PALACKÝ UNIVERSITY, OLOMOUC

MOTIVATING AND EXCITING METHODS IN MATHEMATICS AND SCIENCE

Case Studies

2009

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CONTENT

FOREWORD

MOTIVATE ME in Maths and Science – *Motivating and Exciting Methods in Maths and Science* – is a project under the COMENIUS 2.1 programme of the European Commission.

The main aim of the project is to make trainee teachers and their tutors, as well as in-service teachers, aware of new pedagogical methods for the learning of mathematics and science, specifically to use materials produced in the project PROMOTE MSc to develop appropriate methods aimed at increasing students' motivation.

This has been done by

- Exchanging data and views on pedagogical methods in teaching of mathematics and science in a European context.
- Producing a glossary of methods to be used by trainee teachers and their tutors, as well as by in-service teachers of mathematics and science.
- Establishing a framework by which trainee teachers and their tutors can develop and/or test methods using materials from PROMOTE MSc.
- Evaluating methods and materials using a questionnaire.
- Collecting case studies that document successful use of MOTIVATE ME methods and PROMOTE materials.

This book contains the collection of case studies that have been produced in the framework of this project. It is intended for trainee teachers and their tutors, as well as for in-service teachers, to demonstrate examples of how the materials of the PROMOTE MSc project can be taught in a motivating way, using methods described in the MOTIVATE ME glossary.

The electronic version of this book, as well as the glossary and all other project materials, can be found at the homepage of the project:

http://www.MotivateMeMathsScience.eu

The materials of this project have been produced by teams from the United Kingdom (UK), Austria (AT), Czech Republic (CZ), Italy (IT) and Slovakia (SK).

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CASE STUDY 1

Title of case study	**Evaluation of two Promote MSc activities; Number Puzzle 1 and Number Puzzle 2**
Origin of case study	UK Team

Description

The activities were carried out by three mathematics trainee teachers with different ability Year 7 classes – pupils aged 11-12 years old.

Target Audience	Lower secondary school pupils
Key words	Problem Solving, exposition, modelling, discussion, small group work, independent learning,
Delivery method/s	Following exposition and modelling by the teacher, pupils were encouraged to work either individually or in small groups.

Background

The lessons took place in schools in the North East of England in 2008 and were led by trainee teachers completing their final teaching practice before being awarded Qualified Teacher Status in the UK. The trainee teachers completed a lesson evaluation that considered the teaching approach used and also pupil engagement.

Content

In Number Puzzle 1 pupils were involved in problem solving activities related to numerical operations and in Number Puzzle 2 pupils used problem solving strategies related to number operations and the use of brackets.

Evaluation

The three trainee teachers were generally very positive in the usefulness of the Promote MSc activities but were less positive in the teaching approaches used. All the trainees suggested that they would make changes to the teaching approach used in certain circumstances, for example, allowing the use of calculators for lower attaining pupils or giving greater consideration to the pre-

requisite knowledge needed. One trainee also highlighted the need for an extension activity for higher attaining pupils.

Recommendations for good practice

The trainee teachers that trialled the activities were teaching a range of ability groups and they identified the need for differentiation to be taken into account when using the activities with some groups.

Evaluation of Number Puzzles 1 and 2

Summary

Trainee secondary mathematics teachers completing their final teaching placement in 2008 used the two number puzzle activities during their teaching practice. Two of the trainees were placed in large urban 11-16 secondary schools in the North East of England whilst the third was placed in a smaller 11-16 secondary school in a small town in the region. The trainees completed a lesson evaluation that considered the teaching approach used and also pupil engagement. The pupils that participated in the activities were in Year 7 (pupils aged between 11 and 12).

Introduction

Since both activities were concerned with number operations and use of brackets, they fitted well into the mathematics scheme of work identified within the National Curriculum for Mathematics for lower secondary school pupils where it was required that pupils should be taught to 'add, subtract multiply and divide integers' and 'use brackets and the hierarchy of operations. In addition, the National Curriculum required that pupils should be taught to 'explore connections in mathematics to develop flexible approaches to increasingly demanding problems; select appropriate strategies to use for numerical problems and 'make mental estimates of the answers to calculations; use checking procedures to monitor the accuracy of their results'. Trainee teacher introduced both activities through **exposition** and **modelling**, working through one or two similar problems, engaging pupils in **discussion** to the approach to the problems. In one lesson the activity was given as a starter activity where pupils only completed a selection of questions from the worksheet. This was

done to consolidate prior learning concerned with the use of brackets. In the other lessons the activities formed the main part of the lesson and pupils engaged in the number puzzle activities either **individually** or in **small groups**.

Analysis

All three trainees evaluated the lesson(s) taught considering the usefulness of the Promote activities, pupils' engagement in the lesson(s) and also the teaching approach used. The three trainees agreed or strongly agreed that the Promote activities were useful and that pupils engaged well with the activities. However of the four evaluations of the appropriateness of the teaching approach, in two of the lessons trainees indicated that they were unsure about the teaching approach used.

Trainee teachers were also asked what might they change and why. The following responses were given to this question.

Student teacher A Number Puzzle 1 Year 7 top set

It might be useful to try the activity with calculators to improve the engagement of some who were struggling to do the calculations.

Student teacher A Number Puzzle 2 Year 7 top set

I used this as a starter activity selecting a few target numbers to try – I may consider using this as a main lesson activity.

Student teacher B Number Puzzle 2 Year 7 set 2

The activity itself was good and I can't think of any changes that would improve it. My delivery should possibly have involved more description of BIDMAS as I gave the activity to pupils without re-covering prior work

Student teacher C Number Puzzle 2 Lower Ability Year 7

Perhaps an extension sheet for higher ability pupils.

Conclusions and Recommendations

The three trainee teachers were generally very positive in the usefulness of the Promote activities but were less positive in teaching approaches used. It was also found that there was good pupil engagement when using the activities in class. However, the trainees suggested they would make changes to the teaching approach used in some circumstances – for example, having an extension sheet for higher attaining pupils, allowing the use of calculators for lower attaining pupils or giving greater consideration to the pre-requisite knowledge needed. This indicates the need to ensure that pupils have the

necessary pre-requisite knowledge prior to introducing the activities and also the need to provide for differentiation within the classroom.

Appendix A

The following responses to questionnaires were given by trainee teachers who trialled the activities.

Q1 I found the Promote activity useful

Student teacher	Activity	Class	Comment
Student teacher A	Number Puzzle 1	Year 7 top set	agree
Student teacher A	Number Puzzle 2	Year 7 top set	strongly agree
Student teacher B	Number Puzzle 2	Year 7 set 2	strongly agree
Student teacher C	Number Puzzle 2	Lower Ability Year 7	agree

Q2 I found the teaching methods appropriate

Student teacher	Activity	Class	Comment
Student teacher A	Number Puzzle 1	Year 7 top set	not sure
Student teacher A	Number Puzzle 2	Year 7 top set	strongly agree
Student teacher B	Number Puzzle 2	Year 7 set 2	agree
Student teacher C	Number Puzzle 2	Lower Ability Year 7	not sure

Q3 The students engaged well with the activity

Student teacher	Activity	Class	Comment
Student teacher A	Number Puzzle 1	Year 7 top set	agree
Student teacher A	Number Puzzle 2	Year 7 top set	agree
Student teacher B	Number Puzzle 2	Year 7 set 2 strongly	agree
Student teacher C	Number Puzzle 2	Lower Ability Year 7	strongly agree

Q4 I feel confident in using the activity

Student teacher	Activity	Class	Comment
Student teacher A	Number Puzzle 1	Year 7 top set	agree
Student teacher A	Number Puzzle 2	Year 7 top set	strongly agree
Student teacher B	Number Puzzle 2	Year 7 set 2	agree
Student teacher C	Number Puzzle 2	Lower Ability Year 7	strongly agree

Q5 I feel confident in the teaching approach used in the activity

Student teacher	Activity	Class	Comment
Student teacher	A Number Puzzle 1	Year 7 top set	agree
Student teacher	A Number Puzzle 2	Year 7 top set	agree
Student teacher	B Number Puzzle 2	Year 7 set 2	disagree
Student teacher	C Number Puzzle 2	Lower Ability Year 7	agree

CASE STUDY 2

Title of case study	**Dinosaur Mechanics: an introduction to biomechanics**
Origin of case study	UK Team

Description

An introductory activity involves the use of moments of forces and Dempster's segmental body data to estimate the muscular force generated in the bicep to maintain the forearm in a horizontal position. A class discussion on skeletal adaptation follows.

Dinosaur models are weighed in air and fully immersed in water. Their volumes determined from the upthrust. The volume of the dinosaur model is scaled up and mass of a real dinosaur estimated.

