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Specific Support Actions

D23-30 Motivation Study: Results, Evaluation and Interpretation

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1. Foreword

This deliverable “D23-30 Motivation Study: Results, Evaluation and Interpretation” is a report merging “D23 Results of the Motivation Study” and “D30 Motivation Study: Evaluation and Interpretation.”

The decision to merge these two deliverables was taken bilaterally between the workpackage leader and project coordinator in order to provide a coherent and comprehensive document which presents the theoretical background, objectives, methodology and results with their evaluation and interpretation, drawing together a set of six definitive conclusions on the motivational effects of science centres on learning.

2. Theoretical Background

1.1 Motivational effects of science centres: towards evidence based education

Science centres list their main goals with somewhat different words (and languages!), but the key terms are world wide as follows: the institute will advance public understanding of science, create positive attitudes towards science and technology, encourage – especially – young people to learn science and take up careers in science and technology, and maximise the opportunities in society for scientific applications. How much evidence do we have to show that these main goals will be realised in the everyday functions of a science centre? Answering this question is not easy although we know that everyday experience suggests that these pragmatic outcomes can be achieved.

It is important to address this issue in context because the various stakeholders such as relevant authorities, sponsors and visitors need to attest to the effectiveness of the science centre movement. Because they are – still – fairly new institutions, science centres, in particular, face this question more frequently than other more traditional institutions. Additional data, with the focus on educational research and learning has to be the goal for any developing work at science centres.

The educational role of science centres has been considered more or less as self-evident. However, some classical educational theories can be detected in the principles underlying science centre education, although few educators in these institutions have been explicit in their approach. They have relied, rather, on the practical and common-sense application of loosely formulated pedagogy. Every-day knowledge tells us that students are eager to have lessons in informal settings. Field trips, camp schools, visits to industry, to a museum or science centre, or even having an art lesson in the school yard, are positive occasions in students' minds. The big challenge, is can this situation motivation be ennobled into real interest into the topic as intrinsic motivation. In the PENCIL-project fourteen science centres around the Europe were developing their educational solutions towards best practices to be delivered for large audiences inside science centres and schools via XPLORA portal.

1.2 Description of the attending institutes and learning environments

To receive more evidence based education experiences – and not only everyday anecdotes -the motivation survey was administrated in the following four science centres:

The National Marine Aquarium, Plymouth, UK

The National Marine Aquarium created for The Pencil Project "Climate Lab" for teachers, pupils and science centres dealing with the topic of climate change. It gave an opportunity for the target group (students between 9-15 years from ten local schools) to investigate marine issues with climate change. The open learning environment was combining the aquarium, science centre exhibition, and the special web-site created for the project. The students attending the survey were at the age of twelve to thirteen years.

Ellinogermaniki Agogi, Athens, Greece

Ellinogermaniki Agogi is a private school covering all stages of education… **The Pencil Project Virtual Observatory** brought together pedagogical experts, researchers, scientists, and students to introduce the use of robotic telescopes in school education. The VO system is mainly based on the integration of the services offered by the EUDOXOS project in Greece. The target age group was students of the school between 15-17 years, and their teachers. However, the students attending the survey were at the age of twelve to thirteen years.

Cité de l'espace, Toulouse, France

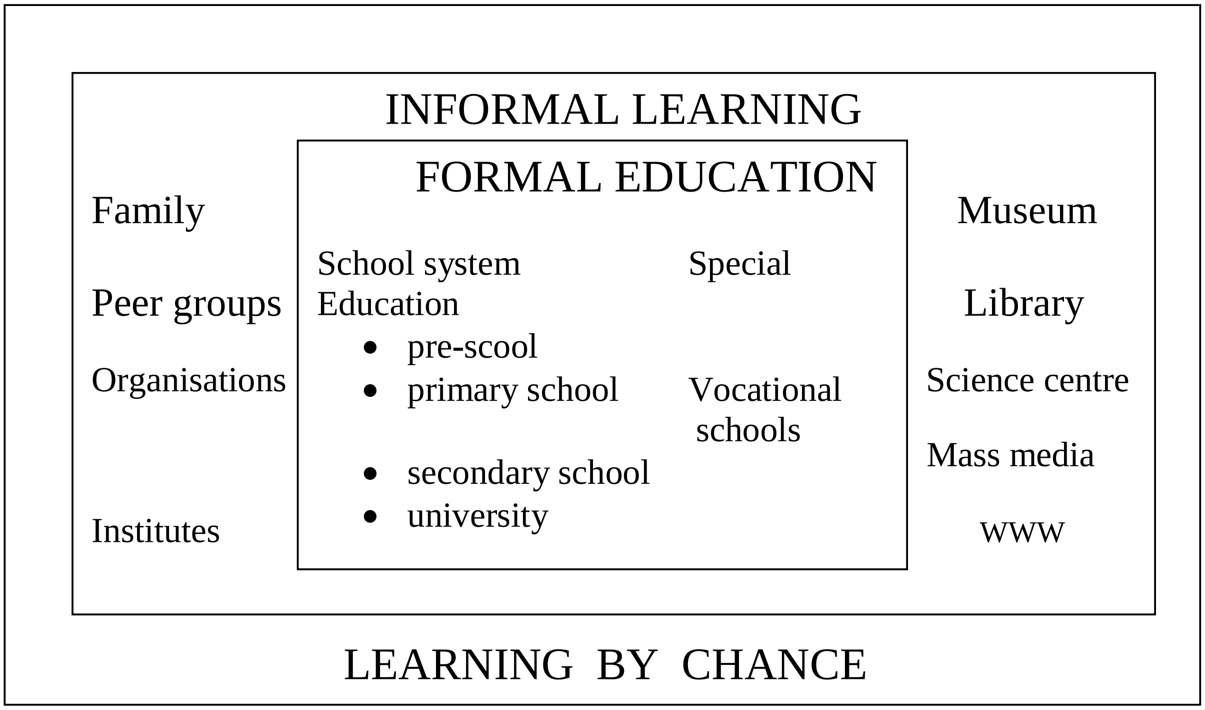
La Cité de l'espace is a science centre dedicated to space sciences. The Pencil project **Future technologies for science learning** aimed to find out the role of innovative technologies used in la Cité de l'espace to improve science learning. The target age group of the project was 8-12 years old pupils from several local schools. For the survey, the oldest pupils (12 years) were chosen to get the evaluation comparable with the other three countries.

Heureka, the Finnish Science Centre

In the Pencil Project **Chemistry for Primary Schools**, Heureka, the Finnish Science Centre developed new methods for teaching and learning chemistry by using the science centre laboratory as an open learning environment combining informal learning and formal school education. The target group was pupils aged between 6-13 years old from several local schools. The pupils attending the survey were 12-13 years old (6th class in the Finnish school system).

1.3 Combining informal and formal learning

A science centre is a learning laboratory in two senses. First of all, it is a place where visitors can learn scientific ideas by themselves using interactive exhibit units. Second, it is a place where informal education can be studied in an open learning environment. The purpose of the survey is to further develop science centre education as an effective form of informal learning.



To advance public understanding of science, new forms of education are actively being sought. A huge amount of information especially about modern phenomena is obtained in a personal way from family, friends, peer groups. Furthermore, the roles of television, libraries, magazines and newspapers are also essential. Museums and science centres have increased the number of their visitors regularly during the last decade. Most of these forms of education can be classified as informal learning either focused on young people via informal, out-of-school education programmes or as clearly informal learning occurring totally outside of any educational institutions for young people or adults.

1.4 The Model for Motivation: Situation, Instrumental and Intrinsic Motivation

The following theoretical model with definitions describes different types of motivations. The model will also be used in the empirical part of survey.

A: Extrinsic motivation

Situation motivation: Motivation grows from a new situation. Temporary, external factors are important. Social relations are often an affecting factor. Entertainment is always a significant factor.

Typical features:

* Short-lasting motivation
* Learning is easily disturbed
* Learning is oriented to irrelevant subjects

Instrumental motivation: The basis of this motivation is to get a reward and/or to avoid punishment. The main stimulus is 'to get things done' rather than being interested in the deeper meaning of the subject.
Typical features:

* The goal is often to pass an examination
* The learning of isolated facts, but common principles
* Connections or a theoretical background are less important for the learner
* Facts are very quickly forgotten after an examination

B: Intrinsic motivation

Intrinsic motivation: The basis of this motivation is, a real interest in the topic studied. No other person persuades the learner to learn. The student sees the value of the studies and forms plans to use the knowledge or skill in the future. Curiosity, exploring and problem solving are key elements of this motivation.
Typical features:

* A critical and open-minded attitude towards learning
* seeing the connection between isolated facts and the topic area as a whole
* Connection between theory and practice
* Curiosity, interest, problem-based learning

Most studies about motivation orientation have been conducted in the classroom learning context. In this study such a model is useful in learning in informal settings. The distinction between intrinsic and extrinsic (situation and instrumental) motivation provides a theoretical background to this study.

2 Aims of the Study

2.1 Research Questions

According to earlier findings in the literature, the purpose of this study is to investigate the following questions:

1. What is the motivational background of students visiting the science centre exhibition?
2. How does science centre visits affect the motivation of students?
3. Do well planned visits to a science centre create deep or superficial learning strategies for the students?
4. Is there a difference in the motivational patterns of the students according their school success?
5. Are results of the gender differences in learning similar in school and in science centre learning?

These questions are practical for and relevant to the ways learning in a science centre is organised. However, they are also of wider theoretical interest. The study is designed to test the preliminary results received in earlier research testing the theory of intrinsic and instrumental motivation. Results can also describe the link between formal and informal education, and have potential applications in schools.

2.2 Assessment

The Motivation Test

Motivation will be measured by the test which has 20 items of different attributes of motivation. Seven items of the test represent the characteristic features of intrinsic motivation: real interest in the topic, no other person forcing the learning, the learner sees the value of the learning; curiosity, exploration and problem solving are key elements of motivation. Twelve items of the test represent the characteristic features of instrumental motivation: the basis of motivation is to get a reward and/or to avoid punishment; to get things done rather than for interest; the context in which learning takes place is important. (Original test: see Salmi 1993, 80-111; see Annex A-B)

Visual and Cognitive Ability Reasoning Test: VSA - RAVEN

The visual and cognitive test consists of 60 visual multi-choice items. Each item has a figure with one part missing. The students have to choose the missing figure from 6 alternatives. There is a time limit of 12 minutes to perform the test. This test-pattern is widely standardised during decades of use in several countries. It is also very much “gender free” measuring instrument. Most of all, no translations are needed, because the test is based on figures and symbols. This makes it most usable for the European wide research. Also the students *like* to fill in this test – resembling popular and trendy quizzes in media. (Original licensed test: see Raven, Raven & Court 2000, 1-130). See Annex D.

Knowledge test
The knowledge learning was tested with open ended and multi-choice items as post- and pre-test of different topics in different places: Toulouse: space science and astronomy; Heureka: chemistry; Ellinogermaniki Agogi: astronomy; Plymouth: climate change and sea ecology. Tests were created according the content of the exhibition of each site separately. See Annex E.

