main headings. These main headings are described in section 1. Section 2 then presents the sub-categories under each heading.

Please tell us in your opinion what **importance** these objectives have.

Ensure that in each case the student is the focus of your response. Please answer each question independently.

1. Objectives for labwork in general

Please rank the following 5 objectives in the order of 1 = highest rank and 5 = lowest rank.

Please use each number only once.

	Objectives for labwork are	**rank**
A	for the student to link theory and practice	
B	for the student to learn experimental skills	
C	for the student get to know the methods of scientific thinking	
D	for the student to increase their motivation, personal development, social competency	
E	for the teacher to evaluate the knowledge of the students	

2. Special subcategories of objectives for labwork

In this section we present a number of sub-categories within each of the five main objectives.

Please think about **their importance for labwork** and tick the appropriate box.

Judge each statement independently even if it seems similar to another statement.

If you feel that there is an additional sub-category, then please write on the back of each page.

A	**For the student to link theory and practice**	very impor-tant	impor-tant	can't decide	less impor-tant	not impor-tant	I don't understand this item
A1	to improve the understanding of the theory						
A2	to verify scientific laws						
A3	to make certain phenomena occur						
A4	to make the understanding of theory better through practice						
A5	to illustrate phenomena to the students						
A6	to make specific experimental methods explicit						
A7	to make observations and perform experiments which will be used in future discussions about specific scientific theories						
A8	to improve the student's systematic approach to their subject						
A9	to introduce notation and technical terms						
A10	to solve problems which arise from an experiment						
A11	to demonstrate technical applications						
A12	to help remember facts and principles						

B	**For the student to learn experimental skills**	very impor-tant	impor-tant	can't decide	less impor-tant	not impor-tant	I don't understand this item
B1	to get experience in standard techniques and procedures						
B2	to learn an experimental procedure by performing it						
B3	to learn and to practice how to write a laboratory report						
B4	to learn how to make careful observations						
B5	to learn how to work properly and safely						
B6	to learn how to handle experimental errors						

C	**For the student to get to know the methods of scientific thinking**	very impor-tant	impor-tant	can't decide	less impor-tant	not impor-tant	I don't understand this item
C1	get to know the scientific approach						
C2	to learn to think scientifically						
C3	to develop the scientific skills of planning and experimenting in general						
C4	to develop a critical approach to interpreting data						
C5	to learn and to handle science as complex networks						
C6	get to know epistemological methods						
C7	get to know how scientists work professionally						
C8	learn to deal with equipment difficulties in general						

D	**For the student to increase their motivation, personal development, social competency**	very impor-tant	import ant	can't decide	less impor-tant	not impor-tant	I don't understant this item
D1	to develop interest						
D2	to enjoy subject and activity						
D3	to develop general skills of communication and interaction						
D4	for the teacher to give and for the student to get motivation						
D5	to learn how to work in teams						
D6	to develop awareness of natural environment, responsibility, tolerance (ethics in science)						

E	**For the teacher to evaluate the knowledge of the students**	very impor-tant	impor-tant	can't decide	less impor-tant	not impor-tant	I don't understand the item
E1	for the teacher to evaluate the knowledge of the students						

3. Special forms of labwork

Different forms of labwork may have special advantages and disadvantages for achieve certain aims.

In this section we present 5 different forms of labwork which could be used to achieve each labwork aim.

Please judge each form of labwork according to **its usefulness** in achieving the specific aim.

We know, that the different forms of labwork listed below are often mixed or combined during lessons. Nevertheless try to imagine a main focus on the described situations.

Please tick the appropriate box.

AIM 1: For the students to become better able to link theory and practice

		1 very useful	2 useful	3 can't decide	4 less useful	5 not useful
1	demonstration experiments are					
2	experiments carried out by the students are					
3	an open ended labwork session is					
4	a (strongly) guided labwork session is					
5	experiments using modern technologies (e.g. for data capture) are					

AIM 2: For the students to learn experimental skills

		1 very useful	2 useful	3 can't decide	4 less useful	5 not useful
1	demonstration experiments are					
2	experiments carried out by the students are					
3	an open ended labwork session is					
4	a (strongly) guided labwork session is					
5	experiments using modern technologies (e.g. for data capture) are					

AIM 3: For students to get to know the methods of scientific thinking

		1 very useful	2 useful	3 can't decide	4 less useful	5 not useful
1	demonstration experiments are					
2	experiments carried out by the students are					
3	an open ended labwork session is					
4	a (strongly) guided labwork session is					
5	experiments using modern technologies (e.g. for data capture) are					

AIM 4: For the motivation of students

		1 very useful	2 useful	3 can't decide	4 less useful	5 not useful
1	demonstration experiments are					
2	experiments carried out by the students are					
3	an open ended labwork session is					
4	a (strongly) guided labwork session is					
5	experiments using modern technologies (e.g. for data capture) are					

AIM 5: For supporting the personal development of students

		1 very useful	2 useful	3 can't decide	4 less useful	5 not useful
1	demonstration experiments are					
2	experiments carried out by the students are					
3	an open ended labwork session is					
4	a (strongly) guided labwork session is					
5	experiments using modern technologies (e.g. for data capture) are					

AIM 6: For improving the social skills of students (i.e. ability of working in a team)

		1 very useful	2 useful	3 can't decide	4 less useful	5 not useful
1	demonstration experiments are					
2	experiments carried out by the students are					
3	an open ended labwork session is					
4	a (strongly) guided labwork session is					
5	experiments using modern technologies (e.g. for data capture) are					

AIM 7: To evaluate students' knowledge

		1 very useful	2 useful	3 can't decide	4 less useful	5 not useful
1	demonstration experiments are					
2	experiments carried out by the students are					
3	an open ended labwork session is					
4	a (strongly) guided labwork session is					
5	experiments using modern technologies (e.g. for data capture) are					

Labwork in Science Education

European Research Project 1996-1998

Fragebogen: "Ziele des Experimentierens in der naturwissenschaftlichen Ausbildung"

Sehr geehrte Kolleginnen und Kollegen,

alle Schüler(innen) der Sekundarstufen I und II und Student(inn)en der verschiedenen naturwissenschaftlichen Studiengänge lernen im Bereich der naturwissenschaftlichen Ausbildung mit Experimenten. Dies reicht von Demonstrationsexperimenten über geführte oder offene Schülerexperimente und Praktika bis zu Projekten. Das Lernen mit Experimenten ist in Schulen und Hochschulen der veschiedenen europäischen Länder sehr unterschiedlich organisiert. Im Rahmen eines Forschungsprojektes mit sechs beteiligten Ländern Europas untersuchen wir, wie Experimentieren organisiert und begleitet werden sollte, um ein Optimum an Lerneffektivität zu erreichen.
In diesem Zusammenhang wenden wir uns an Sie als Lehrer bzw. Lehrerin an Schule oder Hochschule und damit als Experten/in in der naturwissenschaftlichen Ausbildung. Wir bitten Sie, uns die auf den folgenden Seiten aufgeführten Fragen zu beantworten.
Der Fragebogen besteht aus drei Teilen. Im ersten Teil sollen Sie vorgegebene allgemeine Ziele für das Experimentieren in der naturwissenschaftlichen Ausbildung wichten. Im zweiten Teil geben wir ihnen eine ganze Reihe unterschiedlicher Teilziele für das Experimentieren vor. Sie sollen beurteilen, für wie wichtig Sie jedes dieser Teilziele beim Experimentieren halten. Im dritten Teil geben wir Ihnen verschiedene Situationen für das Experimentieren vor. Sie sollen hier die Eignung dieser Situationen für das Erreichen bestimmter Ziele beim Experimentieren beurteilen.

Damit wir Ihre Antworten hinterher einordnen können, bitten wir Sie außerdem, die unten aufgeführten Fragen zu beantworten.