The centre of gravity is estimated from photographs of the dinosaur model suspended from different appendages. The loads borne by the fore and rear legs is then estimated.

Alexander's equation for the walking speed of a dinosaur from fossilized footprints is tested by students making their own trackways in a sandpit.

Target Audience	A-level school pupils, teacher trainees, teachers.
Key words	Dinosaur, moments of forces, upthrust, scale, centre of gravity, mass, weight, exposition, small group work, worksheet, investigation and fieldwork.
Delivery method/s	Whole class, small group and field work.

Background

This work was developed at Edge Hill University to provide a stimulating context for primary trainees following a science subject study strand. Trainees are predominately female and present largely with biology or human biology A-level.

Evaluation

Three different user groups have been evaluated. The results demonstrate high levels of enjoyment, interest and learning. The study could be developed to look for gender differences.

Recommendations for good practice

The teaching environment needs more support for mathematics. However the activities are perceived as supportive of the development of investigative skills at A-level.

Dinosaur Mechanics: An introduction to biomechanics

Introduction

Edge Hill University has a long tradition of teacher training in both the primary and secondary sectors. Until recently primary trainees chose a subject study specialism to study throughout their three years of training. Typically 20 choose science of which only 2-4 are male. It is rare that any trainee presents with A-level physics. The is not surprising since only around 22 %[1] of A-level physics students are female. This unit of study was developed to engage with the interests of the trainee primary teacher, alongside similar themed biophysics. For example, the study of the wave behavior of light in the context of iridescence in some butterfly wings.

Description

(i) Estimation of force developed in bicep.

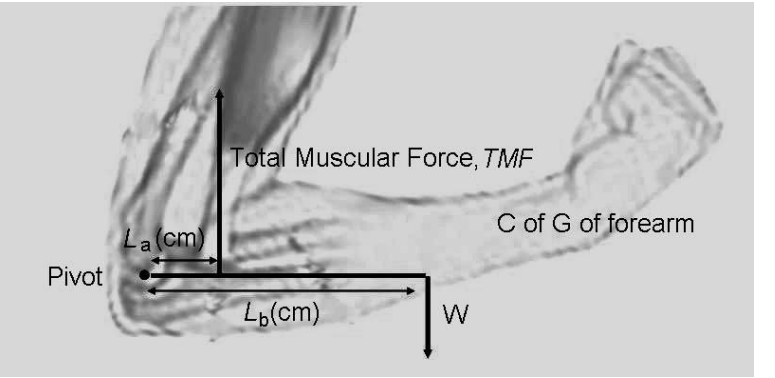
Much of this is derived from the work of Professor Mcneill Alexander[2] of Leeds University. However, we start with an elementary activity designed to estimate the force generated by the bicep when the forearm is held horizontal (Fig. 1)

The students weigh themselves and then use Dempster's Body Segmental Data to ascertain the weight of the forearm and position of the centre of gravity. They then follow the tendon from the bottom of the bicep the point of insertion in the radius. They mark this and the pivot on their arm so they can make the necessary measurements. After calculating the force developed in the bicep

[1] *QCA August 2005*

[2] Alexander R. M. *Doubts and Assumptions in Dinosaur Mechanics,* Interdisciplinary Science Reviews, 1991, Vol 16, No. 2.

(usually 50 N – 200 N) a teacher led discussion on adaptation in animals takes place.



Weight W, acting through the centre of gravity of the arm.

Fig. 1 The arm modelled as a lever

(ii) Mass, centre of gravity and limb loadings of a dinosaur.

The students chose between a Diplodocus, Stegosaurus and Triceratops 1/45th scale model. By finding the weight in air and fully immersed in water, and using the density of water they determine the volume of the model. They then scale the model up and assuming the dinosaur could float in water (elephants do!) they determine mass, and hence weight

They use photographs of the models hanging from different limbs, neck or tail they determine the centre of gravity and use moments to determine the loading on rear and forelimbs.

This provokes a discussion on the athleticism of the animal.

(iii) Walking speeds from trackways.

McNeil Alexander has developed an equation the estimates walking speed[3] of a dinosaur from fossilized footprints.

$$\text{Speed} = 0.25 * (\text{stride length})^{1.67} * (\text{leg length})^{-1.17} * (\text{gravitational constant})^{0.5} \text{ m.s}^{-1}$$

[3] Alexander, R.M., 1976, *Estimates of speeds of dinosaurs*, Nature 261: 129-130

Leg length is four times footlength. The students design an investigation to verify the equation. This involves measuring the actual walking speed of a person while they are creating the trackway and comparing with the speed predicted by Alexander's equation.

Fig. 2 Sixth form students from Ormskirk school collecting data from their trackway

Teaching Methods

The individual activities were briefly introduced by tutor led e*xposition* leading to *small group work* supported by the use of *worksheets*. Activities provided the opportunity for elements of *investigation* and finally *fieldwork.* The words in italics are as defined in MOTIVATEME – Glossary of Terms.

Evaluation

Three groups have completed the activity and have filled out the evaluation form developed by the working group. The first was a group of sixth form A-level physics students from the local school. They had clearly opted into

physics, but not necessarily with the intention of going on to study physics at University. A number were considering going on to take sports science degrees and this is reflected in the evaluation. The second was a first year university group of science trainees. Only one had A-level physics. Finally, a group of biology teachers retraining to teach physics.

The results of questions relating to interest, learning and enjoyment are presented graphically.

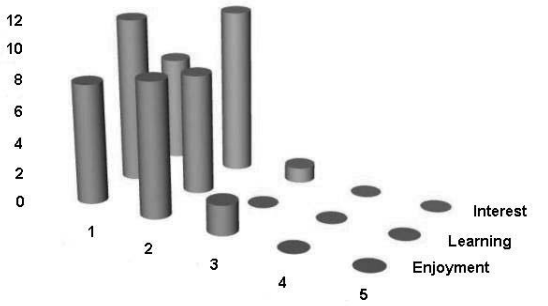


Fig. 3 Students from Ormskirk school

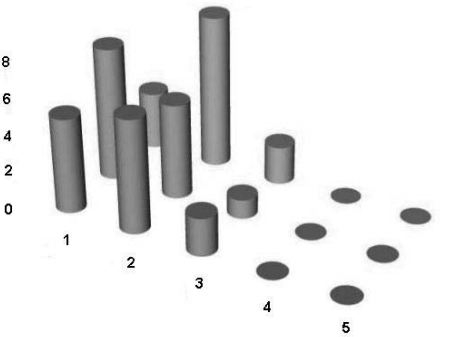


Fig. 4 Year one trainees

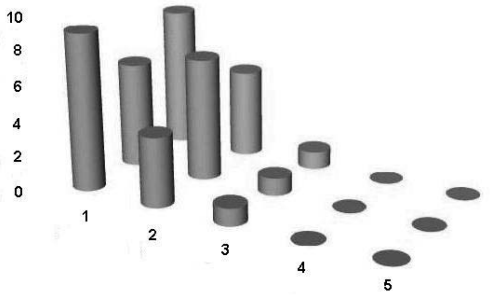


Fig. 5 Biology teachers retraining

Fig. 3 relates to school students who had opted in to physics whilst Fig 4 reveals the attitudes of students who, bar one, had avoided physics. The landscapes are remarkably similar with interest and enjoyment tailing away at the highest level of agreement. Compare this with the biology teachers who are retraining in order to teach physics. Learning tails away whilst interest and enjoyment show strongly.

It was difficult to find consensus with most of the remaining questions. The mathematical element was clearly the least enjoyable. Four boys from the sixth form school wanted to know more about biomechanics. I supposed that these were more interested in sports science. But three others simply wanted to know more about dinosaurs. Two who were more critical doubted the science. One wanted a more accurate way of answering the questions the activity poses. However, the activities are open. There are no right answers. This, and the context, may make this set of activities more girl friendly although there is insufficient data for me to comment. Three female students showed reluctance to become fully involved with the activity at the sandpit being unwilling to take their shoes off!

The Teachers Comments

The teachers became involved in all activities after I had given the initial briefing. They strongly agreed with the questions involving interest, learning and enjoyment. They were most positive, wanting to build the day into their physics program in future. They felt that abstract ideas in class are given real context for students. They particularly liked the practical aspects commenting that the use of long jump pit was excellent.

They felt there was good practice for the pupils PSA/ISA[4] preparation and commended the support for calculator skills, manipulation of equations and selection of equipment for the design of investigations.

Conclusions

There is clear evidence that this activity contributes to the enjoyment, interest and learning amongst a diverse range of users. It is clear that more supports is needed with mathematics. Students had particular difficulty with scaling and manipulating units, for example converting from cm^3 to m^3. A proforma to guide the students through the mathematical has been suggested. As has the need for more clarity in scaling up the three dimensional dinosaur model. I have used this material with science graduates and rarely find an individual who can recognize that scaling a $1/45^{th}$ model requires multiplying by 45^3 rather than 45. Perhaps the last word should be left to an Ormskirk School student……..