Semantic Differential (SD) test
The standardised test is measuring how the learning process is experienced by the students. It contains 14 multi-choice items (Likert scale 1 to 5). The test was administrated as a pre and post test: the pre test was measuring the science education experience at classroom settings and the post test was measuring the science education experience in open learning science centre settings. Scores on a science-related semantic differential test are small but significant predictors of physics and chemistry achievement. The benefits of using SD is the high reliability of such tests, and the very short time it takes the students to read and answer it. (See for example Osgood, C.F., Suci, G.J., & Tenenbaum, P.H. 1975; CONNECT Evaluation Report; EC/FP6-2002-IST-1-507844). See Annex C.

School success rating
The teachers of the school classes were ranking their students according their previous overall school success in science, mathematics, and mother language. The pupils were classified in three groups: below average (A-; 25 %), average (A; 50%), and above average (A+; 25%).

2.3 Design of the study

The tests took were administrated twice: T1: as a pre-test before the visits; and T2: as a post-test a week after the visits.

All the tests took place in 4 countries attending the project: Greece, UK, France, and Finland.

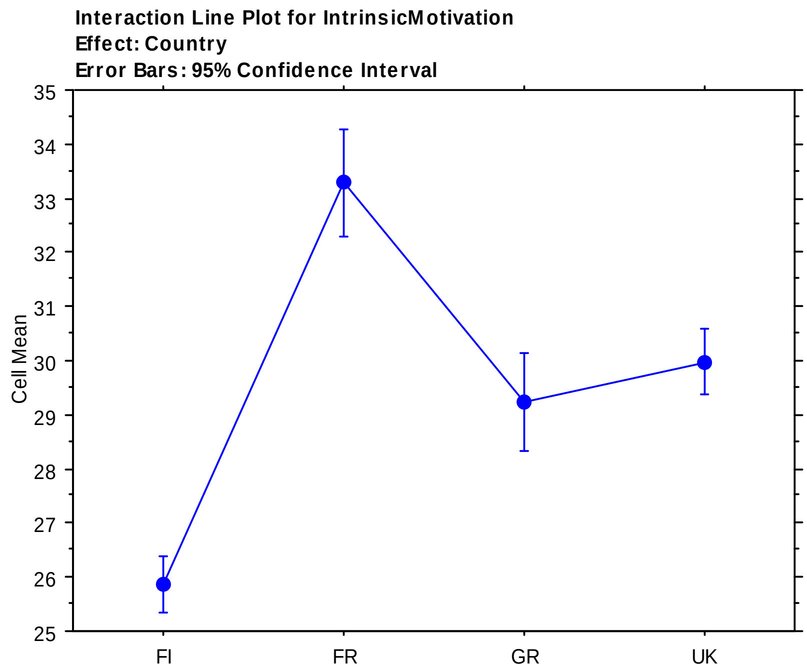
Country	**Topic**	**n (pupils)**	**age (years)**
Finland	Chemistry	313	12-13
Greece	Astronomy	181	11-12
UK	Climate change	216	12-13
France	Space science	116	11-12

3 Comparing motivation in four countries: France, Finland, Greece, UK

3.1 Intrinsic and instrumental motivation

As a background factor the motivational background of the pupils was measured in four countries. The school attending to this survey were not selected by randomised sample, but merely chosen from schools already deciding to come to visit the science centre. There were clear differences in the intrinsic motivation of the pupils in different countries as shown in the figure below:

Figure 3.1.1. Intrinsic motivation: comparing FR, FI, GR, and UK



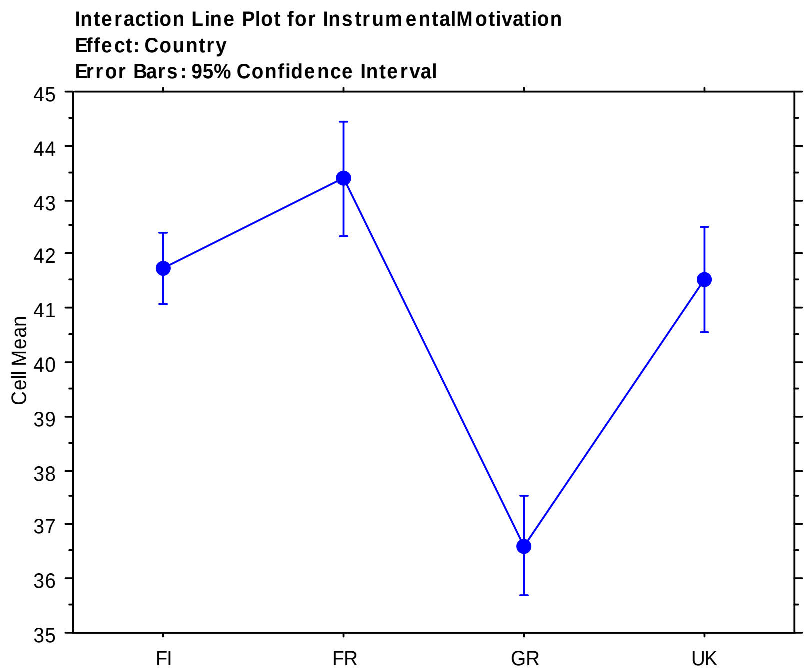
The intrinsic motivation level was lowest in Finland and highest in France, and the differences were statistically significant ($p < .05$) compared also the Greece and UK, which were at the same level.

Unpaired t-test for IntrinsicMotivation
Grouping Variable: Country
Hypothesized Difference = 0

	Mean Diff.	DF	t-Value	P-Value
FI, FR	-7,423	414	-13,779	<,0001
FI, GR	-3,355	469	-6,836	<,0001
FI, UK	-4,113	497	-10,006	<,0001
FR, GR	4,068	261	5,849	<,0001
FR, UK	3,310	289	6,007	<,0001
GR, UK	-,758	344	-1,424	,1554

Also the instrumental was measured as a pre-test in four countries. These results look different from intrinsic motivation as shown in the next figure:

Figure 3.1.2. Instrumental motivation: comparing FR, FI, GR, and UK



Again, the instrumental motivation was on the highest level among the pupils in France. The difference compared the results in to Finland, Greece, and UK was statistically significant ($p < .05$).
In this test the pupils in Greece had the lowest instrumental motivation, and now Finland and UK were practically on the same level.

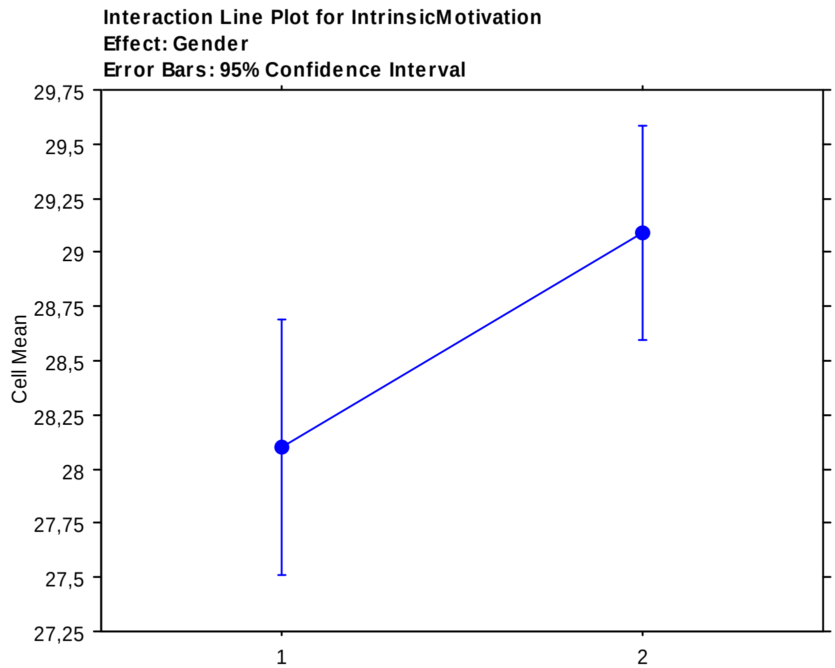
Unpaired t-test for InstrumentalMotivation
Grouping Variable: Country
Hypothesized Difference = 0

	Mean Diff.	DF	t-Value	P-Value
FI, FR	-1,648	413	-2,540	,0115
FI, GR	5,136	477	9,097	<,0001
FI, UK	,219	494	,382	,7027
FR, GR	6,784	268	9,345	<,0001
FR, UK	1,867	285	2,419	,0162
GR, UK	-4,917	349	-7,193	<,0001

3.2 Motivation and gender in four countries: France, Finland, Greece, and UK

According to the literature and earlier results the girls have more positive attitude towards the school, and also their motivation level is higher compared to the boys. This overall assumption was supported by the data collected from four European science centres' school visits as shown in the next figure:

Figure 3.2.1. Intrinsic motivation: gender

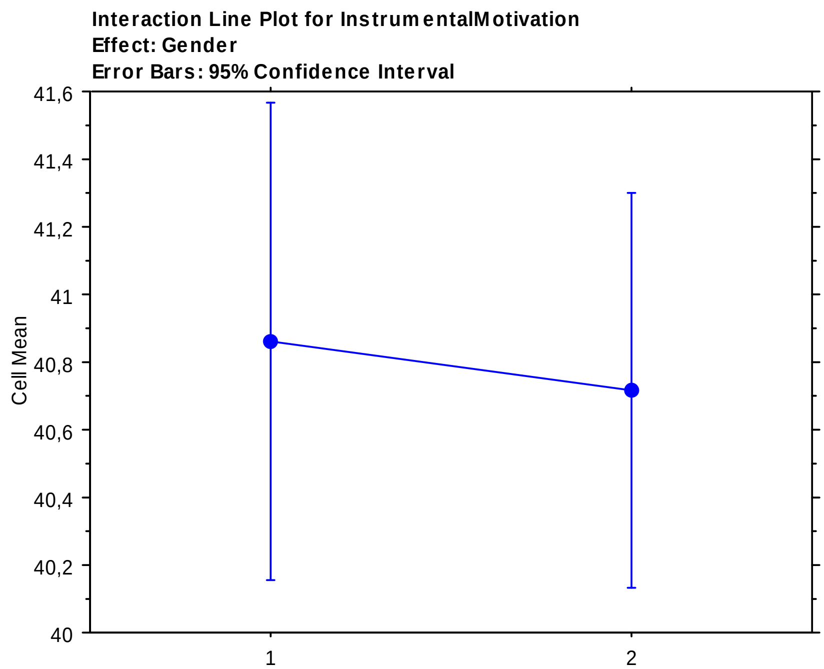


male *female*

The girls had clearly higher intrinsic motivation level than the boys.
The difference was statistically significant (p <.05).

Certain extrinsic elements like competing, earning salaries or avoiding punishments related to achievements very often create instrumental motivation for the boys. The pre-test results gave clear indication of that theoretical hypothesis in reality as shown in the next figure:

Figure 3.2.2. Instrumental motivation: gender



male *female*

There was practically no difference in the instrumental motivation level between the girls and boys measured in four countries. The instrumental motivation level of the boys explains why they have certain interest in school, and their total motivation does not collapse.