Vielen Dank im voraus für Ihre Mitarbeit!

Manuela Welzel und Kerstin Haller

(Organisatorinnen der Umfrage)

Name: _____

Land: _____

Institution (bitte unterstreichen) **Sekundarstufe II** **Universität**

In bezug auf welches Fach geben Sie Ihre Antworten?: **Biologie** **Chemie** **Physik**

Führen Sie selbst im Unterricht Experimente durch bzw. organisieren Sie Schülerexperimente bzw. betreuen Sie selbst naturwissenschaftliche Praktika? **ja / nein**

Eine Pilotstudie zu **Zielen des Experimentierens** in der naturwissenschaftlichen Ausbildung, die wir in sechs europäischen Ländern durchgeführt haben, führte zu einem **Spektrum verschiedener Ziele,** aus denen Ober- und Unterkategorien gebildet werden konnten. Diese Zielkategorien basieren auf individuellen Aussagen und Antworten unterschiedlicher Lehrer dieser Länder. Wir denken, daß die verschiedenen Ziele unterschiedlich wichtig für das Experimentieren in der naturwissenschaftlichen Ausbildung sein können.

Bitte beurteilen Sie, **wie wichtig** Ihrer Meinung nach die folgenden Ziele für das Experimentieren in der naturwissenschaftlichen Ausbildung sind.

Bitte beachten Sie dabei, daß in jedem Fall die Lernprozesse von Schülern im Mittelpunkt unseres Interesses stehen.
Bitte beantworten Sie jede Frage unabhängig von den anderen.

1. Allgemeine Ziele des Experimentierens

Bitte **ordnen Sie** die folgenden Zielkategorien **nach ihrer Wichtigkeit** von 1 (höchster Rang) bis 5 (niedrigster Rang).

Jeder Rang (1 bis 5) soll nur einmal vergeben werden.

	Durch Experimentieren soll	**Rang**
A	die/der Lernende Theorie und Praxis miteinander verbinden	
B	die/der Lernende experimentelle Fähigkeiten erwerben	
C	die/der Lernende Methoden wissenschaftlichen Denkens kennenlernen	
D	die/der Lernende besser motiviert werden, ihre/seine Persönlichkeit und ihre/seine soziale Kompetenz weiterentwickeln	
E	der/die Lehrende die Möglichkeit haben, das Wissen der Lernenden zu prüfen	

2. Spezielle Teilziele des Experimentierens

Wir geben Ihnen nun verschiedene spezielle Teilziele naturwissenschaftlichen Experimentierens vor. Sie entstammen der Pilotstudie und stellen Unterkategorien der allgemeinen Ziele dar. Als solche sind sie unterschiedliche Ausprägungen oder Beschreibungen der Hauptziele. Bitte überlegen Sie, für wie wichtig Sie diese Ziele für das Experimentieren in der naturwissenschaftlichen Ausbildung halten. Kreuzen Sie jeweils das entsprechende Kästchen an!

Beurteilen Sie jede Aussage unabhängig von den anderen, auch wenn es so aussehen sollte, als gäbe es zwischen den einzelnen Aussagen keine Unterschiede.

Sollten wir Zielkategorien nicht aufgeführt haben, die Sie aber für wichtig halten, können Sie diese in die jeweils freie Zeile unter jeder Tabelle eintragen und bewerten. Auch Kommentare sind willkommen.

A	**die/der Lernende** soll Theorie und Praxis miteinander verbinden **Ziel des Experimentierens ist es,**	sehr wichtig	wichtig	kann ich nicht entscheiden	weniger wichtig	nicht wichtig	Ich verstehe die Aussage nicht
A_1	das Verständnis der Theorie zu erleichtern						
A_2	naturwissenschaftliche Gesetze zu verifizieren						
A_3	bestimmte Phänomene zu erzeugen						
A_4	das Verständnis der Theorie durch Praxis zu vertiefen						
A_5	Phänomene zu illustrieren						
A_6	zu zeigen, daß für bestimmte wiss. Inhalte bestimmte experimentelle Methoden notwendig sind.						
A_7	zu beobachten und zu experimentieren, um es später in der Theorie verwenden zu können						
A_8	einen fachsystematischen Ansatz exemplarisch zu vertiefen						
A_9	Notationen und technische Terme einzuführen						
A_{10}	Probleme zu lösen, die von Experimenten kommen						
A_{11}	technische Anwendungen zu demonstrieren						
A_{12}	das Erinnern von Fakten und Prinzipien zu unterstützen						

B	**die/der Lernende** soll experimentelle Fähigkeiten erwerben **Ziel des Experimentierens ist es,**	sehr wichtig	wichtig	kann ich nicht entschei-den	weniger wichtig	nicht wichtig	Ich ver-stehe die Aussage nicht
B1	Erfahrungen in Standardtechniken und -methoden zu sammeln						
B2	Methoden anhand von Beispielen zu lernen						
B3	das Protokollieren zu lernen und zu üben						
B4	aufmerksames Beobachten zu lernen						
B5	sauberes und sicheres Arbeiten zu lernen						
B6	zu lernen, mit Meßfehlern umzugehen						

C	die/der Lernende soll Methoden wissenschaftlichen Denkens kennenlernen **Ziel des Experimentierens ist es,**	sehr wichtig	wichtig	kann ich nicht entschei den	weniger wichtig	nicht wichtig	Ich ver-stehe die Aussage nicht.
C1	die wissenschaftliche Herangehensweise kennenzulernen						
C2	wissenschaftliches Denken zu lernen						
C3	Fähigkeiten des Planens und Durchführens von Experimenten zu entwickeln						
C4	eine kritische Herangehensweise bei der Interpretation von Daten zu entwickeln						
C5	Naturwissenschaften als komplexe Netzwerke zu verstehen und zu behandeln						
C6	wissenschaftliche Erkenntnismethoden kennenzulernen						
C7	kennenzulernen, wie Wissenschaftler arbeiten						
C8	zu lernen, mit apparativen Schwierigkeiten umzugehen						

D	die/der Lernende soll besser motiviert werden, seine Persönlichkeit und soziale Kompetenz soll sich weiterentwickeln **Ziel des Experimentierens ist es,**	sehr wichtig	wichtig	kann ich nicht entscheiden	weniger wichtig	nicht wichtig	Ich verstehe die Aussage nicht.
D1	Interesse zu entwickeln						
D2	Freude am Fach und an der Tätigkeit zu entwickeln						
D3	allgemeine Fähigkeiten der Kommunikation und der Interaktion weiterzuentwickeln						
D4	zu motivieren						
D5	zu lernen, wie man im Team arbeitet						
D6	Umweltbewußtsein, Verantwortung und Toleranz zu entwickeln						

E	der/die Lehrende soll die Möglichkeit haben, das Wissen der Lernenden zu prüfen **Ziel des Experimentierens ist es,**	sehr wichtig	wichtig	kann ich nicht entscheiden	weniger wichtig	nicht wichtig	Ich verstehe die Aussage nicht.
E1	das Wissen der Lernenden zu prüfen						

3. Verschiedene Arten des Experimentierens

Verschiedene Arten des Lernens mit Experimenten können spezielle Vor- und Nachteile bezüglich der Erreichbarkeit bestimmter Ziele haben.
Deshalb geben wir Ihnen nun für die vorne genannten Hauptziele fünf verschiedene Experimentiersituationen vor. Sie sollen beurteilen, inwieweit die einzelnen Situationen für das Erreichen der einzelnen Ziele geeignet sind.
Wir wissen, daß in der Unterrichtspraxis die verschiedenen Formen des Experimentierens, die wir unten aufgeführt haben, oft miteinander kombiniert werden. Sie treten nicht immer in "Reinform" auf. Versuchen Sie trotzdem, sich Unterricht mit dem jeweiligen Schwerpunkt vorzustellen.