….. the equations are psycho!

[4] Practical skills assessment (**PSA**) and Investigative skills assessment (**ISA**) within A-level physics.

CASE STUDY 3

Title of case study	**Renewable Energy Resources/Standby mode**
Origin of case study	UK Team

Description

The lesson was carried out by a Science Trainee with a year 7 class and covered 2 lessons plus one home work from a 12 lesson module. It used the Promote materials "Standby mode" and "Renewable Energy Resources"

Target Audience	Lower Secondary 11-14.
Key Words	Active learning Discussion Exposition Small group work Computer aided Learning Independent learning Pupil presentation Text based learning
Delivery method/s	The promote materials were used for one lesson each (1 hour per lesson) Materials were used in small groups to promote active learning

Background

The lesson took place with a top ability year 7 class in an 11-18 Comprehensive school in the North East of England.

Content

The class looked at the school becoming more environmentally friendly. The caretaker was invited to the class to talk about energy use in the school. The pupils were then introduced to concept of standby and energy use in the home.

Pupils did a school audit of energy and related this to worldwide situation and renewable energy. Pupils made models/leaflets/posters and completed written work.

Evaluation

The trainee stated;

"The link to the pupil's home life making it more realistic"

Although some pupils said they did not find the activities interesting, almost all agreed that they had learned new things.

Recommendations for good practice

"Looking at ways and including ideas around making the home more energy efficient. Extending to a science project on energy efficiency"

Renewable Energy Resources/Standby mode

Summary

The trainee thought that the pupils enjoyed relating the activity to the school and their homes and the pupils engaged well with the activity. She felt confident using the materials in this way.

Introduction

The following is a case study of part of a lesson delivered by a final year secondary science trainee in her final teaching practice before graduation. It took place in an 11-18 urban boys Catholic comprehensive school in the North East of England. The school is a larger than average sized secondary school with a stable school population and is recognised by Ofsted as a good and improvingschool.

The trainee is a biology graduate, but has experience of teaching both physics and chemistry to Key Stage 4 (14-16 years) and biology to post 16.

Study

The trainee was teaching a topic dealing with energy for houses. This is taught as part of the unit 8i of the Key Stage 3 (11-14) Science schemes of work

"heating and cooling" dealing with "How can we reduce energy waste in our homes?"

The lesson began with a **discussion** of energy consumption within the school and how this could be reduced to make the school more environmentally friendly.

The school caretaker was invited into the class to give a talk about energy use in the school and stayed for a discussion with the pupils.

Pupils were given information and then asked to do a school audit of energy use within the school.

Pupils were then given a presentation by PowerPoint, including **exposition** by the trainee on energy use in homes and how use of energy could be minimised. They were introduced to the concept of standby mode. The trainee used the Promote materials "*Standby mode*" as an activity within this lesson, to contextualise these concepts.

Part of this lesson includes a Recap of work done at the start of the module on the need to conserve energy resources. The trainee used the part of the unit 7i "Energy resources" which is also part of the Science Key Stage 3 schemes of work.

The topic covers the area "that renewable energy resources include wind, waves, running water, sunlight, biomass and some geothermal sources" she also used materials from Promote materials (*Renewable Energy Resources***)** as part of the lesson

The trainee then split the class into **small groups** and placed sheets with labels taken from the Promote materials *Renewable Energy Resources* around the class.

The pupils were asked to collaborate in groups and match the 10 statements read out from the trainee from the Promote materials to the correct renewable resource.

The statements can be found on line and a hyperlink is given at the end.

Pupils were then given a task, working **independently** both at home and in the following lesson to evaluate renewable energy sources in a global context. This allowed **active learning** to take place. Pupils used **computer aided learning** and **text based learning** to investigate these and build up evidence.

Pupils then worked in small groups to create a 5 minute **presentation** of their findings to the rest of the class.

The trainee chose several teaching methods to try and engage and motivate the pupils These included.

Active learning

Discussion

Exposition

Small group work

Computer aided Learning

Independent learning

Pupil presentation

Text based learning

Analysis

The trainee evaluated the lesson and the use of the Promote materials. She thought that the pupils enjoyed relating the activity to the school and their homes and the pupils engaged well with the activity. She felt confident using the materials in this way.

Responses from the pupils were more mixed.

What did you find the most interesting and enjoyable about the activity, and why?

- Enjoyed doing the activity on our school's use of energy (5)
- Independent research (4)
- Enjoyed presentations as they made it clear (3)
- The talk by the caretaker (2)
- Doing work at home (2) finishing it
- Going in the yard
- Creating the poster

What did you find the least interesting and enjoyable about the activity, and why?

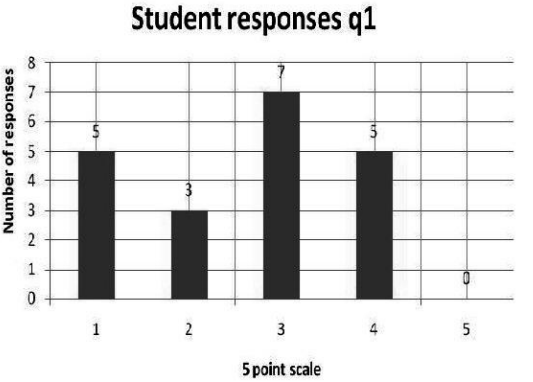
- I did not find anything to stop me enjoying the project (5)
- The long writing bits (4)
- Gathering the information (2)
- Too much pressure
- The bit about coal gas and oil

- Most things
- Bit boring doing the research
- Doing it at home
- It was hard work

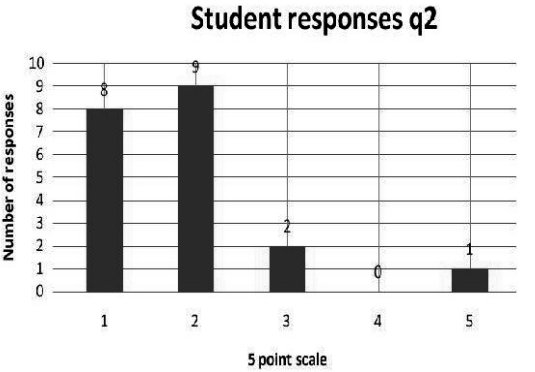
When the data was analysed quantitatively it showed

1 Strongly agree 2 Agree 3 Not sure 4 Disagree 5 Strongly disagree

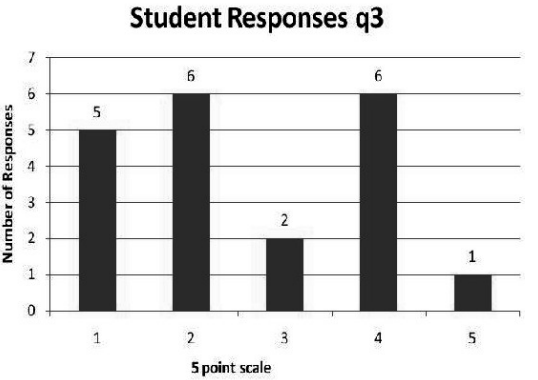
I enjoyed this activity



I learned new things



I found the activity interesting



It showed that only 5 pupils from 20 did not enjoy the activity. When asked if they had learned new things only 1 from 20 gave a negative response.

However when asked if the activity was interesting 7 from 20 gave negative responses.

These data suggest that the approach was successful in motivating these pupils with these materials.

Conclusions and Recommendations

The activity was found to be useful by the trainee teacher and she felt confident in using both sets of materials. She contextualized the activities, linking them to the pupil's home lives and thought this had been very successful.

The majority of pupils also enjoyed the activity and learned new things; those giving negative responses stated hard work and pressure as being their perceived problems.

In conclusion the materials were used in a stimulating and motivating way.