Typically, the intrinsic motivation level of the boys is higher at the younger age 5 to 11 years; as lowest at the age of fourteen; and starts to grow after that for example during the senior high school ages.

4 Case 1: Learning chemistry in laboratory at Heureka, Finland

The Children's' Laboratory of Heureka is located in the Cylinder Hall. The laboratory accommodates a maximum of 24 children, who work mainly in pairs under the supervision of a guide.

4.1 Test group and Control Groups

All the groups had similar pre-test a week before the process, and the similar post-test one week after the project.

The test group A had an internet-based pre-lesson about chemistry one week before the science centre visit; then they visited the science centre exhibition and its laboratory.
The control group B was learning chemistry in the science centre laboratory only (with no pre-lesson).
The control group C was learning chemistry only via internet at classroom-lesson (with no science centre laboratory visit).

Pre-test	**Web-site**	**Visit to centre**	**Post test**
6 classes	X	X	X
3 classes		X	X
3 classes	X		X

Design of the Study at Heureka (n:146 in test group; n:167 in control groups)

T1 = Pre-test

- Motivation test (20 items)
- Pre-Knowledge (23 items)
- School Success (grades given by the teacher (A- ; A ; A+)
- Visual Reasoning Ability (RAVEN; 60 items)
- IMI-test
- Semantic Differential (SD) pre test, 14 items

T2 = Post test

- Post-Knowledge test
- Semantic Differential (SD) post test (14 items)
- IMI-test: situation motivation (25 items)

4.2 Cognitive background

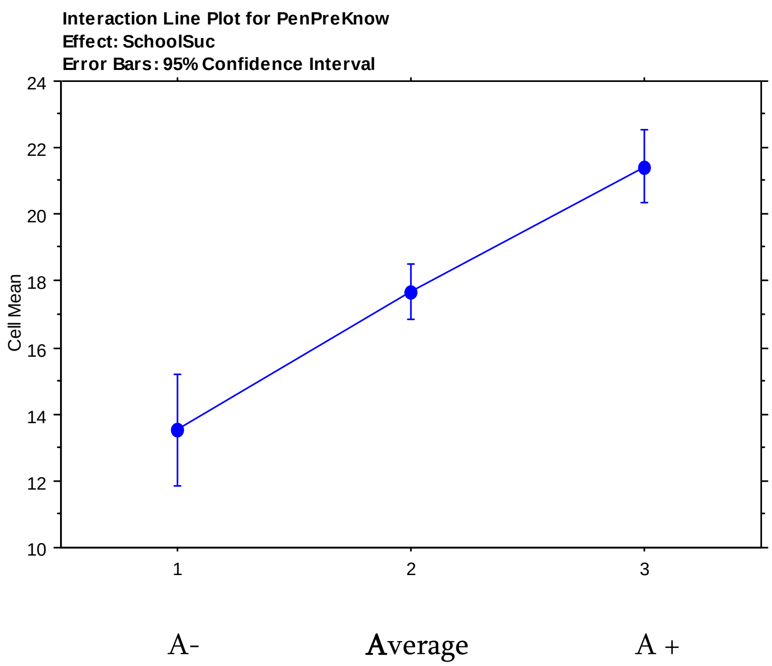
The teachers made an evaluation and grading of their pupils according their school success in following areas: science, mathematics, and mother language.

The pupils were defined in three categories:

A+ = above the average (25 % of the pupils)
A = average (50 % of the pupils)
A- = below the average (25 % of the pupils)

These categories (A; A-; A+) were utilised as background factors in the survey.

Figure 4.2.1. Teachers' grades vs. knowledge pre-test results



The teachers' grades correlated very strongly with the pre-results. The pupils who where above the average with their school grades, performed clearly better also in the pre-knowledge test; and the pupils who had average school success managed also clearly better in the test than the pupils below average.

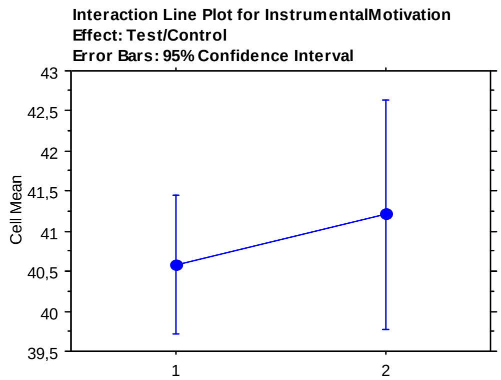
All these differences were statistically significant ($p < .05$).

The results indicate that the teachers know their pupils very well: the independent knowledge test was confirming the evaluation at school.

4.3 Motivational background

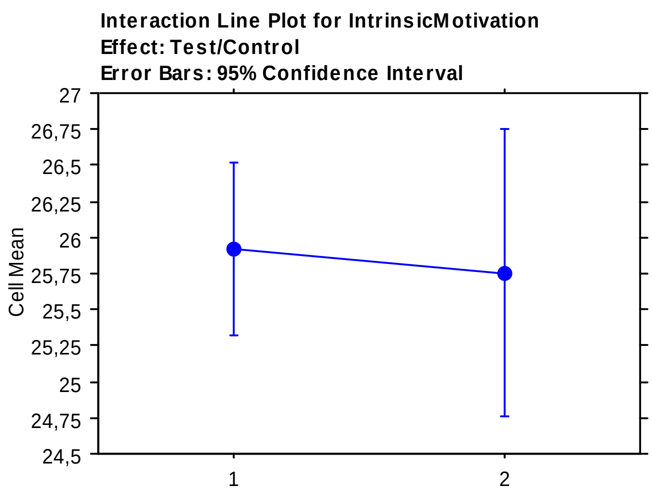
It was important to check the background level of the motivation of the pupils in different schools and classes before the intervention by pre-lessons, web-learning, and the science centre laboratory visit.

Figure 4.3.1. Instrumental motivation: test vs. control groups



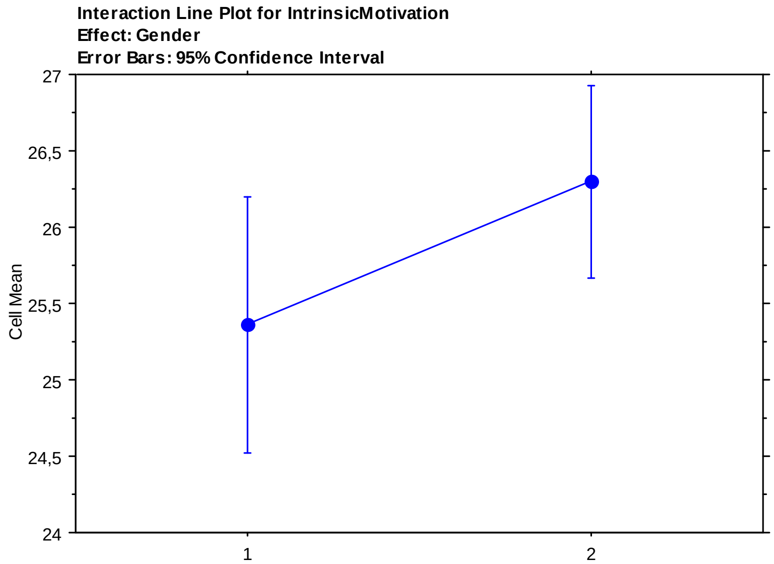
The instrumental motivation background of the groups was homogenous. There was no statistically significant ($p < .05$) difference in instrumental motivation level between the test group and the control groups (see figure above).

Figure 4.3.2. Intrinsic motivation: test vs. control groups



Also the intrinsic motivation level was same both in the test and control groups.

Figure 4.3.3. Intrinsic Motivation: gender

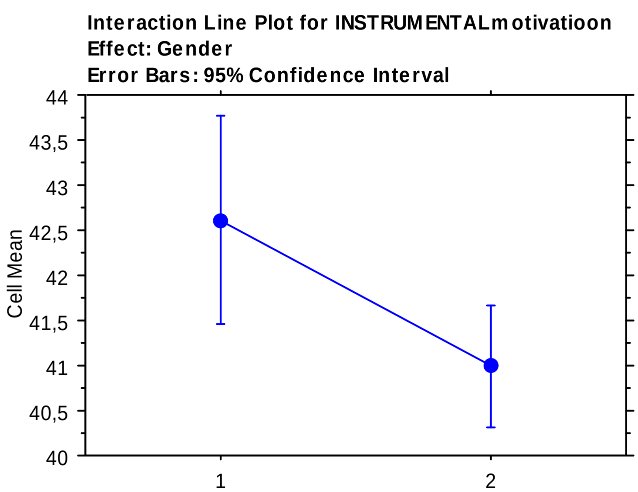


male female

Girls had higher level of intrinsic motivation than boys. However, the difference was not statistically significant ($p > .05$).

According the literature and several other earlier findings, this is typical phenomenon at this age: girls seem to have more own interest in learning and see it more meaningful.

Figure 4.3.4. Instrumental Motivation: gender



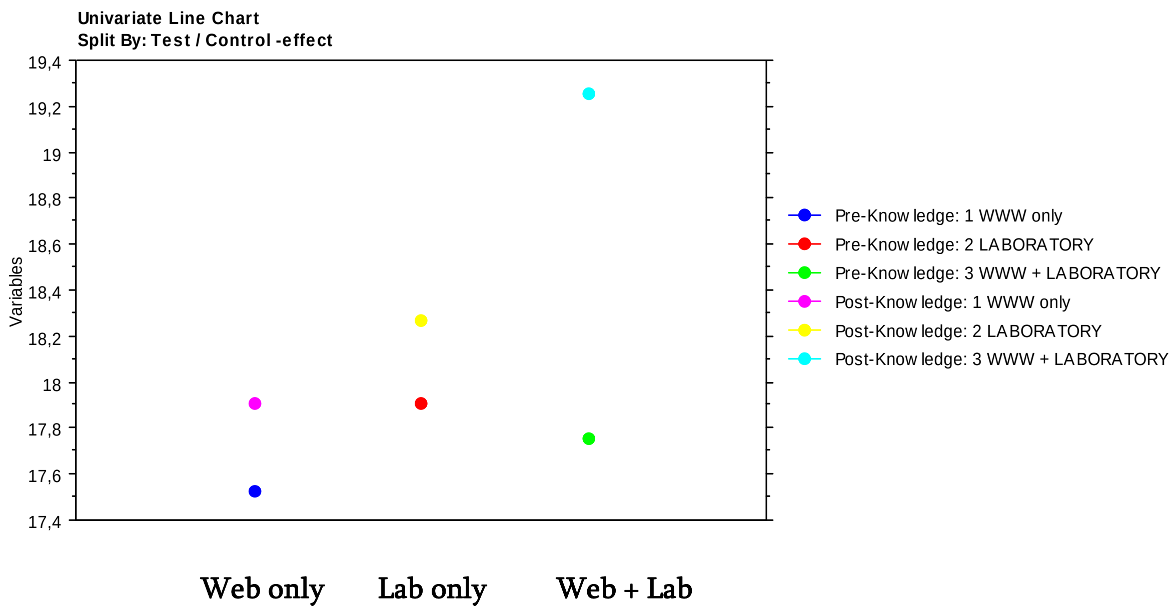
male female

The boys had much higher instrumental motivation level than the girls. The gender difference is clear and statistically significant p < .05). This result gets also support from the earlier studies: boys tend to be more instrumental motivated: the outer factor, salaries, and competition is important motivating effects for the boys at this age specially.