Bitte kreuzen Sie das entsprechende Kästchen an!

Ziel 1: Die/Der Lernende soll Theorie und Praxis miteinander verbinden

	Hierzu sind	1 sehr geeignet	2 geeignet	3 kann ich nicht entscheiden	4 weniger geeignet	5 nicht geeignet
1	Demonstrationsexperimente					
2	Schülerexperimente bzw. Praktika					
3	Experimente oder Projekte mit offener Fragestellung					
4	Experimentieren mit schrittweiser Anleitung					
5	Experimente, bei denen moderne Technologien (Computer, Multimedia) benutzt werden					

Ziel 2: Die/Der Lernende soll experimentelle Fähigkeiten erwerben

	Hierzu sind	1 sehr geeignet	2 geeignet	3 kann ich nicht entscheiden	4 weniger geeignet	5 nicht geeignet
1	Demonstrationsexperimente					
2	Schülerexperimente bzw. Praktika					
3	Experimente oder Projekte mit offener Fragestellung					
4	Experimentieren mit schrittweiser Anleitung					
5	Experimente, bei denen moderne Technologien (Computer, Multimedia) benutzt werden					

Ziel 3: die/der Lernende soll Methoden wissenschaftlichen Denkens kennenlernen

	Hierzu sind	1 sehr geeignet	2 geeignet	3 kann ich nicht entscheiden	4 weniger geeignet	5 nicht geeignet
1	Demonstrationsexperimente					
2	Schülerexperimente bzw. Praktika					
3	Experimente oder Projekte mit offener Fragestellung					
4	Experimentieren mit schrittweiser Anleitung					
5	Experimente, bei denen moderne Technologien (Computer, Multimedia) benutzt werden					

Ziel 4: Der/Die Lernende soll motiviert werden

	Hierzu sind	1 sehr geeignet	2 geeignet	3 kann ich nicht entscheiden	4 weniger geeignet	5 nicht geeignet
1	Demonstrationsexperimente					
2	Schülerexperimente bzw. Praktika					
3	Experimente oder Projekte mit offener Fragestellung					
4	Experimentieren mit schrittweiser Anleitung					
5	Experimente, bei denen moderne Technologien (Computer, Multimedia) benutzt werden					

Ziel 5: Die Persönlichkeitsentwicklung der/des Lernenden soll gefördert werden

	Hierzu sind	1 sehr geeignet	2 geeignet	3 kann ich nicht entscheiden	4 weniger geeignet	5 nicht geeignet
1	Demonstrationsexperimente					
2	Schülerexperimente bzw. Praktika					
3	Experimente oder Projekte mit offener Fragestellung					
4	Experimentieren mit schrittweiser Anleitung					
5	Experimente, bei denen moderne Technologien (Computer, Multimedia) benutzt werden					

Ziel 6: Die sozialen Fähigkeiten der/des Lernenden sollen verbessert werden (z.B. Teamwork)

	Hierzu sind	1 sehr geeignet	2 geeignet	3 kann ich nicht entscheiden	4 weniger geeignet	5 nicht geeignet
1	Demonstrationsexperimente					
2	Schülerexperimente bzw. Praktika					
3	Experimente oder Projekte mit offener Fragestellung					
4	Experimentieren mit schrittweiser Anleitung					
5	Experimente, bei denen moderne Technologien (Computer, Multimedia) benutzt werden					

Ziel 7: Das Wissen der/des Lernenden soll geprüft werden

	Hierzu sind	1 sehr geeignet	2 geeignet	3 kann ich nicht entscheiden	4 weniger geeignet	5 nicht geeignet
1	Demonstrationsexperimente					
2	Schülerexperimente bzw. Praktika					
3	Experimente oder Projekte mit offener Fragestellung					
4	Experimentieren mit schrittweiser Anleitung					
5	Experimente, bei denen moderne Technologien (Computer, Multimedia) benutzt werden					

Το πείραμα στη διδασκαλία των φυσικών επιστημών

Ευρωπαϊκό Ερευνητικό 'Εργο 1996-1998

Ερωτηματολόγιο για τους στόχους των διδασκόντων

Αγαπητοί συνάδελφοι,

Οι μαθητές της Πρωτοβάθμιας και Δευτεροβάθμιας Εκπαίδευσης καθώς και οι φοιτητές των Πανεπιστημιακών Τμημάτων Φυσικών Επιστημών μαθαίνουν και με τη βοήθεια πειραμάτων. Τα πειράματα αυτά μπορεί να είναι από πειράματα επίδειξης που πραγματοποιούνται από το διδάσκοντα μέσα στην τάξη έως εργαστηριακές ασκήσεις και ερευνητικές εργασίες που πραγματοποιούνται από τους μαθητές ή/και τους φοιτητές. Οι παραπάνω διαδικασίες οργανώνονται με διαφορετικό τρόπο στα διάφορα Ευρωπαϊκά Σχολεία και Πανεπιστήμια. Συμμετέχοντας σε μία έρευνα, η οποία πραγματοποιείται σε έξι ευρωπαϊκές χώρες, σχετικά με το ρόλο του πειράματος στη διδασκαλία των φυσικών επιστημών επιδιώκουμε να καταγράψουμε τους διάφορους τρόπους οργάνωσης της διδασκαλίας με χρήση πειραμάτων και οργάνωσης/επίβλεψης των εργαστηριακών ασκήσεων.

Στα πλαίσια της παραπάνω έρευνας σας ζητάμε να απαντήσετε στις ερωτήσεις αυτού του ερωτηματολόγιου.

Το ερωτηματολόγιο αποτελείται από τρία μέρη:

Στο πρώτο μέρος παραθέτουμε γενικούς στόχους των εργαστηριακών ασκήσεων ή/και της διδασκαλίας με χρήση πειραμάτων και ζητάμε να τους ιεραρχήσετε, σύμφωνα με τις δικές σας πεποιθήσεις.

Στο δεύτερο μέρος παραθέτουμε πολλούς ειδικούς στόχους, για κάθε έναν γενικό στόχο του πρώτου μέρους και ζητάμε να χαρακτηρίσετε τη σπουδαιότητα που έχει, κατά την γνώμη σας, καθένας από αυτούς.

Στο τρίτο μέρος ζητάμε να χαρακτηρίσετε τη χρησιμότητα διαφορετικών μορφών διδασκαλίας με χρήση πειραμάτων και οργάνωσης/επίβλεψης των εργαστηριακών ασκήσεων για την επίτευξη των αναφερόμενων γενικών στόχων.

Για να κατηγοριοποιήσουμε τις απαντήσεις σας, παρακαλούμε να συμπληρώσετε και τις ερωτήσεις που βρίσκονται στο κάτω μέρος αυτής της σελίδας.

Σας ευχαριστούμε.

Όνομα .....

Χώρα .....

Εκπαιδευτικό ίδρυμα (βάλτε σε κύκλο) Λύκειο Πανεπιστήμιο

Αντικείμενο διδασκαλίας στο οποίο αναφέρονται οι απαντήσεις σας: Βιολογία Χημεία Φυσική

Εσείς προσωπικά διδάσκετε χρησιμοποιώντας πειράματα στο μαθημά σας; ναι / όχι (βάλτε σε κύκλο)

Εσείς προσωπικά κάνετε εργαστηριακές ασκήσεις στους φοιτητές ή μαθητές σας; ναι / όχι (βάλτε σε κύκλο)

Η πιλοτική έρευνα, που πραγματοποιήθηκε σε έξι ευρωπαϊκές χώρες, έχει οδηγήσει σε ένα φάσμα διαφορετικών κατηγοριών στόχων (γενικών και ειδικών) του εργαστηρίου. Οι κατηγορίες αυτές βασίζονται σε ατομικές δηλώσεις και απαντήσεις καθηγητών της Δευτεροβάθμιας και της Τριτοβάθμιας Εκπαίδευσης. Κάθε κατηγορία στόχων μπορεί να είναι σημαντική σε διαφορετικό βαθμό για τη διδασκαλία με χρήση πειραμάτων, καθώς και για την οργάνωση και επίβλεψη των εργαστηριακών ασκήσεων.