References and Appendices

http://www.promotemsc.org/

http://www.promotemsc.org/results/UK/Renewable_Energy_Resources.pdf

http://www.promotemsc.org/results/AT/Stand_by_Modus.pdf

Ulovec A et al (2008) Motivating and Exciting Methods in Mathematics and Science Glossary of terms. ISBN 978-80-244-1830-8

CASE STUDY 4

Title of case study	**Card sort on electrical appliances and energy ratings**
Origin of case study	UK Team

Description

The activity was carried out by a Science Trainee with a year 7 class and covered part of 1 lesson (1 hour). It used the Promote materials "Energy Quiz"

Target Audience	Lower secondary teachers
Key words	Group work Discussion, Active learning, Card sort
Delivery method/s	This was used as a starter activity during a lesson on energy. Card sorts were given out and pupils worked in small groups comparing energy transfer in a range of household appliances

Background

The lesson took place with a top ability year 7 class in an 11-18 Comprehensive school in the North East of England

Content

Each group was given a set of cards with pictures of common household appliances and had to sort them into their expectations of power usage. This involved much group dialogue and discussion and used prior knowledge

Evaluation

*"*The card sort activity was something pupils are used to doing and it got them discussing ideas and sharing opinions. It was also useful in addressing misconceptions as a lot of pupils thought the bigger objects would transfer more energy and smaller objects transfer less. They did seem genuinely surprised by the results"

Recommendations for good practice

"Pupils did not seem to engage with this activity very well and the general consensus was that they were just guessing the power ratings, they felt they

didn't actually learn from the activity. Perhaps an investigation where the pupils could actually discover the power ratings themselves may have been more effective."

Card sort on electrical appliances and energy ratings

Summary

The activity was carried out by a Science Trainee with a year 7 class and covered part of 1 lesson (1 hour) on energy. It used the Promote materials "Energy Quiz" The card sort activity was something pupils are used to doing and it got them discussing ideas and sharing opinions. It was also useful in addressing misconceptions as a lot of pupils thought the bigger objects would transfer more energy and smaller objects transfer less.

Introduction

The following is a case study of part of a lesson delivered by a final year secondary science trainee in her final teaching practice before graduation. It took place in an 11-18 rural comprehensive school in the North east of England. The school is an average sized secondary school with a large successful sixth form and is recognised by Ofsted as an outstanding school.

The trainees is a biology graduate, but has experience of teaching both physics and chemistry to Key Stage 4 (14-16 years) as well as biology to post 16.

Study

The activity was used within a lesson on energy saving lamps as part of a unit 9I Energy and electricity. This is a top set year 7 class and this lesson was used to extend their understanding energy = power × time. The main activity of the lesson involved in investigating lights in the home and how long these would be active and then calculating energy use. The unit asks them to "Demonstrate the energy used by a range of electrical devices, *eg for heating, lighting,* (over a fixed period of time for comparison purposes) and show how these comparisons relate to the power ratings on devices.

The materials “Energy quiz” from Promote materials was used as a starter activity to introduce the topic.

This activity consists of a card sort of different household appliances. The activity started with a **whole class discussion** and then pupils were asked to discuss the cards in **small groups** and arrange them in order of expected energy consumption using knowledge obtained in previous lessons. This allowed an element of **active learning** by pupils. They were then given the correct answers and had to comment as to how their expected answers correlated with the correct responses.

The trainee chose several teaching methods to try and engage and motivate the pupils These included.

Group work

Discussion

Active learning

The statements are shown in an appendix and are from the Promote materials translated from the original German.

Analysis

The trainee stated that “The card sort activity was something pupils are used to doing and it got them discussing ideas and sharing opinions. It was also useful in addressing misconceptions as a lot of pupils thought the bigger objects would transfer more energy and smaller objects transfer less. They did seem genuinely surprised by the results”

Pupil comments backed this 13 from 28 stated that they enjoyed the activity but only 7 said that they found the activity interesting, however only one pupil from 28 said they had not learned new things from the activity. So although many pupils found the mode of the activity less than enjoyable, almost all found the activity a positive experience with regards to learning.

Qualitative replies showed

What did you find the most interesting and enjoyable about the activity, and why?

Finding out that the answers where different to what I expected (7)

Working in pairs and sorting out answers (4)

Nothing activity boring (4)

Putting electrical things in the right order (3)

Working with something we had not done before (2)

Debating with other group members (2)

Finding out how much power everything had (2)

Enjoyed the sorting part

What did you find the least interesting and enjoyable about the activity, and why?

Everything because it was boring (9)

That we got every single one wrong (7)

The design of the cards. Better with a picture or colour (3)

Having to do stuff I feel I don't need to know

There was no practical

Sorting the cards out

Slightly dull as we have done activities like this before

Conclusions and Recommendations

The trainee said "Pupils did not seem to engage with this activity very well and the general consensus was that they were just guessing the power ratings, they felt they didn't actually learn from the activity. Perhaps an investigation where the pupils could actually discover the power ratings themselves may have been more effective."

However the evidence is that pupils did learn, but felt that this was yet another card sort. The materials proved to be useful, but more imagination needed to be used in the mode of delivery.

References and Appendices

Energy-Quiz

Gudrun Dirmhirn (gudrun_dirmhirn@gmx.at)

Different household appliances have different energy ratings.

The more ratings the more energy one needs.

Small cards with different household appliances are prepared.

Pupils are to arrange the devices according to their energy consumption.

Particularly suitable for younger pupils.

Energy Quiz

1. First cut out the small cards
2 Arrange each according to its energy consumption
3 The higher this is, the more energy each uses
4 Begin with the device that you think has the lowest energy consumption
5 use the letters on the cards to line them up correctly

 E	 M	 U	 S
 Z	 L	 U	 W
 H	 T	 C	 T

Info sheet energy quiz

Solution

Lining up

Energy saving lamp (60 W)	11 W	U
Radio	30 W	M
60W – Bulb	60 W	W
Computer monitor	100 W	E
Handmixer	300 W	L
Microwave	900 W	T
Toaster	950 W	S
Coffee machine	1 000 W	C
Espresso machine	1 450 W	H
Vacuum cleaner	1 800 W	U
Washing machine	2 150 W	T
Heater	2 200 W	Z

CASE STUDY 5

Title of case study **Vectors in fieldwork**
Origin of case study AT Team

Description

Material about vectors was used in fieldwork setting. Students got map of campus area and sheet of paper with one task. Solution of task (vector) has to be drawn on map, this leads to the position of next station. Students had to walk to next station and receive sheet of paper with next task, whose solution is again to be drawn on map and leading to next station etc.

Target Audience School pupils, age 15 years
Key words Vectors, fieldwork
Delivery method/s Fieldwork, exposition, small group work

Background

In a seminar of teaching methods for future mathematics teachers, students had to choose one of four materials from PROMOTE MSc (Vectors, 3-dimensional space, fractions, Mathematics in the gym hall) and one of five teaching methods described in MOTIVATE ME (exposition, small group work, fieldwork, peer teaching, active learning). They had to prepare a 60-minute-lesson using the given material and method, then perform this lesson in front of their peers in exactly the same way as they would in school (peers were asked to act as school pupils).

Content

"Materials for Vectors", units 2-8

(http://www.promotemsc.org/results/AT/Materialien_fuer_Vektoren.pdf)

Evaluation

Students and teachers both considered the combination of Vector materials with fieldwork method the most interesting one of the possible combinations. Most students answered "strongly agree" or "agree" on the question whether *they* enjoyed the lesson. Also the majority of the students "strongly agreed" or

"agreed" that they learned something new. Many students commented positively on the fact that the lesson was outside the classroom.

Recommendations for good practice

Requires sufficient time for preparation

Vectors in fieldwork

Summary

Teacher trainees used the PROMOTE MSc "Materials for Vectors" (units 2-8) and prepared a lesson using mainly fieldwork. This lesson was then performed in front of their peers acting as school pupils. The lesson started with an introduction and repetition of properties of vectors (exposition), as well as an explanation of the organisation of the unit. Students had to build groups and got a map of the campus area, a sheet of paper with one task, and a sheet for doing calculations and writing down solutions. They were then asked to solve the task (small group work). The solution (a vector) had then to be drawn on the map; this gave the position of the next "station", i.e. the place where the sheet with the next task could be found. At the end of the lesson, students were back in the classroom and handed in the solutions paper.

Background

In a seminar of teaching methods for future mathematics teachers, groups of two students had to choose one of four materials from PROMOTE MSc (Vectors, 3-dimensional space, fractions, Mathematics in the gym hall) and one of five teaching methods described in MOTIVATE ME (exposition, small group work, fieldwork, peer teaching, active learning). They had about one month time to prepare a 60-minute-lesson using the given material and method, then perform this lesson in front of their peers – 16 teacher trainees in mathematics – in exactly the same way as they would in school. The peers were asked to act as school pupils.

Study

Two female teacher trainees received the "Materials for Vectors" about one month before the lesson. They chose units 2-8 to be performed, using mainly *fieldwork*. In preparation, teachers went to the campus on the morning of the lesson and positioned sheets with tasks on four (mostly outdoor) locations on the campus.