4.4 Pre- and Post-Knowledge

The main result is – like in many teaching trials with intervention – that they all do learn!

Figure 4.4.1. Learning chemistry: pre and post knowledge test by test and control groups

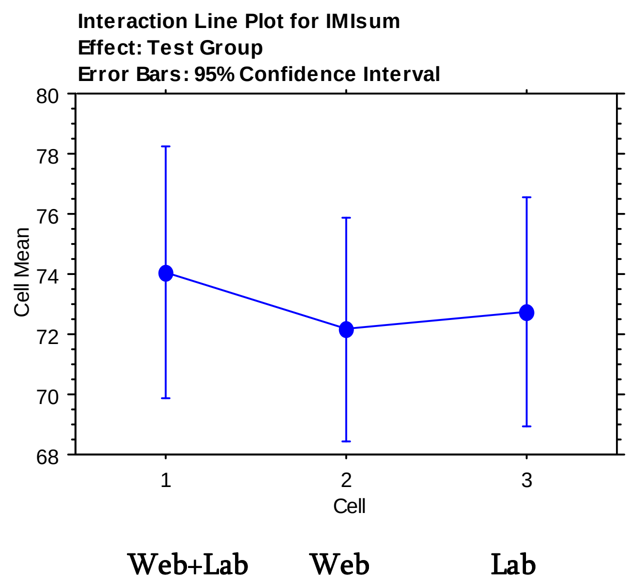


While analysing the results more carefully, it turns out that the pupils at the age of twelve years do learn only slightly better at science centre laboratory than the comparison group at school classroom by similar web-based activities. However, the cognitive learning results related to chemistry became much better *only if* the pupils had a pre- and post-lesson at school. This difference was statistically significant (p < .05).

4.5 Post-Motivation

The pupils who attended both the Web and the science centre Laboratory learning were slightly more motivated than pupils with either Web-based activities only or Laboratory learning only (as show in the next figure).

Figure 4.5.1. IMI-post test situation motivation

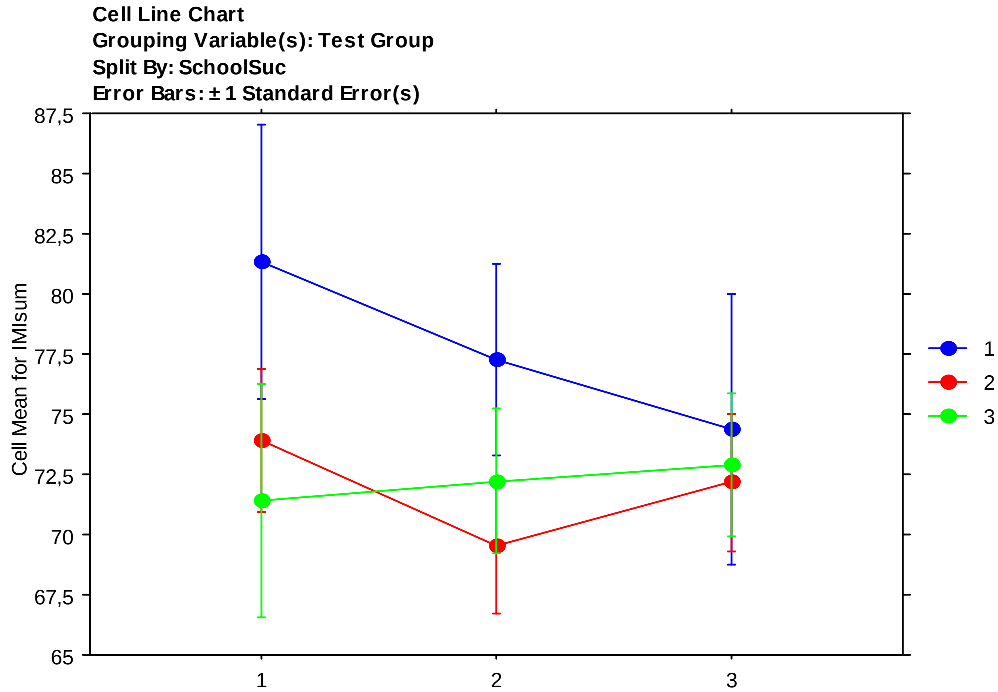


One obvious explanation is that all these activities were new and attractive for the pupils, and the overall situation motivation measured by the IMI-motivation instrument was showing comparatively high values, i.e. the pupils really did like these learning activities. However, the difference was not statistically significant between any of the groups ($p > .05$).

4.6 Post-Motivation and school success: comparison of test and control groups

According to the literature and some earlier results, the pupils who already are “good” at school also get most motivated at the science centre exhibitions. As an explanation, several reasons have been suggested: 1. the science centres are more “academically” orientated; 2. the exhibitions are planned in the way that certain amount of cognitive, pre-knowledge is needed to understand the message; and 3. the teachers are encouraging more the pupils already interested in science. However, the results of this survey gave now different results (as shown in the next figure):

Figure 4.6.2. Post motivation vs. school success



A- **Average** **A +**

Blue 1 = web + exhibition visit ; Red 2 = exhibition visit only; Green 3 = web only

The pupils attending both the web-based pre-lesson and the science centre laboratory were most motivated in all the groups after the project (see the blue line above).

It is also remarkable that in the group visiting only the exhibition (the red line) the pupils below average (A-) had higher motivation that the others – especially compared to average group (A). However, the web based activities were found a bit more motivating by the pupils above average in school success (A+).

The combination of Web + Science Centre Laboratory motivated especially pupils below average (**A-),** and the average school success group (**A**). The difference of the motivation level of these pupils was statistically significant ($p < .05$) compared to the pupils having *web-only* or *visit only*. This difference was not so clear among the pupils managing above average (**A+**) at school.

5 Case 2: Learning astronomy in Cite de l’espace in Toulouse, France

Astronomy – meaning at first stars, moon, sun and space – is rather popular topic among young pupils at school. Recently, as a consequence of urban life style, people have less empirical “alive” experience of the night sky and stars. This has made the planetarium even more interesting and attractive among the students, although the students now are lacking some own direct and basic knowledge about the topic.

5.1 Test groups

The second survey took place Cite de l’espace in Toulouse, France. The pupils (n: 118) visited the planetarium and the science centre exhibition.

All the school classes had similar internet-based pre-lesson about astronomy one week before the science centre visit. Then they visited the science centre exhibition and its planetarium. The post-tests were administrated one week after the visit.

The focus on the study in Toulouse was to show the link between motivation and visual experience in the planetarium with supporting effect of the exhibition.

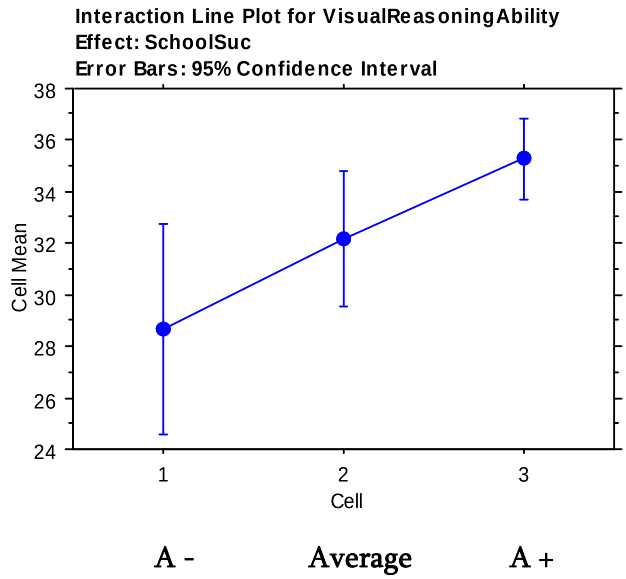
5.2 School Success and Visual Reasoning Ability (VRA)

The teachers made an evaluation and grading of their pupils’ school success in following areas: science, mathematics, and mother language. The pupils were defined in three categories:

A+ = above the average (25 % of the pupils)
A = average (50 % of the pupils)
A- = below the average (25 % of the pupils)

These categories (A; A-; A+) were utilised as background factors in the survey.

Figure 5.2. Teachers' grades vs. Visual Reasoning Ability (VRA)



The results show clear trend between the teachers' ratings of their pupils' school success and the independent VRA-test: the better the pupils manage in VRA-test, the better they manage at school.

Unpaired t-test for VisualReasoningAbility
Grouping Variable: SchoolSuc
Hypothesized Difference = 0

	Mean Diff.	DF	t-Value	P-Value
1, 2	-3,472	59	-1,529	,1317
1, 3	-6,589	68	-3,740	,0004
2, 3	-3,117	85	-2,137	,0355

The difference was statistically significant ($p < .05$) between the above average (A+) and other groups, but not statistically significant ($p > .05$) between A– and A groups.

5.3 Learning Astronomy and Space Science: comparing school and science centre

The standard SD-Semantic Differential Test was measuring the attitudes of the students: How meaningful is the learning process for them? In addition, they are comparing the way the same topic or phenomenon is taught at school and in open learning environment like a science centre.

According the SD-test, the pupils felt the learning of astronomy in exhibition and planetarium environments more positive pedagogical experience than learning at school. The difference was statistically significant ($p < .05$).

Paired t-test
Hypothesized Difference = 0

	Mean Diff.	DF	t-Value	P-Value
SumSDpre, SumSDpost	-2,402	96	-3,375	,0011

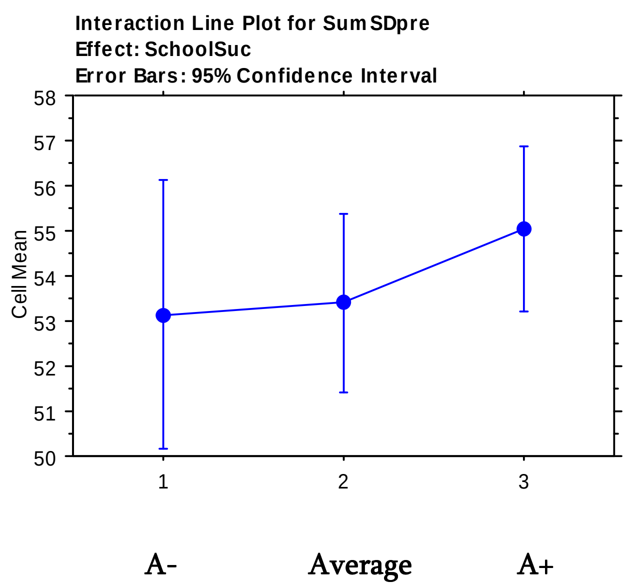
Planetarium is a strong visual media and it gives besides the emotional experience also easily adopted basic facts about the sky and space.

This is also strongly related to the situation motivation found in the post-test.