Σας παρακαλούμε να εκφράσετε τη γνώμη σας για τη σπουδαιότητα των παρακάτω στόχων.

Σας παρακαλούμε να εστιάσετε το ενδιαφέρον σας στους μαθητές, καθώς απαντάτε για κάθε περίπτωση.

Παρακαλούμε, απαντήστε την κάθε ερώτηση ανεξάρτητα από τις υπόλοιπες.

1. Γενικοί στόχοι των εργαστηριακών ασκήσεων ή/και της διδασκαλίας με χρήση πειραμάτων.

Παρακαλούμε ιεραρχείστε τους παρακάτω 5 στόχους χρησιμοποιώντας τους αριθμούς από το 1 για τον σπουδαιότερο μέχρι και τον αριθμό 5 για τον λιγότερο σπουδαίο. Χρησιμοποιείστε κάθε αριθμό μία μόνο φορά.

	στόχοι των εργαστηριακών ασκήσεων ή/και της διδασκαλίας με χρήση πειραμάτων είναι:	Σειρά ιεράρχησης
Α	να συνδέσει ο μαθητής/φοιτητής τη θεωρία με την πρακτική.	
Β	να αναπτύξει ο μαθητής/φοιτητής πειραματικές δεξιότητες.	
Γ	να γνωρίσει ο μαθητής/φοιτητής τις μεθόδους της επιστημονικής σκέψης.	
Δ	να δημιουργηθούν κίνητρα στον μαθητή/φοιτητή, να αναπτύξει ο μαθητής/φοιτητής κοινωνικές δεξιότητες και να εξελιχθεί ως προσωπικότητα	
Ε	να αξιολογήσει ο δάσκαλος τη γνώση του μαθητή/φοιτητή	

2. Ειδικοί στόχοι των εργαστηριακών ασκήσεων ή/και της διδασκαλίας με χρήση πειραμάτων.

Στους πίνακες που ακολουθούν σας παραθέτουμε ειδικούς στόχους, μορφοποιημένους σε προτάσεις, για καθένα από τους πέντε προαναφερθέντες γενικούς στόχους.
Σε κάθε πίνακα περιλαμβάνονται οι διαφορετικές δυνατότητες ή περιγραφές των ερμηνειών που μπορούν να αποδοθούν σε κάθε κύριο στόχο.
Παρακαλούμε αξιολογείστε τη σπουδαιότητα κάθε ειδικού στόχου και σημειώστε στο ανάλογο τετραγωνάκι. Κρίνετε την κάθε πρόταση ανεξάρτητα από τις υπόλοιπες, ακόμα κι αν φαίνεται παρόμοια με κάποια άλλη.
Εάν κάποιος ειδικός στόχος μας έχει διαφύγει, παρακαλούμε συμπληρώστε τον στην κενή γραμμή στο τέλος κάθε πίνακα. Μπορείτε να προτείνετε οποιονδήποτε άλλο ειδικό στόχο θέλετε σχετιζόμενο με οποιαδήποτε κατηγορία.

Ειδικοί στόχοι για τον γενικό στόχο:
Α) να συνδέσει ο μαθητής/φοιτητής τη θεωρία με την πρακτική.

		πολύ σημαντικό	σημαντικό	δεν μπορώ να αποφασίσω	λιγότερο σημαντικό	καθόλου σημαντικό	δεν το καταλαβαίνω
Α1	να διευκολυνθεί στο να καταλάβει καλύτερα την θεωρία						
Α2	να επαληθεύσει τους επιστημονικούς νόμους						
Α3	να προκαλέσει (συγκεκριμένα) φαινόμενα						
Α4	να κατανοήσει καλύτερα τη θεωρία μέσα από την πρακτική						
Α5	να παρουσιαστούν φαινόμενα στους μαθητές/φοιτητές						
Α6	να κατανοήσει ειδικές πειραματικές μεθόδους σε διαφορετικά κεφάλαια.						
Α7	να παρατηρήσει και να πειραματιστεί για μελλοντική χρήση στην ανάπτυξη της θεωρίας						
Α8	να εμβαθύνει με παραδείγματα στη συστηματική προσέγγιση ενός θέματος						
Α9	να γνωρίσει την ορολογία και τους τεχνικούς όρους						
Α10	να λύνει προβλήματα που προκύπτουν από ένα πείραμα						
Α11	να επιδειχτούν στους φοιτητές/μαθητές τεχνικές εφαρμογές						
Α12	να βοηθηθεί στο να θυμάται ευκολότερα αρχές						

Ειδικοί στόχοι για τον γενικό στόχο:

Β) ο μαθητής/φοιτητής να αναπτύξει πειραματικές δεξιότητες

Β		πολύ σημαντικό	σημαντικό	δεν μπορώ να αποφασίσω	λιγότερο σημαντικό	καθόλου σημαντικό	δεν το καταλαβαίνω
Β1	να αποκτήσει εμπειρία σε βασικές τεχνικές και διαδικασίες						
Β2	να μάθει μια μέθοδο με τη χρησιμοποίηση ενός παραδείγματος						
Β3	να μάθει και να εξασκηθεί να γράφει εργαστηριακές αναφορές						
Β4	να μάθει να κάνει προσεκτικές παρατηρήσεις						
Β5	να μάθει να δουλεύει με έναν κατάλληλο και ασφαλή τρόπο						
Β6	να μάθει να χειρίζεται τα πειραματικά σφάλματα						

Ειδικοί στόχοι για τον γενικό στόχο:

Γ) ο μαθητής/φοιτητής να γνωρίσει τις μεθόδους τις επιστημονικής σκέψης

Γ		πολύ σημαντικό	σημαντικό	δεν μπορώ να αποφασίσω	λιγότερο σημαντικό	καθόλου σημαντικό	δεν το καταλαβαίνω
Γ1	να μάθει την επιστημονική προσέγγιση						
Γ2	να γνωρίσει την επιστημονική σκέψη						
Γ3	να αναπτύξει τις δεξιότητες του σχεδιασμού και της εκτέλεσης πειράματος.						
Γ4	να αναπτύξει κριτική προσέγγιση στην ερμηνεία των δεδομένων						
Γ5	να μάθει και να χειρίζεται τις φυσικές επιστήμες ως διαπλεκόμενες γνώσεις						
Γ6	να γνωρίσει τις επιστημολογικές μεθόδους						
Γ7	να γνωρίσει πως δουλεύει ο επιστήμονας						
Γ8	να μάθει να αντιμετωπίζει τις δυσκολίες των πειραματικών συσκευών						

Ειδικοί στόχοι για τον γενικό στόχο:

Δ) ο μαθητής/φοιτητής να αναπτύξει κίνητρα, κοινωνικές δεξιότητες και να εξελιχθεί σαν προσωπικότητα

Δ		πολύ σημαντικό	σημαντικό	δεν μπορώ να αποφασίσω	λιγότερο σημαντικό	καθόλου σημαντικό	δεν το καταλαβαίνω
Δ1	να αναπτύξει ενδιαφέρον						
Δ2	να χαρεί το περιεχόμενο και τη δραστηριότητα						
Δ3	να αναπτύξει δεξιότητες επικοινωνίας και αλληλεπίδρασης με τους συμμαθητές του						
Δ4	να δημιουργηθούν κίνητρα στο μαθητή/φοιτητή						
Δ5	να μάθει να δουλεύει σε ομάδες						
Δ6	να ευαισθητοποιηθεί για το φυσικό περιβάλλον, να αποκτήσει υπευθυνότητα, και ανοχή στις απόψεις των άλλων (επιστημονική ηθική)						

Ε) ο δάσκαλος να αξιολογήσει τη γνώση του μαθητή

Ε		πολύ σημαντικό	σημαντικό	δεν μπορώ να αποφασίσω	λιγότερο σημαντικό	καθόλου σημαντικό	δεν το καταλαβαίνω
Ε1	ο δάσκαλος να αξιολογήσει τη γνώση του μαθητή						

3. Ειδικές μορφές των εργαστηριακών ασκήσεων ή/και της διδασκαλίας με χρήση πειραμάτων.