At the beginning of the lesson, the teachers gave five minutes *exposition* (repetition of content already known by students to refresh their memories) on properties of vectors. The students were then asked to form four groups of four people each. The students then got several *worksheets*:

- A map of the campus area
- A sheet of paper with instructions
- A worksheet containing one task from "Materials for Vectors", units 2-8
- A worksheet with numbers 1-5 printed on them, with space for writing down solutions
- Several empty sheets for calculations

The instructions were then summarised by the teachers: Each group has to solve their task in the classroom, resulting in a vector that represents their starting position, draw their starting position on the map, walk there, find the sheet with the next task, solve the task in *small group work* (solution is a vector), and add this vector to their current position to find the position of the next task on their map.

Students started solving the classroom tasks in *small group work*. These were – on purpose – mainly easy addition tasks, so students solved them fairly quickly and went out of the classroom to their respective starting positions. Also the two teachers and two aides went to the positions of the tasks, so that at each position one teacher or aide was present to support the students.

On their starting position, students found laminated (water proofed) envelopes with several copies of the new task. They took one sheet for each group member and solved the respective tasks (from units 2-8) in small group work. The solution of each task required approximately 7-8 minutes. All tasks could be solved by paper and pencil and would not require a calculator. Nevertheless some students used their mobile phone calculators for arithmetic. Also some students used their mobile phones in situations when they left a position and could not find the correct new position.

At the end all students were instructed to come back to the classroom and hand in their calculation sheets and the solution sheet. Originally it was planned to use *discussion and debate* on the solutions in classroom within the lesson after all students were back, but this had to be cancelled due to lack of time.

Analysis

All participants received the questionnaires and filled them in immediately after the lesson. From all the combinations of four PROMOTE MSc materials (Vectors, 3-dimensional space, fractions, Mathematics in the gym hall) and five MOTIVATE ME methods (exposition, small group work, fieldwork, peer teaching, active learning) that were tested in the seminar, this one was considered most interesting by the students. Most students (14) answered "strongly agree" or "agree" on the question whether they enjoyed the lesson. Also the majority of the students (10) "strongly agreed" or "agreed" that they learned something new.

Answers to "what did you find most interesting and enjoyable" included

- It was great to be outdoors
- Leaving the classroom
- Working outside
- Not a typical math lesson
- I never went outside during a lesson before, it was great
- We worked together
- It is much more fun to go outside instead of learning

Answers to "what did you find least interesting and enjoyable" included

- Vector repetition at the beginning
- Explanations of "how it all works"
- It would have been enough to explain organisation on the worksheet, not repeat it in classroom

Answers to "what would you like to find out more about" included

- Can we go outdoors in other lessons?

- Vectors in reality
- What would you have done if it rained?
- Doing other maths topics outside

Detailed results of the questionnaire (16 students):

1. I enjoyed the lesson: 2.0
2. I learnt something new: 2.2
3. I did interesting things in the lesson: 1.0
4. Most interesting: Work outside the classroom (8 students)
5. Least interesting: Lengthy introduction on organisation (3 students)
6. Would like to find out more about: How to use fieldwork in elementary mathematics

Recommendations

Fieldwork requires a lot of preparation time. It is a good idea to keep some spare time; the lessons can easily be longer than the teacher originally anticipated. It is recommended to have other teachers helping out, particularly if you want to leave the building. If you have done fieldwork before with the same students, organisational explanations can be kept to a minimum.

CASE STUDY 6

Title of case study	**3-D-space in small group work**
Origin of case study	AT Team

Description

Material about 3-D-space was used in small group work setting. Students got sheet of paper with tasks. Tasks had to be solved in small groups (4-5 people per group), one task per group. Solution of tasks then had to be explained on a poster. At the end of the lesson, students had 5 minutes per group to present posters. Posters continued to be exhibited together with tasks in the classroom.

Target Audience	School pupils, age 15 years
Key words	Space geometry, small group work
Delivery method/s	Small group work, student presentations, discussion and debate, exposition

Background

In a secondary school in Vienna, the teacher received the materials 3-D-space PROMOTE MSc and the methods booklet from MOTIVATE ME and chose the small group work method. She then prepared a 50-minute-lesson using the given material and method, then performed this lesson.

Content

Fürst/Molnar/Pohanel: A guidebook of three-dimensional Space, pp. 61-65.

Evaluation

Mixed reactions as to the enjoyment of the lesson. However, most students answered “strongly agree” or “agree” on the question whether they learned something new. A majority of the students “strongly agreed” or “agreed” that they did interesting things in the lesson.

The teacher was very positive about the material and methods, and considered the method very appropriate for the chosen materials. She also thought the

students were engaged with the material and particularly with the method. She would like to have the whole material in German

Recommendations for good practice

Think about group composition and whether groups should form on the students' choice or on the teacher's choice.

3-D-space in small group work

Summary

Teacher received PROMOTE MSc materials "A guidebook of three-dimensional space" (using pages 61-65) in English and booklet with methods of MOTIVATE ME. She prepared a lesson using mainly small group work and student presentations. This lesson was then performed in a regular classroom. The lesson started with check of homework and a short repetition of the last unit (elementary 3D-vector properties and operations), then an explanation of the organisation of the lesson. Students were organised into groups by teacher and got a sheet of paper with one task (word problem) per group. They were then asked to solve the task (small group work). The group had then to create a poster presenting and explaining the solution. At the end of the lesson, the groups had to present their posters in front of their peers.

Background

In a secondary school in Vienna, the teacher (female mathematics and psychology teacher with 3 years teaching experience) received the PROMOTE MSc materials 3-D-space and the methods booklet from MOTIVATE ME and chose the small group work method. She then prepared a 50-minute-lesson using the given material and method, then performed this lesson with her 24 students (15-16 years old) in a regular secondary school classroom.

Study

One female teacher received the "3D-Space" material about two weeks before the lesson. She read all the material and chose tasks from pages 61-65 (word

problems), preparing them to be used mainly in *small group work*. She prepared worksheets with one task per sheet to be handed out to five groups, one sheet per group.

At the beginning of the lesson, the teacher checked *homework*, then gave five minutes *exposition* (repetition of last lesson's content) on elementary 3D-vector properties and vector operations. The students were then asked to form five groups of five people each, according to the teacher's choice. The students then got one *worksheet* per group containing one word problem from "3D-space" materials.

The instructions were then summarised by the teachers: Each group has to solve their task on the work sheet in small group work, and then has to create a poster about the solution and present the poster to the class.

Students started solving the tasks in *small group work*. Tasks were word problems and took the groups about 10 minutes to solve. They then created the posters, also in small group work, which took about 10 minutes per group.

At the end of the lesson there were 5-minute *student presentations* where students presented the posters to their peers. The posters were then taped to the wall of the classroom, together with the worksheets with the corresponding task. Students were asked to think about improvements on the methods of solving the tasks, to be *discussed* in the next lesson.

Analysis

All (24) students and the teacher received the questionnaires and filled them in immediately after the lesson. There were mixed reactions to the question whether the students enjoyed the lesson. While 10 strongly agreed, 6 disagreed. However, most students (21) answered "strongly agree" or "agree" to the question whether they learned something new. A majority of the students (15) "strongly agreed" or "agreed" that they did interesting things in the lesson.

The teacher was very positive about the material and methods, and considered the method very appropriate for the chosen materials. Although she had rarely used small group work before, she felt confident doing it. She also thought the students were engaged with the material and particularly with the method. She would like to have the whole material in German.

Answers to "what did you find most interesting and enjoyable" included

- Working together
- The task was interesting

- Helping my friends
- I loved creating the poster
- Doing the presentation
- Poster drawing

Answers to "what did you find least interesting and enjoyable" included

- Super boring introduction
- Listening to the presentation
- I want to form my own group, not having the teacher tell me which group I am in

Answers to "what would you like to find out more about" included

- 3-D vector graphics in computer games
- Whether other classes also do posters
- Where else can you use 3D vectors – computers, games?

Detailed results of the questionnaire (24 students):

1. I enjoyed the lesson: 2.5
2. I learnt something new: 1.5
3. I did interesting things in the lesson: 2.0
4. Most interesting: Poster presentation (8 students), poster creation (5 students)
5. Least interesting: Repetition of elementary vector properties (2 students)
6. Would like to find out more about: 3-D-vector graphics in computer games (2 students)

Recommendations

It would be good to think about whether group composition in your particular class should be decided by the teacher or the students. This also depends on how well the teacher knows the students, whether the teacher wants to deliberately mix up the students or prefers pre-formed group, gender distribution etc.

CASE STUDY 7

Title of case study **3-D-space in fieldwork**
Origin of case study AT Team

Description

Material about 3-dimensional space was used in fieldwork setting. Students formed groups of five and got map of campus area, digital camera and sheet of paper with one task per group. Solutions of tasks had to be put on answer sheet, practical activities (measuring etc.) had to be captured with digital camera. In the next lesson, students came back to classroom and explained the tasks, showed the photos, and presented the solutions in PowerPoint presentation.