5.4 School success and attitude towards classroom science education

Most often the pupils who are managing well at school also like their lessons more. This was also the case in the French data of pupils (see figure below):

Figure 5.4. School success vs. meaningfulness of classroom science education

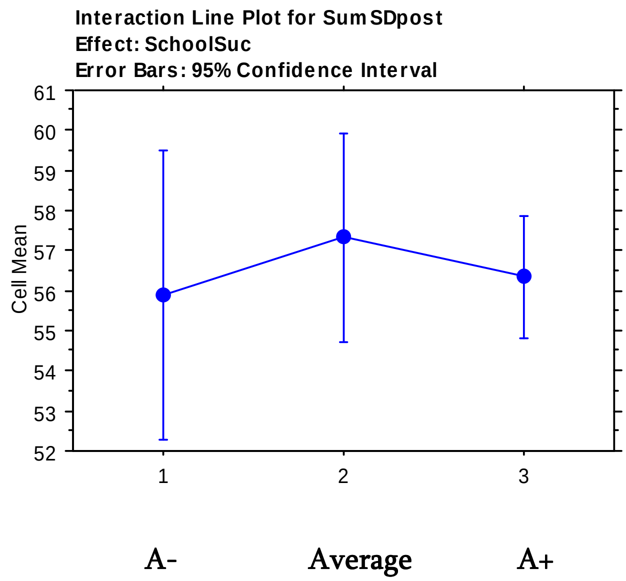


The pupils in the A+ group did like their science lessons more and felt it meaningful. However, the difference was not statistically significant. It is also remarkable that the variation in the below average (A-) group was bigger than in the other groups.

5.5 School success and attitude towards learning in science centre

According to the literature and most of the earlier finding in the science centre exhibitions these open learning environments tend to feed the learning process of the pupils who already are managing well at school. However, the results from the planetarium and exhibition of Cité de l'espace were somewhat different in this sense (see figure below):

Figure 5.4. School success vs. meaningfulness of classroom science education



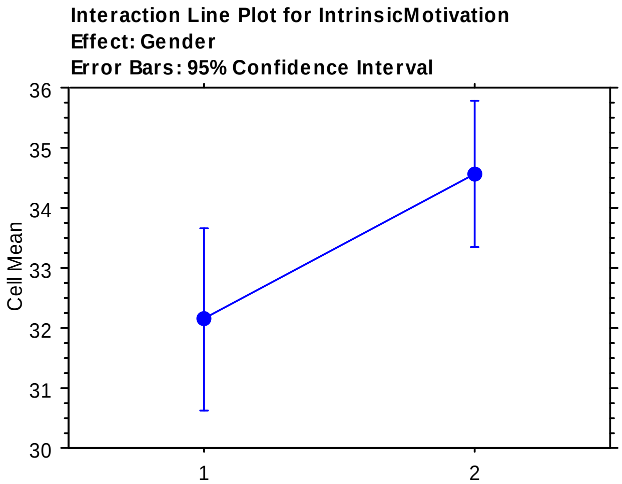
The SD-test shows that all the groups experienced the planetarium as a meaningful and motivating learning experience. The effect was strongest in the group A, and slightly stronger effect in group A- than in A+ (as can be noticed from the next table):

School success	SD-pre	SD-post
A-	53,14	55,57
A	53,41	57,32
A+	55,04	56,34

5.6 Motivation background: intrinsic, instrumental, and situation motivation

The intrinsic motivation of the pupils in France was at average level before the test period.

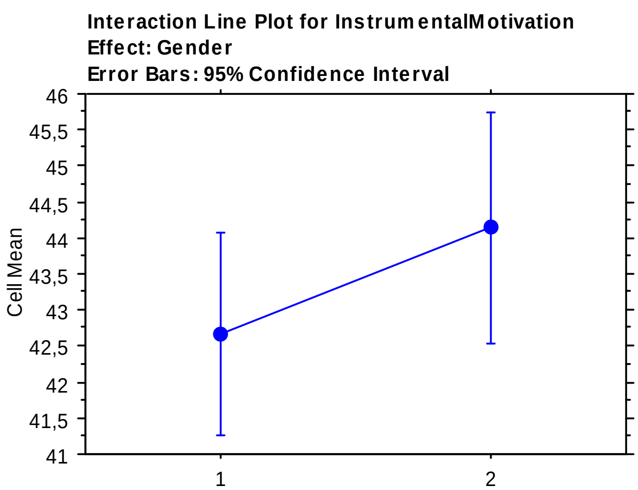
Figure 5.6.1. Intrinsic motivation: gender



male female

The data in France was similar as in Finland: the girls at the age of 13 years have clearly higher intrinsic motivation to learn. The difference was statistically significant ($p<.05$).

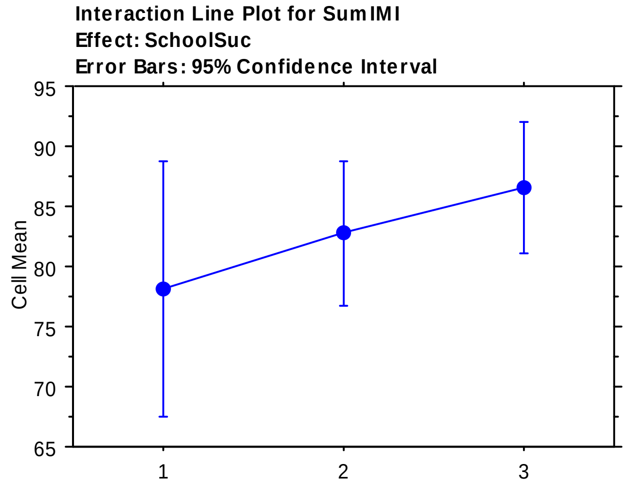
Figure 5.6.2. Instrumental motivation: gender



male female

However, the gender difference in instrumental motivation was different compared to earlier findings: the girls had also higher instrumental motivation level than the boys.
The new environment with strong stimulus and impulse easily and nearly automatically create strong situation motivation. This happened also during the planetarium visit (see next figure):

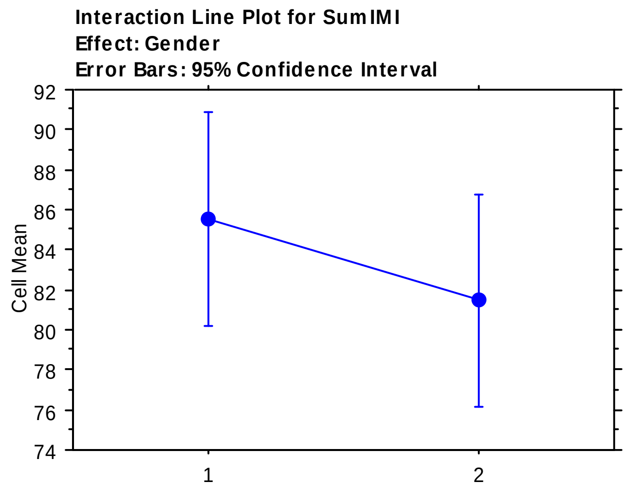
Figure 5.6.3. Situation motivation: school success



A- Average A+

All the pupils get the high level situation motivation according the IMI-test. The classes were homogenous in this sense, and no statistically significant differences were found according the different background of the pupils in their school success.

Figure 5.6.4. Situation motivation: gender



male female

The situation motivation was on higher level among the boys than the girls.

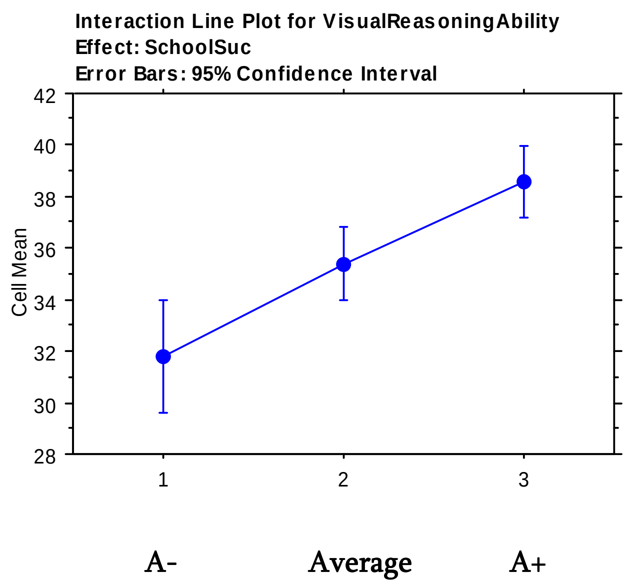
6 Case 3: Hands-on science in the Observatory of EA, Greece

The astronomy part took place in Greece, at Ellinogermaniki Agogi School facilities.
The school has several advantaged science education demonstrations and equipments. The observatory with a real telescope is combining formal and informal education. In the PENCIL motivation survey the observatory was tested by 181 pupils with the focus on motivation.

6.1 Cognitive background

The results of the VSA-Visual Reasoning Ability (RAVEN) test in Greece were very much alike the results in Finland, France and UK. The grades given by the teachers evaluating their students' school success correlated clearly with the points the students did achieve in the VSA-test (see the next figure):

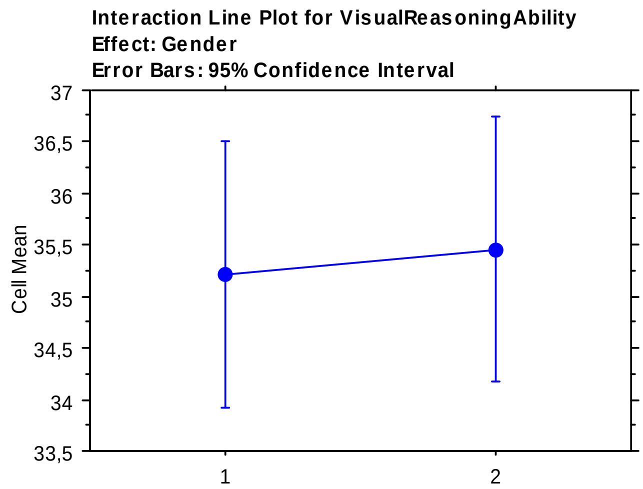
Figure 6.1.1. Visual Reasoning Ability vs. School Success



The better scores the pupils received in VRA-test, the better they manage at school. This test indicates well the level of the cognitive tasks the students can manage. The results also show clearly that the teachers do know their students very well: the results of the teacher evaluation and RAVEN-test are very much in uniform.

VRA-test was utilised in this European survey, because it is not giving the favour to the boys as many other technically orientated measurement instruments do.