Οι διαφορετικές μορφές διδασκαλίας με πειράματα ή οργάνωσης των εργαστηριακών ασκήσεων μπορεί να έχουν πλεονεκτήματα και μειονεκτήματα όσον αφορά την επίτευξη συγκεκριμένων στόχων.
Έτσι σας παραθέτουμε για κάθε κύριο στόχο πέντε διαφορετικές μορφές διδασκαλίας με χρήση πειραμάτων ή/και οργάνωσης των εργαστηριακών ασκήσεων για την επίτευξη των αναφερόμενων γενικών στόχων.

Παρακαλούμε να τις κρίνετε σύμφωνα με την χρησιμότητα που νομίζετε πως έχουν στην επίτευξη του συγκεκριμένου στόχου.
Γνωρίζουμε ότι οι διαφορετικές μορφές διδασκαλίας με πειράματα και οργάνωσης εργαστηριακών ασκήσεων που αναφέρονται παρακάτω συχνά εμπλέκονται και συνδυάζονται κατά τη διάρκεια των μαθημάτων. Παρόλα αυτά προσπαθείστε να φαντασθείτε τον κύριο στόχο κάθε κατάστασης που περιγράφεται.
Σας παρακαλούμε σημειώστε στο ανάλογο τετράγωνο.

Στόχος 1: Για να συνδέσει ο μαθητής/φοιτητής καλύτερα τη θεωρία με την πρακτική

		1 πολύ χρήσιμα	2 χρήσιμα	3 δεν μπορώ να απο-φασίσω	4 λιγό-τερο χρήσιμα	5 καθόλου χρήσιμα
1	τα πειράματα επίδειξης είναι					
2	τα πειράματα που εκτελούν οι μαθητές/φοιτητές είναι					
3	μια εργαστηριακή άσκηση για την εκτέλεση της οποίας δεν καθοδη-γούνται οι μαθητές/ φοιτητές είναι					
4	μια εργαστηριακή άσκηση για την εκτέλεση της οποίας καθοδη-γούνται λεπτομερώς οι μαθητές/ φοιτητές είναι					
5	τα πειράματα στα οποία χρησιμο-ποιούνται νέες τεχνολογίες είναι					

Στόχος 2: Για να αναπτύξει ο μαθητής/φοιτητής πειραματικές δεξιότητες

		1 πολύ χρήσιμα	2 χρήσιμα	3 δεν μπορώ να απο-φασίσω	4 λιγό-τερο χρήσιμα	5 καθόλου χρήσιμα
1	τα πειράματα επίδειξης είναι					
2	τα πειράματα που εκτελούν οι μαθητές/φοιτητές είναι					
3	μια εργαστηριακή άσκηση για την εκτέλεση της οποίας δεν καθοδη-γούνται οι μαθητές/ φοιτητές είναι					
4	μια εργαστηριακή άσκηση για την εκτέλεση της οποίας καθοδη-γούνται λεπτομερώς οι μαθητές/ φοιτητές είναι					
5	τα πειράματα στα οποία χρησιμο-ποιούνται νέες τεχνολογίες είναι					

Στόχος 3: Για να γνωρίσει ο μαθητής/φοιτητής τις μεθόδους τις επιστημονικής σκέψης

		1 πολύ χρήσιμα	2 χρήσιμα	3 δεν μπορώ να απο-φασίσω	4 λιγό-τερο χρήσιμα	5 καθόλου χρήσιμα
1	τα πειράματα επίδειξης είναι					
2	τα πειράματα που εκτελούν οι μαθητές/φοιτητές είναι					
3	μια εργαστηριακή άσκηση για την εκτέλεση της οποίας δεν καθοδη-γούνται οι μαθητές/ φοιτητές είναι					
4	μια εργαστηριακή άσκηση για την εκτέλεση της οποίας καθοδη-γούνται λεπτομερώς οι μαθητές/ φοιτητές είναι					
5	τα πειράματα στα οποία χρησιμοπο-ιούνται νέες τεχνολογίες είναι					

Στόχος 4: για να αναπτύξει ο μαθητής/φοιτητής κίνητρα

		1 πολύ χρήσιμα	2 χρήσιμα	3 δεν μπορώ να απο-φασίσω	4 λιγό-τερο χρήσιμα	5 καθόλου χρήσιμα
1	τα πειράματα επίδειξης είναι					
2	τα πειράματα που εκτελούν οι μαθητές/φοιτητές είναι					
3	μια εργαστηριακή άσκηση για την εκτέλεση της οποίας δεν καθοδη-γούνται οι μαθητές/ φοιτητές είναι					
4	μια εργαστηριακή άσκηση για την εκτέλεση της οποίας καθοδη-γούνται λεπτομερώς οι μαθητές/ φοιτητές είναι					
5	τα πειράματα στα οποία χρησιμο-ποιούνται νέες τεχνολογίες είναι					

Στόχος 5: Για να υποστηριχθεί η εξέλιξη της προσωπικότητας του μαθητή/φοιτητή

		1 πολύ χρήσιμα	2 χρήσιμα	3 δεν μπορώ να απο-φασίσω	4 λιγό-τερο χρήσιμα	5 καθόλου χρήσιμα
1	τα πειράματα επίδειξης είναι					
2	τα πειράματα που εκτελούν οι μαθητές/φοιτητές είναι					
3	μια εργαστηριακή άσκηση για την εκτέλεση της οποίας δεν καθοδη-γούνται οι μαθητές/ φοιτητές είναι					
4	μια εργαστηριακή άσκηση για την εκτέλεση της οποίας καθοδη-γούνται λεπτομερώς οι μαθητές/ φοιτητές είναι					
5	τα πειράματα στα οποία χρησιμο-ποιούνται νέες τεχνολογίες είναι					

Στόχος 6: Για να βελτιώσει ο μαθητής/φοιτητής τις κοινωνικές του δεξιότητες (π.χ. η δεξιότητα της συνεργασίας σε μια ομάδα)

		1 πολύ χρήσιμα	2 χρήσιμα	3 δεν μπορώ να απο-φασίσω	4 λιγό-τερο χρήσιμα	5 καθόλου χρήσιμα
1	τα πειράματα επίδειξης είναι					
2	τα πειράματα που εκτελούν οι μαθητές/φοιτητές είναι					
3	μια εργαστηριακή άσκηση για την εκτέλεση της οποίας δεν καθοδη-γούνται οι μαθητές/ φοιτητές είναι					
4	μια εργαστηριακή άσκηση για την εκτέλεση της οποίας καθοδηγούνται λεπτομερώς οι μαθητές/ φοιτητές είναι					
5	τα πειράματα στα οποία χρησιμο-ποιούνται νέες τεχνολογίες είναι					