Target Audience School pupils, age 16 years
Key words Space geometry, fieldwork
Delivery method/s Fieldwork, small group work, student presentations

Background

In a seminar of teaching methods for future mathematics teachers, students had to choose one of four materials from PROMOTE MSc (Vectors, 3-dimensional space, fractions, Mathematics in the gym hall) and one of five teaching methods described in MOTIVATE ME (exposition, small group work, fieldwork, peer teaching, active learning). They had to prepare two 45-minute-lessons using the given material and method, then perform this lessons in front of their peers in exactly the same way as they would in school (peers were asked to act as school pupils).

Content

Fürst/Molnar/Pohanel: A guidebook of three-dimensional space, pp. 74-119.

Evaluation:

Students gave the combination of 3D materials with fieldwork method the highest overall rating in the questions of enjoyment, interest and learning effects. Many students commented positively on the fact that the lesson was

outside the classroom, that it was an unusual activity and that moving and doing something practical supported their learning process.

Recommendations for good practice

It would be good if students already have some experience with fieldwork and group work, as the tasks to be solved require co-ordinated efforts of the group members.

3-D-space in fieldwork

Summary

Teacher trainees used the PROMOTE MSc material "A guidebook of three-dimensional space" (using tasks from pages 74-119) and prepared a double-lesson using mainly fieldwork. This lesson was then performed in front of their peers acting as school pupils. The lesson started with an explanation of the organisation of the unit. Students had to build groups and got a map of the campus area, a sheet of paper with one task per group, several answer sheets, and a digital camera. They were then asked to solve the tasks (small group work) and record the practical activities with the digital camera. The solutions had to be put on the answer sheet. In the next lesson, students had to present a PowerPoint presentation, using the digital photos, to show the tasks and explain the solutions.

Background

In a seminar of teaching methods for future mathematics teachers, groups of two students had to choose one of four materials from PROMOTE MSc (Vectors, 3-dimensional space, fractions, Mathematics in the gym hall) and one of five teaching methods described in MOTIVATE ME (exposition, small group work, fieldwork, peer teaching, active learning). They had about one month to prepare two 45-minute-lessons using the given material and method, then perform this lesson in front of their peers – 15 teacher trainees in mathematics – in exactly the same way as they would in school. The peers were asked to act as school pupils.

Study

One male and one female teacher trainees received the materials "A guidebook of three-dimensional space" about one month before the lessons. They chose tasks from pages 74 – 119 to be performed, using mainly *fieldwork*, *small group work* and *student presentations*. In preparation, teachers went to the campus one week before the first lesson and tried out the practical tasks.

At the beginning of the lesson, the students were asked to form four groups of four people each. The students then got several materials:

- A map of the campus area
- A sheet of paper with instructions
- A *worksheet* containing one practical task per group from "A guidebook of three-dimensional space"
- A *worksheet* with space for writing down the solution
- Several empty sheets for calculations
- A digital camera

The instructions were then summarised by the teachers: Each group has to walk to given positions on the map (the positions were not drawn on the map, but given as vectors), solve the corresponding task in *small group work*, take pictures of the activities (e.g. measuring angles, using instruments to measure height etc.), and write down the solution on the worksheet.

Students went out starting the *fieldwork*, walking to the designated positions and started solving the tasks in *small group work*. These were all practical tasks: Measuring and calculating the height of a tree, measuring and calculating the volume of a pool, estimating the area of several roofs, and using a simple theodolite. The two teachers went to the positions of the tasks (the positions were fairly close to each other), supervised the work and provided assistance when necessary. Most groups assigned one student to take the pictures while the other three tried to solve the tasks. In one group, each student took pictures for five minutes. The students needed between 20 and 30 minutes for the tasks. At the end of the first lesson, all students gathered in the classroom and it was again explained that they had to create a PowerPoint presentation of their solution, using the digital pictures and their notes, and present this in the next lesson.

In the second lesson (three days later), most groups chose one representative for the presentation. One group presented as a team with changing roles as speakers. *Student presentations* took about 7 minutes per group, with all groups having made ample use of their digital cameras. At the end of each presentation, students had the chance to ask questions. All presentations drew some questions, as explanations were at times only understandable for other group members who had done the activities by themselves (e.g. references to tools that were not explained in the presentation). The questions were answered by the students and in one case by the teacher. At the end of the second lesson *inquiry* was used to ensure that students recognised the common theme of the tasks.

Analysis

All participants received the questionnaires and filled them in immediately after the second lesson. From all the combinations of four PROMOTE MSc materials (Vectors, 3-dimensional space, fractions, Mathematics in the gym hall) and five MOTIVATE ME methods (exposition, small group work, fieldwork, peer teaching, active learning) that were tested in the seminar, this one got the best overall rating by the students. In all three quantitative questions most students answered “strongly agree” or “agree”, which was not normally the case.

Answers to “what did you find most interesting and enjoyable” included

- Using tools
- Leaving the class
- Be outdoors
- Had fun working with my hands
- Would like math to be that interesting all the time
- Doing things not alone but in a group was very helpful
- Teacher did not talk all the time

Answers to “what did you find least interesting and enjoyable” included

- Deciding who does what
- I was not allowed to take the pictures
- I think we did not need the questions at the end of the second lesson

Answers to “what would you like to find out more about” included

- Where else is geometry in life?
- Why are there so many different kinds of roofs?
- The theodolite
- How can you use fieldwork in other parts of the curriculum

Detailed results of the questionnaire (15 students):

1. I enjoyed the lesson: 1.3
2. I learnt something new: 1.5
3. I did interesting things in the lesson: 1.2
4. Most interesting: Work outside the classroom (9 students)
5. Least interesting: Discussing with the other students who does what (3 students)
6. Would like to find out more about: How to use fieldwork in other parts of mathematics

Recommendations

Fieldwork requires a lot of preparation time. If you have done fieldwork before with the same students, organisational explanations can be kept to a minimum, and it also allows for more coordinated efforts of the group. It is also a good idea to wrap up the fieldwork with presentations or summary of what happened so that there is a connection with the other lessons.

CASE STUDY 8

Title of case study	**Plane geometry in fieldwork**
Origin of case study	AT Team

Description

Material about plane geometry was used in fieldwork setting. Students got sheet of paper with concepts of plane geometry and instructions on how to enact these concepts, as well as a digital camera. Students formed groups of 4-5 and went to the gym hall of the school. The different concepts were enacted and pictures were taken with the digital camera. Students then came back to the classroom and explained concepts to other groups, presenting digital pictures.

Target Audience	School pupils, age 13 years
Key words	Plane geometry, triangle, fieldwork, gym hall
Delivery method/s	Fieldwork, small group work, brainstorming, peer teaching

Background

In a secondary school in Vienna, the teacher received the materials "Mathematics in the gym hall" from PROMOTE MSc and the methods booklet from MOTIVATE ME and chose the fieldwork method. She then prepared a 50-minute-lesson using the given material and method, then performed this lesson.

Content

"Mathematics in the gym hall"

(http://www.promotemsc.org/results/AT/Mathematik_im_Turnsaal.pdf)

Evaluation

The vast majority of the students "strongly agreed" or "agreed" that they had enjoyed the lesson. A majority also strongly agreed or agreed that they did interesting things in the lesson. There were mixed feelings about whether something new had been learned.

The teacher was very positive about the material and methods, and considered the method very appropriate for the chosen materials. She felt confident with the methods, even though some were new for her. She also thought the students were engaged with the material and also with the method of fieldwork. She would have liked more support for the peer teaching method.

Recommendations for good practice

The group composition played an important role here. The teacher spent a lot of time trying to get people to work together. Those groups who were ready to work together got a lot out of the unit, while those with difficulties in working as a group lost interest soon, regardless of the motivating effects of the materials or the method.

Plane geometry in fieldwork

Summary

Teacher received PROMOTE MSc materials "Mathematics in the gym hall" in German and booklet with methods of MOTIVATE ME. She prepared a lesson using mainly fieldwork, small group work and peer teaching. The lesson started in a regular classroom with an explanation of the organisation of the unit. Students had to build groups of four to five people and got a worksheet with one concept of plane geometry per group, and a digital camera. All groups then went to the gym hall of the school, and the groups enacted their respective concept, using objects of the gym hall as well as their own bodies. Each group covered the activities with the digital camera. At the end of the lesson (back in the classroom) the groups had to explain the concepts to the others, using the digital pictures.

Background

In a secondary school in the suburbs of Vienna, the teacher (female mathematics and science teacher with 2 years teaching experience) received the PROMOTE MSc materials Mathematics in the gym hall and the methods booklet from MOTIVATE ME and chose the fieldwork method. She then

prepared a 50-minute-lesson using the given material and method, then performed this lesson with her 19 students (13 years old) in a regular secondary school classroom and this schools' gym hall.