Figure 6.1.2. Visual Reasoning Ability vs. Gender



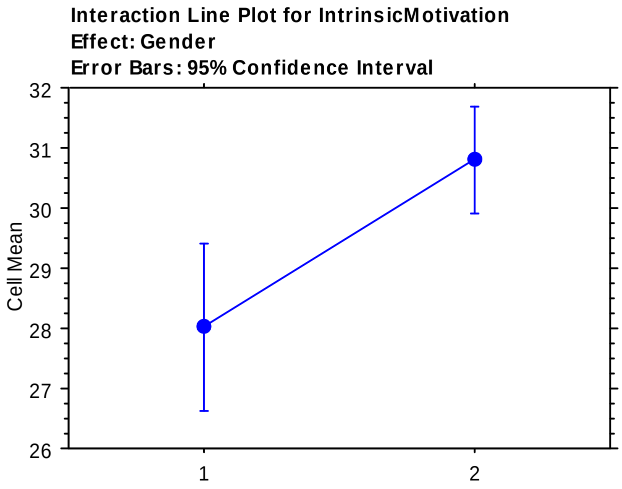
male *female*

The results between girls and boys were extremely the same; practically no gender differences in visual reasoning ability were found.

6.2 Motivational background

As a pre-test, the pupils made the standard intrinsic motivation test (see figure below).

Figure 6.2.1. Intrinsic Motivation



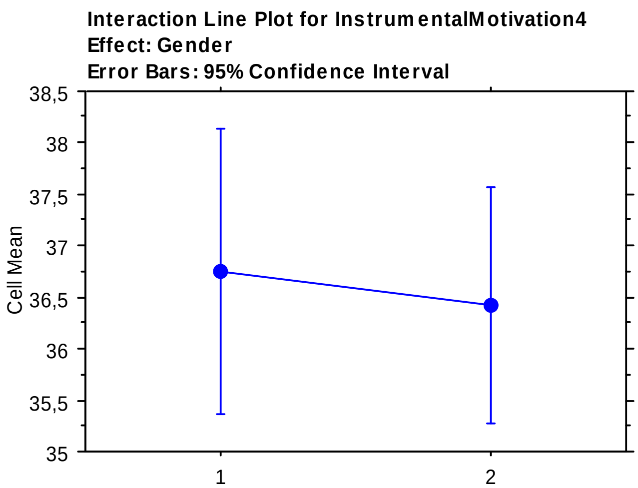
male female

The results resembled a lot the data in Finland and France: the girls at this age (13 years) have much stronger intrinsic motivation level than the boys.

The difference was statistically significant ($p < .05$).

As a pre-test, the pupils made also the standard instrumental motivation test (see figure below).

Figure 6.2.2. Instrumental Motivation



male female

Here, the results resembled – again - the data in Finland, but not the data collected from France and UK. Typically, the boys had slightly higher instrumental motivation level than the girls. However, the difference was very small and not statistically significant ($p > .05$).

The results indicate that the boys are often motivated either by salary-punishment type of achievement motivation; or inspired by the competitive element of the learning process.

6.3 Learning astronomy: comparing classroom and open learning environment

Astronomy – meaning at first stars, moon, sun and space – is rather popular topic among young pupils at school. Recently, as a consequence of urban life style, people have less and less direct experience of the night sky and stars.

The standard SD-Semantic Differential Test was measuring the attitudes of the students: How meaningful is the learning process for them? In addition, they are comparing the way the same topic or phenomenon is taught at school and in open learning environment like a science centre.

According the Semantic Differential (SD) test, the pupils felt the learning of astronomy in the observatory by the help of telescope more positive pedagogical experience than learning at school.

	SDpre	SDpost
Mean	42,908	44,704
Std. Deviation	3,701	3,827
Std. Error	,300	,310
Coeff. of Variation	13,700	14,647

The difference was statistically significant ($p < .05$) as seen below:

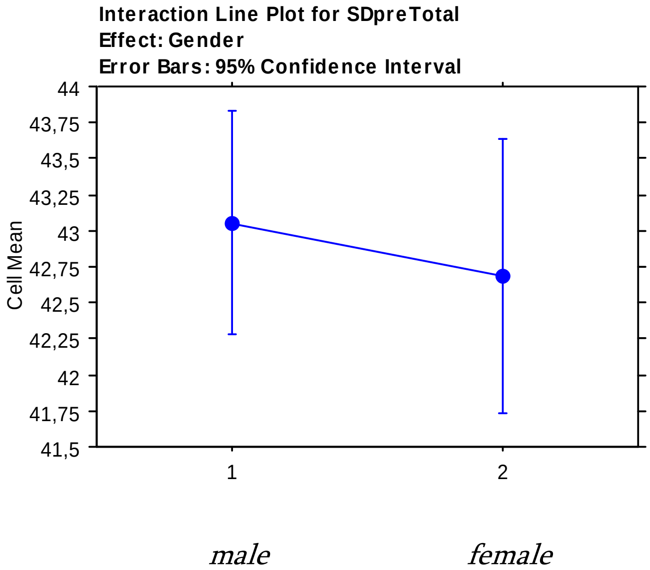
Paired t-test
Hypothesized Difference = 0

	Mean Diff.	DF	t-Value	P-Value
SDpreTotal, SDpostTotal	-1,796	151	-4,076	<,0001

The modern telescope gives an enormous visual experience for example from the Moon. However, it became evident that the pupils get also more intrinsically motivated. They were interested about the cognitive content, and also the technology itself: how it is possible to see so far and observe remote objects.

6.3.1 Meaningful science education in classroom: gender

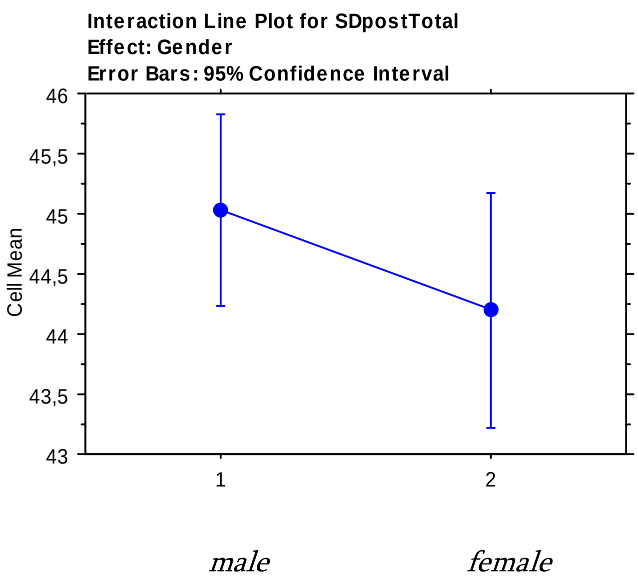
Most often, girls tend to give more positive feed-back concerning the value of classroom education, and their attitude towards school tend to be more respectful. However, in the data from Greece did not support this hypothesis as seen from the figure below:



The boys felt the science education in formal classroom slightly more meaningful than the girls. This gender difference was not statistically significant ($p > .05$).

6.3.2 Meaningful science education in observatory: gender

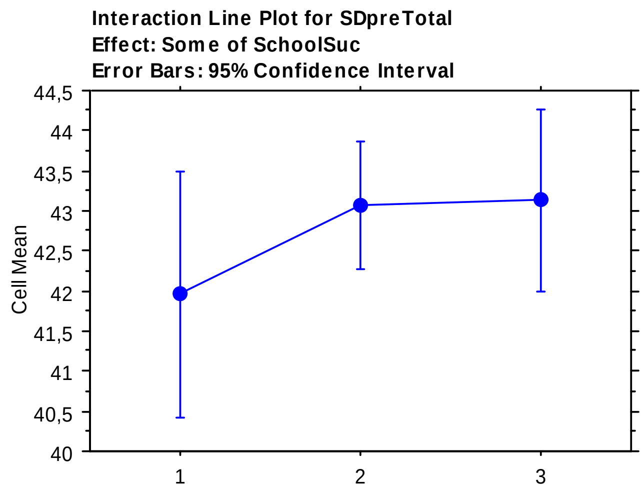
At this age (13-14 years) physics and technology tends to start to become more favourable for boys. The observatory and telescope was not most "techno" phenomenon, but the boys liked it a bit more than girls (as seen from figure below):



However, the gender difference was not statistically significant ($p > .05$). Very often the aesthetic and visual component of astronomy and stars get girls interested about the topic.

6.3.3 Meaningful science education in classroom: school success

The overall trend and dilemma of formal education is that the pupils who manage well at school also like it more – or dislike it less. This was the case also according the data from Greece (see figure below):

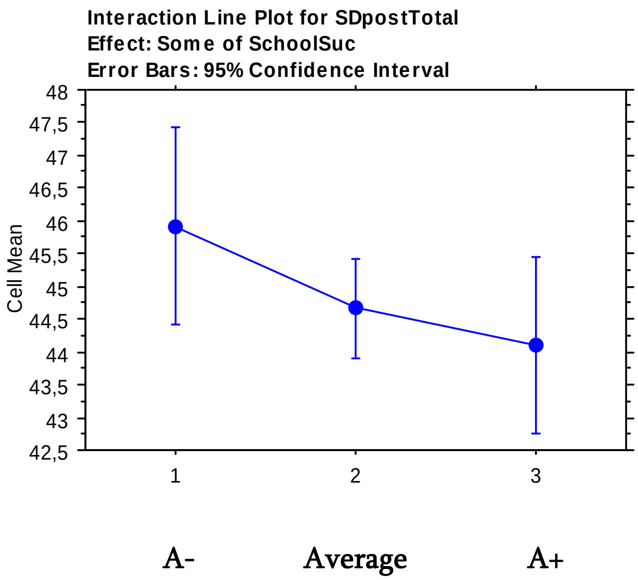


A-　　　Average　　　A+

Especially the pupils (group A-) who are not receiving good grades at school did not feel the learning process as positive as the others. It is also very typical that the above average (group A+) students can be critical towards the school education. Now they were in the same level as the
group A. However, the differences between the groups were not statistically significant.

6.3.4 Meaningful education in observatory: school success

According to the literature and many previous results science centres, exhibitions and other open learning environments are motivating setting for all the learners, but very often these places turn out to be more favourable and interesting for the pupils who manage well at school. In this sense the data from Greece was different, and resembling the results from Finland.



The pupils (group A-) who were not receiving very good grades at school felt the observatory visit and hands-on learning by telescope more meaningful and motivating than the others. The most probable reason for this is that they felt to understand and learn new things.

7 Case 4: Learning climate change in NMA, Plymouth, UK

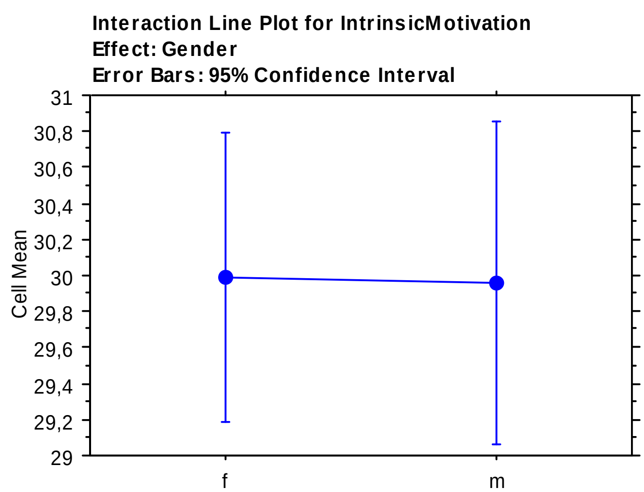
The National Marine Aquarium created for The Pencil Project "Climate Lab" which consisted of web-site, science centre exhibition, and the aquarium. The content was dealing with the topic of climate change, ecology, and biology. It gave an opportunity for the target group (students between 9-15 years from ten local schools) to investigate marine issues with climate change.