Στόχος 7: Για την αξιολόγηση της γνώσης του μαθητή/φοιτητή

		1 πολύ χρήσιμα	2 χρήσιμα	3 δεν μπορώ να απο-φασίσω	4 λιγό-τερο χρήσιμα	5 καθόλου χρήσιμα
1	τα πειράματα επίδειξης είναι					
2	τα πειράματα που εκτελούν οι μαθητές/φοιτητές είναι					
3	μια εργαστηριακή άσκηση για την εκτέλεση της οποίας δεν καθοδη-γούνται οι μαθητές/ φοιτητές είναι					
4	μια εργαστηριακή άσκηση για την εκτέλεση της οποίας καθοδη-γούνται λεπτομερώς οι μαθητές/ φοιτητές είναι					

5	τα πειράματα στα οποία χρησιμο-ποιούνται νέες τεχνολογίες είναι					

Tema 3

"Obiettivi dell'attività di laboratorio nell'insegnamento delle scienze"

Caro collega,

vorremmo invitarla a collaborare a una recerca che stiamo svolgendo. Intendiamo definire quale sia il ruolo dell'attività sperimentale "scolastica" rispetto all'apprendimento delle diverse discipline scientifiche. Per attività sperimentale intendiamo gli esperimenti demostrativi, gli esperimenti e le esercitazioni condotte dagli studenti in forma guidata o aperta, fino alle progettazione di attività ideate dagli studenti stessi. L'apprendimento attraverso l'esecuzione di esperimenti è promosso in modi molto diversi nelle scuole e nelle università Europee.

Nall'ambito del progetto di ricerca condotto in sei paesi europei stiamo analizzando come è organizzata l'attività di laboratorio e come viene integrata per ottimizzare il processo di apprendimento.

Ci rivolgiamo pertanto a lei, come insegnante nella scuola o nell'università, e quindi come esperto nell'insegnamento delle scienze, pregandola di rispondere alle domande del questionario presentate nelle tre sezioni del questionario. Nella prima sezione si chiede di classificare gli obiettivi parziali es si chiede di valutare l'importanza di ciascuno nell'attività di laboratorio; nella terza si propongono diverse situazioni per l'attività de laboratorio e si chiede di valutare quanto siano adequate rispetto al raggiungimento dei diversi obiettivi.

Per poter classificare le sue risposte, le chiedamo anche di completare le indicazioni riportate in questa pagina. La ringraziamo per la collaborazione.

Nome: .....

Nazione: .....

Scuola: **scuola secondaria superiore;** **università**

Materia alla quale si riferiscono le sue risposte: **Fis.;** **Bio.;** **Chim.**

Nel suo insegnamento conduce lei stesso esperimenti (o esercitazioni) o li organizza per gli studenti? **si;** **no**

Uno studio pilota, che abbiamo condotto in sei naziioni Europee, ha consentito di definire una ampia gamma di obiettivi che abbiamo ordinato in categorie principali e secondarie. Sulla base di ferarchie prefigurate nelle risposte deli insegnanti di questi paesi. Noi riteniamo che i diversi obiettive possano avere pesi diversi nella attività di laboratorio relative all'insegnamento delle scienze.

Le chiediamo di esprimere la sua valutazione dell'importanza dei seguenti obiettivi nell'insegnamento delle scienze, tenendo presente che noi siamo interessati essenzialmente al processo di apprendimento dello studente. Risponda a ciascuna domanda in modo indipendente dalle altre.

1. Obiettivi generali per l'attività di laboratorio

	Attraverso l'attività di laboratorio	**N.**
A	lo studente deve collegare la teoria alla pratica	
B	lo studente deve acquisire abilità sperimentali	
C	lo studente deve familiarizzare con la logica del pensiero scientifico	
D	lo studente deve potenziare la motivazione, sviluppare ulteriormente la sua personalità e la capacità di socializzazione	
E	l'insegnante deve avere la possibilità di valutare le conoscenze degli studenti	

2. Obiettivi particolari dell'attività di laboratorio

Le proponiamo ora diversi obiettive particolari dell'attività di laboratorio**,** emersi dallo studio pilota, che rappresentano sottocategorie degli obiettivi principali riportati nella prima parte. Questi obiettivi particolari riguardano aspetti o implicatzioni degli obiettivi principali. Indichi quanto considera importante ogni obiettivo per l'attività di laboratorio nell'insegnamento scientifico, mettendo una crocetta nella casella corrispondente alla sua valutazione.
Valuti ciascuna affermazione in modo indipendente dalle altre, anche se alcune possono sembrarle simili. Se ritiene che abbiamo trascurato qualche categoria di obiettivi che lei ritiene importanti, può agguengerla usando le righe vuote alla fine di ogni tabella. Sono graditi commenti.

A	**lo studente deve collegare la teoria alla pratica;**	Molto import.	Import.	Poco import.	Non import.	Non so decidere	Non capisco
A1	facilitare la comprensione della teoria						
A2	verificare leggi scientifiche						
A3	riprodurre fenomeni emblematici						
A4	approfondire la comprensione della teoria attraverso la pratica						
A5	illustrare fenomeni						
A6	mostrare che le conoscenze scientifiche sono correlate a specifici metodi sperimentali						
A7	fornire strumenti sperimentali che consentano poi di utilizzare i risultati nella teoria						
A8	approfondire un aspetto specialisto attraverso casi esemplari						
A9	introdurre significativamente notazioni e termini tecnici						
A10	consentire la soluzione di problemi che emergono dall'attività sperimentale						
A11	mostrare applicazioni technice						
A12	rafforzare la memorizzazione di fatti e principi						

B	lo studente deve acquisire abilità sperimentali; **obiettivo dell'attività di laboratorio è:**	Molto import.	Import.	Poco import.	Non import.	Non so decidere	Non capisco
B1	fornire un repertorio di esperienze in tecniche e procedure standard						
B2	insegnare metodi attraverso esempi						
B3	esercitare nella stesura di relazioni sulle attività di laboratorio						
B4	insegnare ad effettuare osservazioni accurate						
B5	insegnare a lavorare in modo accurato e sicuro						
B6	insegnare a trattare gli errori sperimentali						

C	**lo studente deve** familiarizzare con la logica del pensiero scientifico; **obiettivo dell'attività di laboratorio è:**	Molto import.	Import.	Poco import.	Non import.	Non so decidere	Non capisco
C1	conoscere i modi de procedere della scienza						
C2	conoscere il pensiero scientifico						
C3	sviluppare abilità necessarie per la progettazione e per la conduzione di esperimenti						
C4	sviluppare un approccio critico alla interpretazione dei dati						
C5	capire a trattare le scienze come un sistema complesso						
C6	conoscere i metodi adatti per la costruzione del sapere scientifico						
C7	sapere come lavorano gli scienziati						
C8	imparare a superare difficoltà tecniche						

D	**lo studente deve** potenziare la motivazione, sviluppare ulteriormente la sua personalità e la capacità di socializzazione; **obiettivo dell'attività di laboratorio è:**	Molto import.	Import.	Poco import.	Non import.	Non so decidere	Non capisco
D1	sviluppare interesse						
D2	rendere piacevole la materia e le attività affrontate						
D3	sviluppare capacità generali di comunicazione e di interazione						
D4	rafforzare la motivazione						
D5	insegnare a lavorare in gruppo						
D6	sviluppare l'attenzione nei confronti dell'ambiente naturale, il senso di responsabilità, la tolleranza (etica nella scienza)						

E	l'insegnante deve avere la possibilità di valutare le conoscenze degli studenti; **obiettivo dell'attività di laboratorio è:**	Molto import.	Import.	Poco import.	Non import.	Non so decidere	Non capisco
E1	valutare le conoscenze deglie studenti						

3. Diverse forme de attività di laboratorio

Le attività di laboratorio possono incidere positivamente o negativamente su differenti forme di apprendimento rispetto al raggiungimento di specifici obiettivi.