Study

One female teacher received the "Mathematics in the gym hall" material in German about three weeks before the lesson. She prepared them to be used mainly in *fieldwork*, with elements of *small group work* and *peer teaching*. She prepared *worksheets* with one task (concept of plane geometry) per sheet to be handed out to four groups, one sheet per group.

At the beginning of the lesson, the teacher then gave three minutes *exposition* (repetition of last lesson's content) on the main ideas of plane geometry. The students were then asked to form four groups of four to five people each, according to the students' choice. The students then got one *worksheet* per group from the PROMOTE material (this contained one geometrical concept to be explained), several sheets of empty paper to take notes, and a digital camera per group.

The instructions were then summarised by the teachers: Each group has to enact or otherwise represent the concept on the work sheet in small group work, using whatever means are available in the gym hall, take pictures of the representation, take notes and what their ideas were and why they chose this representation, and explain the concepts in classroom to the other students.

Students walked to the gym hall together with the teacher (gym hall door was in the same corridor as the classroom) and started discussing the concepts in the groups. For one group it was quite hard to start working together, instead the members tried to only think about their own ideas. In another group the members developed ideas by themselves then presented them to the other group members and voted which one will be used. The other two groups used *brainstorming* and chose an idea after that. The groups then started to enact the concepts (centre of gravity of a triangle, angle bisector, altitude of a triangle, circumscribed circle of a triangle), using ropes, poles, soccer balls, and their own bodies. They took pictures of their activities with the digital camera. In three groups one of the group members took the pictures, in the fourth group students asked the teacher to take the pictures as they all were busy with the enactment. The fieldwork in the gym hall took about 20 minutes.

After the fieldwork, the students came back to the classroom, and each group explained their concept to the other groups, using their notes and particularly

the pictures from the digital camera (which was connected to a data projector), in *peer teaching*. At the end the teacher wrote all four concepts on the blackboard, together with some graphic representation.

Analysis

All (19) students and the teacher received the questionnaires and filled them in immediately after the lesson. The vast majority of the students (16) "strongly agreed" or "agreed" that they had enjoyed the lesson. A majority also strongly agreed or agreed that they did interesting things in the lesson. There were mixed feelings about whether something new has been learned, while 10 students "agreed", 7 students "disagreed", despite the fact that these geometrical concepts had not been taught in this class before.

The teacher was very positive about the material and methods, and considered the method very appropriate for the chosen materials. She had never used fieldwork or peer teaching before (but had used small group work regularly), nevertheless she felt confident doing it. She also thought the students were engaged with the material and also with the method of fieldwork (less so with the peer teaching method). She would have liked more hints for the peer teaching activity.

Answers to "what did you find most interesting and enjoyable" included

- We actually moved in the math lesson
- Nice idea to use the gym hall for math
- Working with my friends
- Taking pictures
- That you can see mathematics is not only numbers
- Explaining something in mathematics to my friends

Answers to "what did you find least interesting and enjoyable" included

- My group did not want to work
- Lazy group members
- The gym hall makes me feeling unwell, because I hate p.e.

Answers to "what would you like to find out more about" included

- Can we do that again?
- More geometry out there
- Play games with movement and mathematics in them (is there such a thing?)

Detailed results of the questionnaire (19 students):

1. I enjoyed the lesson: 1.3
2. I learnt something new: 2.5
3. I did interesting things in the lesson: 1.8
4. Most interesting: Moving around in mathematics lesson (3 students)
5. Least interesting: Working with lazy group (2 students)
6. Would like to find out more about: Find more applications of geometry outside classroom

Recommendations

We want to stress the importance of wisely choosing the groups again. The teacher spent a lot of time trying to get people to work together. Those groups who were ready to work together (not necessarily the ones who were motivated from the beginning) got a lot out of the unit, while those with difficulties in working as a group lost interest soon, regardless of the motivating effects of the materials. This of course also depends on how well the teacher knows the students, and whether the teacher wants to choose the groups or let the students do it.

CASE STUDY 9

Title of case study **Problems of Roofs**
Origin of case study CZ Team

Description

This article describes the verification of worksheets on geometry in connection with the practical problems of architects' work. It includes the analysis of the worksheet and the evaluation of a student and teacher questionnaire.

Target Audience 12 – 16 year-old students
Key words problem of roofs
Delivery method/s worksheets

Background

The instruction was done at the secondary school in Olomouc, Zeyer Street, in the school year 2007/2008. The total number of respondents was 190, out of this number there were 85 girls and 105 boys. The topic and worksheets were taken from the materials by Josef Molnár, Jana Stránská and Diana Šteflová, which were processed within the frame of the previous project of the Socrates programme – Comenius: "Promote MSc". The lesson was realized by RNDr. Slavomíra Schubertová, Ph.D., who was a teacher at that school and a postgraduate at the Department of Algebra and Geometry at Palacký University in Olomouc.

Content

I. Introduction
II. Study
III. Analysis of the worksheet
IV. Evaluation of a student questionnaire and a teacher questionnaire

Evaluation

At first the teacher motivated pupils to the architect's work and showed them interesting practical problems of roofs. Pupils were captivated by the useful and meaningful teaching. The worksheet was a creative activity. All pupils were concentrated, captivated, successful and worked by themselves. They were gradually improving in solving problems as they were gaining experience and skills. This absorbing subject matter was the impulse for them to notice various architectural elements more and this topic motivated older pupils so much that it could influence their choice of profession. Girls were more successful, more accurate, more careful and more conscientious in solving problems. In the lesson the pupils showed an extraordinary interest in these problems. Samples of application convinced pupils of usefulness of geometry and motivated them.

Recommendations for good practice

The teaching was done with pupils aged 12 – 16 at the secondary school in Olomouc, Zeyer Street, in the school year 2007/2008. The total number of respondents was 190, out of this number there were 85 girls and 105 boys.

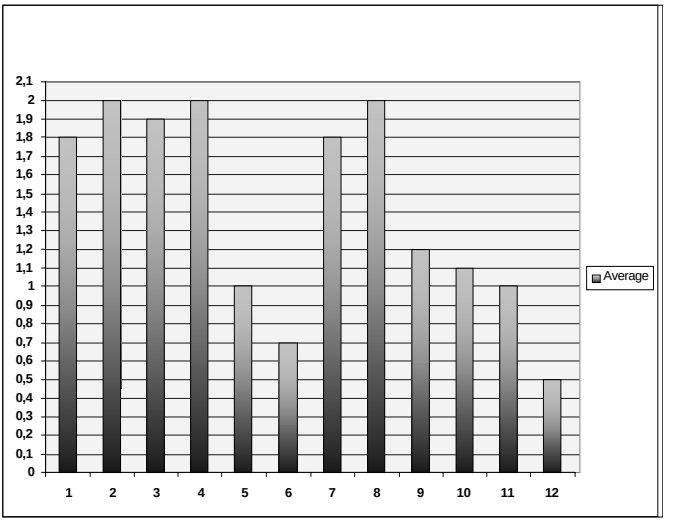
At first the teacher, RNDr. Slavomíra Schubertová, Ph.D., motivated pupils to the architect's work and showed them interesting practical problems of roofs. Pupils were captivated by the useful and meaningful teaching. Then every pupil was given a worksheet with individual problems whose difficulty and complication gradually increased. Pupils wrote their solutions straight on the worksheet that was then assessed. Every respondent worked at his own rate. It was an active creative activity. All pupils were concentrated, captivated, successful and worked by themselves.

Points were awarded for each task in the following way: a pupil was given 1 point for an attempt on a solution, 2 points for a partial solution and 3 points for the complete correct solution. The average score per task is stated in the following table.

Table 1: Average score per task over all respondents – 190 pupils of secondary school

Task	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Average	1,8	2,0	1,9	2,0	1,0	0,7	1,8	2,0	1,2	1,1	1,0	0,5

Graph 1: Average score per task over all respondents



The tasks 4 and 8 appeared as very successful. Fifty-nine respondents solved both of them correctly. Pupils gradually improved in solving problems as they were gaining experience and skills.