The students (n: 216) attending the survey were at the age of twelve to thirteen years.

7.1 Motivational background: intrinsic, instrumental, and situation motivation

The level of the intrinsic motivation in UK data was on the same standard level compared to other countries.

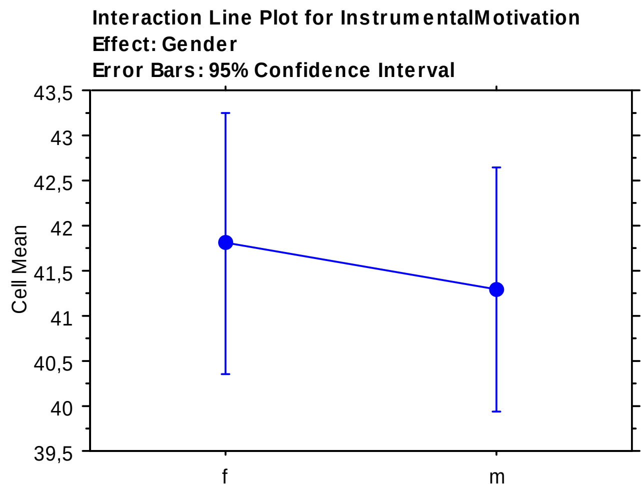
Figure 7.1.1. Intrinsic motivation: gender



The interesting result is that the boys had exactly the same intrinsic motivation level as the girls. This result conflicted with the results in all the other countries (Finland, France, and Greece).

The motivational patters of the pupils in the UK data differed from the other countries in an interesting way as the results of the instrumental motivation test show in figure below:

Figure 7.1.2. Instrumental motivation

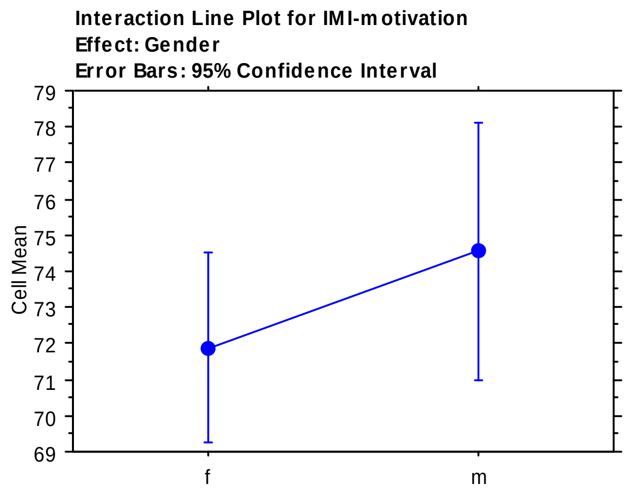


Here, the girls had slightly higher instrumental motivation than the boys. However, the difference is not statistically significant ($p > .05$), were practically on the same level. The results resemble the data from Greece.

In Finland the boys had clearly higher level instrumental motivation. The data from France made an exception from the others: the girls were on high instrumental motivation level.

One week after the visit the students clearly remembered and recognized the motivating effects of the visit (see the figure below).

Figure 7.1.3. Situation motivation



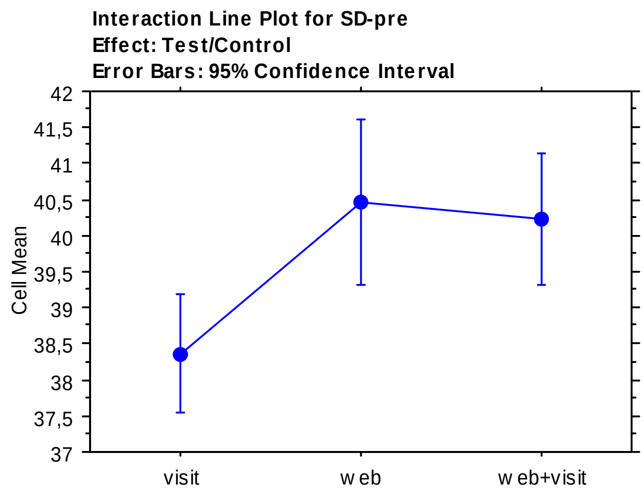
The boys had higher situation motivation level after the visit, but the gender difference was not statistically significant (p >.05). The result correlated clearly the pre-motivation stage of boys and girls.

7.2 Learning about climate change: comparing school and aquarium/science centre

The standard SD-Semantic Differential Test was measuring the attitudes of the students: How meaningful is the learning process for them? In addition, they are comparing the way the same topic or phenomenon is taught at school and in open learning environment like a science centre.

According the Semantic Differential (SD) test, the pupils felt the learning about climate change at school was rather motivating topic.

7.2.1 Meaningful science education in classroom: test vs. control croups



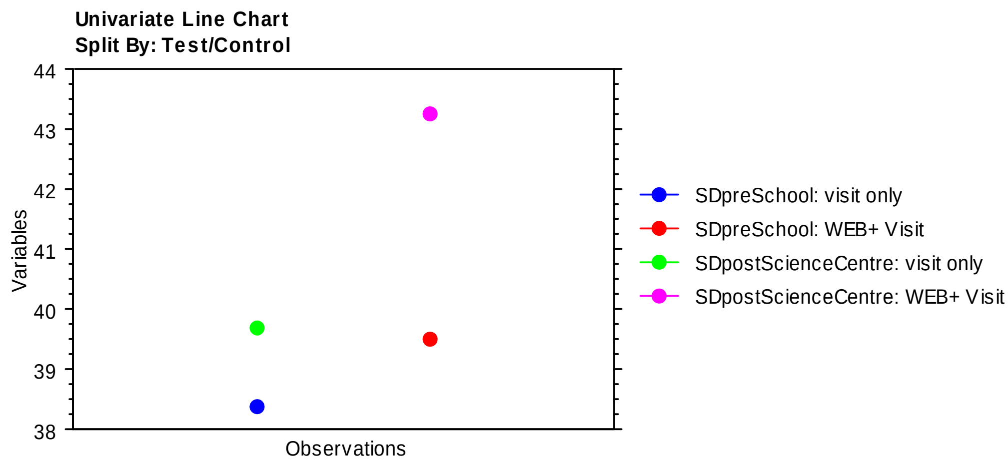
The groups were not similar and homogenous between each other. The start level of the group 1 (visit only) was lower than the other groups before the process. The difference was statistically significant (p <. 05) as can be seen from the figure below. This might tell about different educational culture in different schools in the area.

7.2.2 Meaningful science education in aquarium-science centre: test vs. control groups

Both of the groups *("visit only*" and *"web + visit")* experienced the climate change entity as meaningful learning experience.

According the results of SD-test the pupils felt the science centre visit clearly more meaningful experience than learning the topic at school. The difference was statistically significant: $p = .0045$ in the "Visit only group" and $p < .001$ in the "web + visit" group.

According the results of SD-test the pupils felt the science centre visit clearly more meaningful experience than learning the topic at school. The difference was statistically significant: $p = .0045$ in the "Visit only group" and $p < .001$ in the "web + visit" group.



According the results of SD-test the pupils felt the science centre visit clearly more meaningful experience than learning the topic at school. The difference was statistically significant in both of the groups which visited the science centre: $p = .0045$ in the "Visit only group" and $p < .001$ in the "web + visit" group.

	visit only		web + visit	
	SD-school	SD-science centre	SD-school	SD-science centre
Mean	38,362	39,672	39,489	43,261
Std.Deviation	3,391	3,496	3,647	3,744
Std. Error	,408	,459	,544	,552
Variance	11,499	12,224	13,301	14,019

8 Conclusion

The conclusions based on the four case studies presented in this report strongly indicate the following results:

1. Preparing properly for the visit in forehand at school turned out to be the key element both for the motivation and cognitive knowledge learning.
2. Main effects were found in motivation. All the pupils got strong situation motivation during their science centre visits, but the best results were received among the pupils having also the pre-lesson before the visit.
3. The cognitive and knowledge learning of the pupils visiting the science centre was only slightly better than the comparison group at school classroom or by similar web-based activities. However, the cognitive learning results related to chemistry became much better *only if* the pupils had a pre- and post-lesson at school.
4. The pupils who manage well at school also feel the classroom science education more positively than the others. However, science centres seem to give new challenges also for "non-academically" orientated students, who can utilise their personal learning strategies. The results especially in Greece and Finland showed that the pupils below average (A-) in their school success according experienced the visit most as a meaningful learning experience.
5. The girls had stronger intrinsic motivation, and the boys had higher level in instrumental motivation (with exception the results in UK).
6. In all the four countries, the school success classified according the teachers grades and the results measured by the independent Visual and Cognitive Reasoning Ability –test (RAVEN) showed clear, statistically significant ($p < .05$) correlation. This was important for the reliability and validity of the survey. Also, this visual test was similar in all attending four countries, and the due to its nature with figures no translations/localisations were needed.

Can we take advantage of the motivating effects of science centres? This is the question several informal learning institutes in Europe are facing. The main challenge is can the educational programmes of the science centres enhance the strong situation motivation into real interest into the science as intrinsic motivation. Hands-on pre- and post-materials are the key tool in this process both for cognitive knowledge learning and motivation. Only intrinsic motivation combined with deep-learning strategy can lead into long-term learning results.

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Annex A. Motivation Test for PENCIL Evaluation

No. M / F
School: Class:

Motivation Test for PENCIL Evaluation.

For each statement choose and tick one of the 5 options.
1 = Strongly agree
2 = Agree
3 = Agree a bit
4 = Disagree
5 = Strongly Disagree

1. Learning gives me pleasure 1.☐ 2.☐ 3.☐ 4.☐ 5.☐

2. I want to show the others that even I am good at something.
1.☐ 2.☐ 3.☐ 4.☐ 5.☐

3. The best reward for my achievements Is my parent's joy.
1.☐ 2.☐ 3.☐ 4.☐ 5.☐

4. We ought to be grateful that we are able to go to school.
1.☐ 2.☐ 3.☐ 4.☐ 5.☐

5. At school, I always try to get good grades.
1.☐ 2.☐ 3.☐ 4.☐ 5.☐

6. I do tasks – even difficult ones – eagerly when I know they are useful for my studies.
1.☐ 2.☐ 3.☐ 4.☐ 5.☐

7. I want to learn a lot about different things.
1.☐ 2.☐ 3.☐ 4.☐ 5.☐

8. I behave myself at school because I am afraid of being punished.
1.☐ 2.☐ 3.☐ 4.☐ 5.☐

9. I am ready to work to make the lessons more interesting.
1.☐ 2.☐ 3.☐ 4.☐ 5.☐

10. When I fail, I easily get depressed and think that I'm no good for anything.
1.☐ 2.☐ 3.☐ 4.☐ 5.☐

11. I would work hard at school if I was better rewarded for my achievement.
1.☐ 2.☐ 3.☐ 4.☐ 5.☐

12. I often have a bad conscience about not using my opportunity of studying at school better 1.☐ 2.☐ 3.☐ 4.☐ 5.☐

13. I think it important that my teachers appreciate me and the work I do.
1.☐ 2.☐ 3.☐ 4.☐ 5.☐

14. It is important that we, the whole class, work together so that even the weakest pupils keep up with the others.
1.☐ 2.☐ 3.☐ 4.☐ 5.☐

15. I'm often afraid of failing in my school work.
1.☐ 2.☐ 3.☐ 4.☐ 5.☐

16. I try to work hard at school, because my parents expect me to do well.
1.☐ 2.☐ 3.☐ 4.☐ 5.☐

17. I try to do my homework with the least effort and as quickly as possible.
1.☐ 2.☐ 3.☐ 4.☐ 5.☐

18. I go to school because I have to.
1.☐ 2.☐ 3.☐ 4.☐ 5.☐

19. I believe I can reach the goals I have set myself.
1.☐ 2.☐ 3.☐ 4.☐ 5.☐

20. I would like to do extra home work, if the content of learning is interesting.
1.☐ 2.☐ 3.☐ 4.☐ 5.☐

Annex B. Situational Motivation Test for PENCIL Evaluation

pencil

No. M / F
School: Class:

Situational Motivation Test for PENCIL Evaluation.