Per questo prospettiamo per gli obiettivi principali già menzionati, cinque possibili situazioni sperimentali.

Le chiediamo di giudicare in che misura le singole situazioni sono adatte ai singoli obiettivi.

Sappiamo che le differenti forme di attività di laboratorio elencate sotto, nella pratica dell'insegnamento, vengone spesso combinate fra loro e non sempre intervengono in "forma pura". Tuttavia concentri l'attenzione sulle situazioni vie descritte.

Selezioni la casella più appropriata.

Obbietivo 1: lo studente deve collegare teoria e pratica

	A tal fine si propongono	molto adatto	adatto	poco adatto	non adatto	non so decidere
1	esperimenti dimostrativi eseguiti dall'insegnante					
2	esperimenti (o esercizi) eseguiti dagli studenti					
3	esperimenti o problemi aperti					
4	attività di laboratorio con una guida passo per passo					
5	Esperimenti imperniati sull'uso di tecnologie moderne (computer, multimedia)					

Obbietivo 2: lo studente deve acquisire abilità sperimentali

	A tal fine si propongono	molto adatto	adatto	poco adatto	non adatto	non so decidere
1	esperimenti dimostrativi eseguiti dall'insegnante					
2	esperimenti (o esercizi) eseguiti dagli studenti					
3	esperimenti o problemi aperti					
4	attività di laboratorio con una guida passo per passo					
5	Esperimenti imperniati sull'uso di tecnologie moderne (computer, multimedia)					

Obbietivo 3: lo studente deve familiarizzare con la logica del pensiero scientifico

	A tal fine si propongono	molto adatto	adatto	poco adatto	non adatto	non so decidere
1	esperimenti dimostrativi eseguiti dall'insegnante					
2	esperimenti (o esercizi) eseguiti dagli studenti					
3	esperimenti o problemi aperti					
4	attività di laboratorio con una guida passo per passo					
5	Esperimenti imperniati sull'uso di tecnologie moderne (computer, multimedia)					

Obiettivo 4: lo studente deve essere motivato

	A tal fine si propongono	molto adatto	adatto	poco adatto	non adatto	non so decidere
1	esperimenti dimostrativi eseguiti dall'insegnante					
2	esperimenti (o esercizi) eseguiti dagli studenti					
3	esperimenti o problemi aperti					
4	attività di laboratorio con una guida passo per passo					
5	Esperimenti imperniati sull'uso di tecnologie moderne (computer, multimedia)					

Obbietivo 5: Lo sviluppo della personalità dello studente deve essere stimolato

	A tal fine si propongono	molto adatto	adatto	poco adatto	non adatto	non so decidere
1	esperimenti dimostrativi eseguiti dall'insegnante					
2	esperimenti (o esercizi) eseguiti dagli studenti					
3	esperimenti o problemi aperti					
4	attività di laboratorio con una guida passo per passo					
5	Esperimenti imperniati sull'uso di tecnologie moderne (computer, multimedia)					

Obiettivo 6: Le capacità de socializzazione dello studente devono essere migliorate, per esempio con il lavoro di gruppo

	A tal fine si propongono	molto adatto	adatto	poco adatto	non adatto	non so decidere
1	esperimenti dimostrativi eseguiti dall'insegnante					
2	esperimenti (o esercizi) eseguiti dagli studenti					
3	esperimenti o problemi aperti					
4	attività di laboratorio con una guida passo per passo					
5	Esperimenti imperniati sull'uso di tecnologie moderne (computer, multimedia)					

Obiettivo 7: Le conoscenze dello studente devono essere valutate

	A tal fine si propongono	molto adatto	adatto	poco adatto	non adatto	non so decidere
1	esperimenti dimostrativi eseguiti dall'insegnante					
2	esperimenti (o esercizi) eseguiti dagli studenti					
3	esperimenti o problemi aperti					
4	attività di laboratorio con una guida passo per passo					
5	Esperimenti imperniati sull'uso di tecnologie moderne (computer, multimedia)					

From the common work of the project *'LABWORK IN SCIENCE EDUCATION',* some policy implications : A summary

The following research themes have been addressed at European level by the project :
- the current practice of labwork in Europe [Working papers 2, 3] using a specific tool of description of labwork sessions [Working Paper 1]
- the identification of labwork objectives as defined and ranked by teachers in order of importance [Working Paper 6]
- the image of science as it is related to labwork [Working Papers 4 and 5]
- the effectiveness of labwork which has been documented by 22 case-studies [Working Papers 7 and 8]

These pieces of work showed that there is in Europe a common paradigm of labwork, but that some choices for Education and Science Education are stemming from national traditions. However some implications could be drawn from the work done in six countries, which are summarised below.

1 - Some objectives are not achieved if not addressed specifically. A number of potential objectives are very rarely addressed currently. If these issues were addressed, there is a potential for students to learn more from labwork.

The objectives being defined carefully, it is necessary to attribute a specific place and role to each of them.

- Although ***conceptual knowledge*** underpins all labwork activities, this should not be taken as implying that doing labwork activities necessarily leads to improved conceptual understanding. Indeed, scientific concepts are not usually learned effectively through labwork if the labwork activity is not designed towards this aim

Some case studies show the proportion of time devoted to "talk" about the conceptual and theoretical basis of labwork tasks. In general, the amount of time spent by students in this way is very small, suggesting a need for improvement.
One of the most effective ways of focusing students on the corresponding knowledge, is to address issues of modelling directly. This is made possible in activities such as constructing a model, discussing a model in relation to events, using a model in particular situations, comparing models and searching for the value of a parameter to fit a model. Computers are of great help in such cases, as can videos designed to focus on the theoretical underpinnings of labwork.
The context of open-ended project work is also a powerful strategy because it requires students to draw upon conceptual knowledge in order to solve a given problem, even if the project is introduced before formal teaching of 'theory'.
Another possibility is to ask students to make predictions more often about the behaviour of events, or alternatively about orders of magnitude before actually making measurements. To be meaningful, this requires renewed types of organisation.

- Any piece of labwork requires students to undertake ***procedures***. However teachers cannot expect students to learn about procedures effectively if these are not taught explicitly, and explained and used in a variety of contexts. An argument supporting the teaching of procedures is that, once understood, such procedures are powerful tools to be used in designing experiments, one of the most creative processes in science. Experimental design is a particularly effective context for teaching epistemological knowledge. If students are not taught procedures, then their autonomy for designing experiments will inevitably be reduced.

- During labwork there should be a constant interplay between the ***collection of data*** (observations, measurements etc.) and theory. During the project, the place of measurement was increasingly questioned. If measurement is undertaken as an activity, it should be carefully 'targeted': clear objectives for the activity should be set, and consideration should be given to other activities that might follow on from measurement such as data processing, the evaluation of theories, drawing conclusions and evaluating experimental techniques and apparatus.

Obviously, computers and sensors can play an important role in saving time during these tasks and in some cases it is only possible to make measurements with the aid of computers. But, the significance of the measurement must be addressed directly in teaching and not hidden behind routines.

- ***Data processing and the development of conclusions*** provide opportunities for the development of conceptual and epistemological understanding by students. Our work underlines the very different choices that can be made by teachers. Data processing can be treated as an algorithm, or alternatively can be treated as an opportunity to teach about one of the most important aspects of epistemology: the confidence that can be attributed to data and the uses to which data can be put.

- The development of ***epistemological knowledge*** is rarely addressed in most countries, and in countries where it is addressed, labwork is not the teaching method used. There are opportunities in labwork to promote a reflection on the part of students upon links between theory and data. One approach involves addressing experimental design. Another approach involves the selection of real situations from ongoing research, addressing how the research was operationalised and the main issues addressed during the work as it proceeded.