For each statement choose and tick one of the 5 options.
1 = Strongly agree
2 = Agree
3 = Agree a bit
4 = Disagree
5 = Strongly Disagree

1. After working at this activity for a while, I felt pretty competent.
1.☐ 2.☐ 3.☐ 4.☐ 5.☐

2. I am satisfied with my performance at this task.
1.☐ 2.☐ 3.☐ 4.☐ 5.☐

3. I think I am pretty good at this activity.
1.☐ 2.☐ 3.☐ 4.☐ 5.☐

4. I was pretty skilled at this activity.
1.☐ 2.☐ 3.☐ 4.☐ 5.☐

5. This was an activity that I couldn't do very well.
1.☐ 2.☐ 3.☐ 4.☐ 5.☐

6. I think I did pretty well at this activity, compared to other students.
1.☐ 2.☐ 3.☐ 4.☐ 5.☐

7. I didn't put much energy into this.
1.☐ 2.☐ 3.☐ 4.☐ 5.☐

8. I didn't try very hard to do well at this activity.
1.☐ 2.☐ 3.☐ 4.☐ 5.☐

9. I put a lot of effort into this.
1.☐ 2.☐ 3.☐ 4.☐ 5.☐

10. It was important to me to do well at this task.
1.☐ 2.☐ 3.☐ 4.☐ 5.☐

11. I tried very hard on this activity.
1.☐ 2.☐ 3.☐ 4.☐ 5.☐

12. I thought this was a boring activity.
1.☐ 2.☐ 3.☐ 4.☐ 5.☐

13. This activity did not hold my attention at all.
1.☐ 2.☐ 3.☐ 4.☐ 5.☐

14. I enjoyed doing this activity very much.
1.☐ 2.☐ 3.☐ 4.☐ 5.☐

15. This activity was fun to do.
1.☐ 2.☐ 3.☐ 4.☐ 5.☐

16. While I was doing this activity, I was thinking about how much I enjoyed it.
1.☐ 2.☐ 3.☐ 4.☐ 5.☐

17. I thought this activity was quite enjoyable.
1.☐ 2.☐ 3.☐ 4.☐ 5.☐

18. I would describe this activity as very interesting.
1.☐ 2.☐ 3.☐ 4.☐ 5.☐

19. I believe this activity could be of some value to me.
1.☐ 2.☐ 3.☐ 4.☐ 5.☐

20. I think that doing this activity is useful for learning about science and technology.
1.☐ 2.☐ 3.☐ 4.☐ 5.☐

21. I think this is important to do because it can improve my skills.

1.☐ 2.☐ 3.☐ 4.☐ 5.☐

22. I would be willing to do this again because it has some value to me.

1.☐ 2.☐ 3.☐ 4.☐ 5.☐

23. I think doing this activity could help me to learn quicker than using other media.
1.☐ 2.☐ 3.☐ 4.☐ 5.☐

24. I believe doing this activity could be beneficial to me.
1.☐ 2.☐ 3.☐ 4.☐ 5.☐

25. I think this is an important activity.
1.☐ 2.☐ 3.☐ 4.☐ 5.☐

Annex C. Semantic Differential test

Pre visit version:

Below are descriptive pair of words relating to “studying science in my class”.
The words in every pair are opposite in their meaning. Please mark an X in one of the squares between the words that mostly expresses your attitude towards the two words.

Studying science in my class has been:

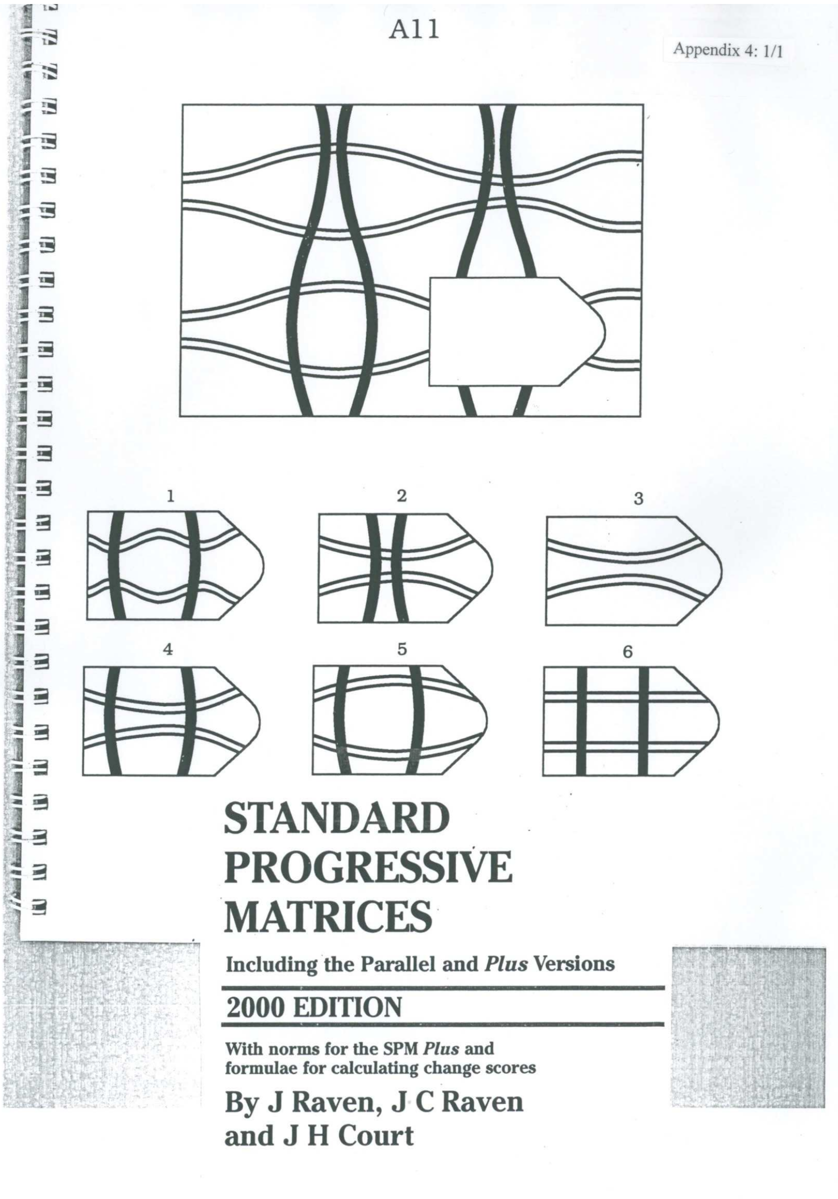
Important						Not important
Not clear						Clear
Enjoyable						Unenjoyable
Well Organized						Poorly Organized
Not interesting						Interesting
Easy						Difficult
Providing free-choice activities for students						Very Structured
Hard to Understand						Easy to Understand
Trivial						Essential
Interactive						Not Interactive
Old						Original
Encouraging students to ask questions						Discouraging students to ask questions
Encouraging student Team-work						Discouraging student Team-work
Useful						Useless

Post-Visit version:
Below are descriptive pair of words relating to "visiting the exhibition".
The words in every pair are opposite in their meaning. Please mark an X in one of the squares between the words that mostly expresses your attitude towards the two words.

Visiting the exhibit ________ was:

Important						Not important
Not clear						Clear
Enjoyable						Unenjoyable
Well Organized						Poorly Organized
Not interesting						Interesting
Easy						Difficult
Providing free-choice activities for students						Very Structured
Hard to Understand						Easy to Understand
Trivial						Essential
Interactive						Not Interactive
Old						Original
Encouraging students to ask questions						Discouraging students to ask questions
Encouraging student Team-work						Discouraging student Team-work
Useful						Useless

Annex D. Visual and Cognitive Ability Reasoning Test: VSA – RAVEN



Annex E. Knowledge Test

1. As water heats up what happens to its volume.
   a. Increases
   b. Decreases
   c. Stays the same

2. What happens to the level of the water if floating ice melts
   a. Goes up
   b. Goes down
   c. Stays the same

3. How much of an iceberg is under the sea
   a. 10%
   b. 50%
   c. 70%
   d. 90%

4. Match the place to the pole:
   a. The Antarctic
   b. The Arctic

5. Increased use of fossil fuels are producing which greenhouse gas
   a. Mustard Gas
   b. Helium
   c. Carbon Dioxide
   d. Butane

6. Without the greenhouse effect what would happen to the planet?
   a. It would stay the same
   b. The world would freeze and we'd go into an ice age
   c. We would freeze at night and fry in the day
   d. The world would get warmer and the land would become desert

7. Which of these things can an animal do if the temperature gets too warm?
   a. Move somewhere colder
   b. Adapt
   c. Get air conditioning
   d. Die

8. What happens to coral if the water gets too warm?
   a. It grows faster
   b. It goes white
   c. It moves to deeper water

d. Nothing

9. What is coastal squeeze?
   a. A traditional hug given to loved ones by the sea
   b. The erosion of coastlines making the amount of inhabitable land smaller
   c. The shrinking of the shore as sea level rises and humans build defences
   d. Animals on the shore being forced to live closer together

10. What is a carbon footprint?
    a. The latest way of measuring shoe size using carbon fibre technology
    b. A measure of the effect you have upon the climate
    c. The amount of carbon used to produce your shoes
    d. A measure of the amount of carbon you save by walking

11. Name three forms of renewable energy

12. Which uses more energy?
    a. Boiling a full kettle
    b. A tumble-dryer on for 40 minutes
    c. A 60W light bulb on for a day
    d. Ironing a shirt

13. How much of the worlds oxygen is produced by marine plants
    a. 10%
    b. 25%
    c. 50%
    d. 75%

14. Is seawater acid or alkali?

15. If the ocean became more acidic what might happen?

    a. Limpet shells would get thinner
    b. Coral reefs will become more susceptible to storm damage
    c. Less carbon will be locked away in the seabed
    d. All of the above.