This raises the issue of the extent to which an unique epistemology can and should be presented to students through labwork, and indeed through the science curriculum more generally. It is necessary to address at a policy level the relative placing of examples from the history of science in the curriculum, and the treatment of epistemology in students' labwork.

2 - Each labwork session should be reasonably ambitious and targeted, the strategy being a clear orientation towards certain objectives.

In fact there is frequently a mismatch between teachers' objectives and what is achieved by students. Students *'do'* what they are intended to do but they do not necessarily *'think'* or *'learn'* as they are intended to think and learn. Teaching strategies ought therefore to be adapted to address selected objectives, putting other possible objectives aside. This is what we call *'targeted* ' labwork sessions.

With this choice, it becomes necessary to organise students' overall programme of labwork activities within a coherent long-term programme and this assumes that the types of labwork undertaken by students should be varied. For example, selected part of the whole experimental process, studies of identified cases encountered in labs to teach images of science, qualitative observations, software used simultaneously with an experiment, computer simulations and projects might all be included within a sequence.
Projects are particularly useful in ensuring that students work under their own direction. If this is to happen a generous time allocation has to be given to project work, possibly several weeks. This supposes to accept to diminish a curriculum crowded by content.

3 - A major outcome of the project is recognising the importance of differentiating between the effectiveness of labwork in terms of promoting learning outcomes, and in terms of the success of labwork at engaging students in particular activities. Both types of effectiveness should be involved in labwork.

It is particularly important for students to be given the opportunity to undertake experimental approaches for themselves, to design experiments, to go through a complete sequence of data processing and to make corresponding decisions about the choice of apparatus, mathematical tools or software. Such activities during labwork cannot be directly linked to specific learning outcomes. However they are crucial for the development of students' scientific understanding in the broader sense.
Linked to effectiveness, specific assessment strategies have to be implemented. Some suggestions about the wording of questions allowing the assessment of specific objectives such as procedures or epistemological meta-knowledge, can be found in case studies from the project.

4 - A condition for improved effectiveness is a different focus for teacher education and a deep change in the focus of resources, labwork sheets and the types of guidance available to students during labwork

The critical role of teachers in ensuring that labwork is effective was emphasised.
For instance, some teachers have a role of labwork developers : they should work in collaboration to identify learning objectives, possibly consulting literature and/or the Internet. They should
also abandon some possible learning objectives to promote others identified as being particularly important. They have to design lectures to be done at a level and with objectives consistent with labwork. In addition, during labwork, teachers have to ask questions to students, and require them to make observations or measurements, calculations of orders of magnitude, mathematical modelling, predictions, etc. as described previously.
The multiple tasks of teachers suggest that it requires specific input during initial and in service training.

The general objectives of promoting student ***autonomy and motivation*** have not been addressed directly in this project. However there is agreement that student autonomy is not only obtained during open ended labwork, but rather that it can be obtained during labwork organised in various different ways in which specific questions are raised in students' minds, and particular guidance is given to students.

Autonomy and motivation are expected as consequences of targeted labwork.

Working Papers
of the project
'LABWORK IN SCIENCE EDUCATION'

1998

*** Working paper 1 ***

A MAP FOR CHARACTERISING THE VARIETY OF LABWORK IN EUROPE

Authors : Robin Millar, Jean-François Le Maréchal and Christian Buty

Language : English .

Annex : The 'map' in one of the national languages

*** Working papers 2 and 3 ***

SCIENCE TEACHING AND LABWORK PRACTICE IN SEVERAL EUROPEAN COUNTRIES

Volume 1 Description of science teaching at secondary level
Authors : Andrée Tiberghien, Karine Bécu-Robinault, Christian Buty, Manuel Fernandez, Hans Fischer, John Leach, Jean-François Le Maréchal, Anastasios Molohides, Albert Chr.Paulsen, Didier Pol, Dimitris Psillos, Naoum Salame, Carlo Tarsitani, Eugenio Torracca, Laurent Veillard, Stefan v. Aufschnaiter and Jean Winther

Volume 2 Teachers' labwork practice, an analysis based on questionnaire at secondary and university levels

Authors : Andrée Tiberghien, Karine Bécu-Robinault, Christian Buty, Hans Fischer, Kerstin Haller, Dorte Hammelev, Lorenz Hucke, Petros Kariotoglou, Helge Kudahl, John Leach Jean-François Le Maréchal, Jenny Lewis, Hans Niedderer, Albert Chr.Paulsen,Dimitris Psillos, Florian Sander, Horst Schecker, Marie-Genevieve Séré, Carlo Tarsitani, Eugenio Torracca, Laurent Veillard, Stefan v. Aufschnaiter, Manuela Welzel and Jean Winther

Volume 3 Analysis of labwork sheets used in regular labwork at the upper secondary school and the first years of University

Authors : Andrée Tiberghien, Laurent Veillard, Jean-François Le Maréchal and Christian Buty

Annexes: Examples of labsheets translated into English form several European countries

Language **:** English

*** Working paper 4 ***

SURVEY 2 : STUDENTS' 'IMAGES OF SCIENCE' AS THEY RELATE TO LABWORK LEARNING.

Authors : John Leach, Robin Millar, Jim Ryder, Marie-Geneviève Séré, Dorte Hammelev, Hans Niedderer and Vasilis Tselfes.

Language : English

*** Working paper 5 ***

TEACHERS' IMAGE OF SCIENCE AND LABWORK. HYPOTHESES, RESEARCH TOOLS AND RESULTS IN ITALY AND IN FRANCE

Authors : Milena Bandiera, Michel Dupré, Marie-Geneviève Séré, Carlo Tarsitani, Eugenio Torracca, Matilde Vicentini

Language : English

*** Working paper 6 ***

TEACHERS' OBJECTIVES FOR LABWORK. RESEARCH TOOL AND CROSS COUNTRY RESULTS

Authors : Manuela Welzel, Kerstin Haller, Milena Bandiera, Dorte Hammelev, Panagiotis Koumaras, Hans Niedderer, Albert Paulsen, Karine Bécu- Robinault and Stefan von Aufschnaiter

Language : English

*** Working paper 7 ***

CASE STUDIES OF LABWORK IN FIVE EUROPEAN COUNTRIES

Editors : Dimitris Psillos and Hans Niedderer

Language : English

*** Working paper 8 ***

THE MAIN RESULTS OF CASE STUDIES : ABOUT THE EFFECTIVENESS OF DIFFERENT TYPES OF LABWORK

Authors : Dimitris Psillos, Hans Niedderer and Marie-Geneviève Séré

Language : English

*** Working paper 9 ***

CATEGORY BASED ANALYSIS OF VIDEOTAPES FROM LABWORK : THE METHOD AND RESULTS FROM FOUR CASE-STUDIES

Authors : Hans Niedderer, Andrée Tiberghien, Christian Buty, Kerstin Haller, Lorenz Hucke, Florian Sander, Hans Fischer, Horst Schecker, Stefan von Aufschnaiter and Manuela Welzel.

Language : English

*** Working paper 10 ***

LES TRAVAUX PRATIQUES DANS L'ENSEIGNEMENT DES SCIENCES DE LA VIE ET DE LA TERRE DANS LES LYCÉES FRANÇAIS

Editors : Didier Pol , Naoum Salamé et Marie-Geneviève Séré

Language : French.

The part concerning the survey *Science Teaching and Labwork Practice in Several European countries,* in English

*** Working papers in each country (France, Denmark, Germany, Great Britain, Greece, Italy)***

THE MAIN RESULTS OF THE SURVEYS OF THE EUROPEAN PROJECT *'LABWORK IN SCIENCE EDUCATION'*

Language : the national language in each country .

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Scientific papers, communications, proceedings and theses concerning the project, can be found in the ANNEX 11 to the final report of the project.

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www.