Table 2: Number of pupils who solved a certain problem correctly

Task	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Successful solutions	47	47	50	59	2	5	50	59	7	3	3	0

Table 3: Individual tasks are arranged according to the number of successful solutions

Task	**4**	**8**	**7**	**3**	**1**	**2**	**9**	**6**	**10**	**11**	**5**	**12**
Successful solutions	59	59	50	50	47	47	7	5	3	3	2	0

This interesting topic motivated older pupils so much that it could influence their choice of profession. This absorbing subject matter was the impulse for

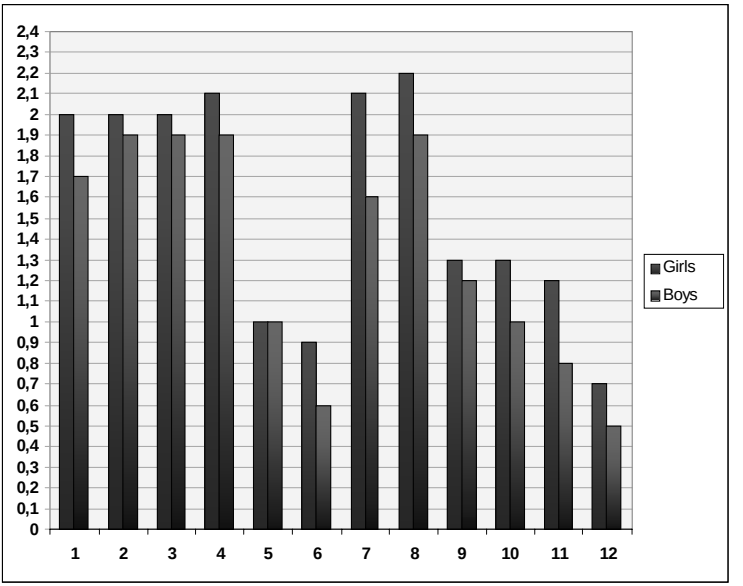
them to notice various architectural elements more. The worksheet provided pupils with creative activity with the possibility of realization, the choice of problems with different difficulty. These things encouraged the success of all pupils.

Girls were more successful, more accurate, more careful and more conscientious in solving problems.

Table 4: Average number of successful solutions achieved by girls and boys

Task	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Girls	2,0	2,0	2,0	2,1	1,0	0,9	2,1	2,2	1,3	1,3	1,2	0,7
Boys	1,7	1,9	1,9	1,9	1,0	0,6	1,9	1,9	1,2	1,0	0,8	0,5

Graph 2: Average number of successful solutions achieved by girls and boys



Then pupils were given a questionnaire which consisted of six questions. The

assessment of the first, second and third question was given with a five-point scale: I strongly agree (1), I agree (2), I am not sure (3), I disagree (4), I strongly disagree (5).

The questions were:

1. I enjoyed the lesson very much.
2. I learnt something new.
3. We did interesting things in the lesson.

Table 5: 42 pupils completed the questionnaire

	(1) I strongly agree	**(2) I agree**	**(3) I am not sure**	**(4) I disagree**
Question 1	10 (23,8 %)	30 (71,4 %)	2 (4,8 %)	0
Question 2	3 (7,1 %)	22 (52,4 %)	16 (38,1%)	1 (2,4 %)
Question 3	11 (26,2 %)	30 (71,4 %)	1 (2,4 %)	0

4. What did you find the most enjoyable in the lesson and why?
   - we did something new instead of the normal lesson
   - we have learnt how roofs look from the air
   - observing of different kinds and constructions of roofs and their adaptation to certain conditions
   - kinds of roofs – I did not know that they could be so rugged and complex
   - drawing roofs
   - I tried to design a roof
   - roofs, because it was funny
   - practising the precision of geometry
   - drawing
   - everything because we were not learning
   - drawing was funny because I like it
   - it was something new we had not known before
   - it was a fine change

- the moment when the teacher was showing us the houses because they were interesting

5. What did you find the least enjoyable in the lesson and why?
   - I did not enjoy it towards the end of the lesson
   - some constructions were difficult for me
   - everything was amusing and interesting
   - the smallest and easiest roofs were the least amusing because they were not so exciting
   - the accuracy of the pictures was the least interesting
   - drawing by ruler because I could not find it

6. I would like to find out more about:

Teacher's answers

1. PROMOTE material is useful and helps to support the instruction 1
2. The delivery methods were suitably chose 1
3. The pupils/students were captivated by the material 1
4. The delivery methods activated the pupils/students 1
5. The material suited me 1
6. The delivery methods suited me 1
7. What were the positive things about the chosen material and method?
   - The pupils were interested in the topic, were active and captivated. Also weaker students enjoyed the lesson when they worked at their own rate.
8. What do you recommend to be changed about the chosen material and method?
   - The method of worksheets suited me, the material was chosen well.

CASE STUDY 10

Title of case study	**Activities Developing the Spatial Imagination**
Origin of case study	Czech team

Description

This article describes the activities which were used in the lesson that was aimed at developing the spatial imagination. It includes the analysis of the lesson and the evaluation of a student and trainee teacher questionnaire.

Target Audience	13 – 14 year-old students
Key words	cards, cube, cube net, dice, level competition, spatial imagination
Delivery method/s	small group work, collaborative learning, problem-based learning

Background

The instruction was done at the grammar school in Olomouc (Gymnázium Olomouc – Hejčín) in the school year 2008/2009. It took one lesson and 28 pupils participated in it. Some materials for the lesson, such as Painted Cube created by Norman Smith, were taken from a handbook, *Provide Motivation Through Exciting Materials in Mathematics and Science.* The lesson was created and realized by Bc. Alena Ondráčková, a trainee teacher of Master Programme of Teaching Training in Mathematics for Secondary Schools at Palacký University in Olomouc, during her first teaching practice.

Content

7. Introduction
8. Study
9. Evaluation of a student questionnaire and a trainee teacher questionnaire

Evaluation

According to the completed questionnaires, the pupils enjoyed the lesson, especially the card game and the competition with levels. They appreciated mainly the work in teams. However, the problems used during the instruction

were not much new for them and seemed to be too easy for some. The pupils considered the activity of furnishing the living room as boring and the least enjoyable. The combination of competition and team work was very successful in this class, which was a very good class and the cooperation with them was excellent. The chosen methods took advantage of the pupils' competitiveness effectively, so there was no need to motivate them more.

Recommendations for good practice

A teacher who teaches the class regularly will know the exact level of their knowledge and competences, so they can easily adapt the difficulty of the problems to the pupils.

The instruction was done at the grammar school in Olomouc (Gymnázium Olomouc – Hejčín) in the school year 2008/2009. 28 pupils aged 13 – 14 years old participated in it. The lesson was created and realized by Bc. Alena Ondráčková, a trainee teacher of Master Programme of Teaching Training in Mathematics for Secondary Schools, during her first teaching practice.

The lesson was divided into several activities to prevent pupils from being bored. The core was the small group work. The division into groups of four was done very smoothly and easily. It showed that the students were willing and open to cooperate both with the trainee teacher and with one another.

The first activity was a card game that should motivate the students and introduced them to the topic of the lesson, i.e. development of the spatial imagination. However, on the cards there were no traditional pictures, but there were mathematical problems. The pupils put together the pairs – the problem and its solution – and tried to get rid of their cards as soon as possible. One card was single, so it had to remain in somebody's hands and this was the loser of this game. On that card a word was written – a cube, which meant partly the topic of the lesson and partly the following activity that was a quick revision of their knowledge about the cube. The game received very warm response from the pupils and enthusiastic shouting could be heard during the game.

The next activity was “the furnishing of the living room”. Pupils got two different cube nets and should draw given pieces of furniture on “the floor”, on “the ceiling” and on “the walls” of the room in correct projection. Each group was also given a dice to help pupils with less developed spatial imagination. A time limit of their sketching was ten minutes but most of the pupils were not very interested in it so they handed their “living rooms” after five minutes.

The last activity was an eight-level competition with problem-based tasks. The

pupils were still working in groups. At the beginning of the game, each team was given the first level – a piece of paper with a few problems. When they solved it, they came to the trainee teacher to check their answers. If all was correct, they proceeded to the next level and got new tasks. When there was a mistake, the group stayed at that level until they came with right solutions. Natural competitiveness was motivating enough for the pupils to try to solve it as fast as possible. Each level consisted of a few tasks concerned with the spatial imagination, such as views at the solids, cube nets, rotating or inverting solids. Given problems were similar to those that were used in the entrance exams to Masaryk University in Brno. Even though such tasks are solved by applicants of the university, the pupils didn't have big problems with them and worked very quickly. Although the first three teams had already solved all eight levels, the rest of the teams continued solving and tried to get as far as possible. More than a half of the teams did all eight levels. It could be seen during the game that the pupils liked this competition, which was confirmed by their answers in the questionnaire.

At the end of the lesson, the best sketches of the living room were evaluated.

At last pupils were asked to fill in a questionnaire.

The questions were:

V. I enjoyed the lesson very much.

VI. I learnt something new.

VII. We did interesting things in the lesson.

Table 1: The questionnaire was filled in by 27 pupils.

	(1) I strongly agree	**(2) I agree**	**(3) I am not sure**	**(4) I disagree**	**(5) I strongly disagree**
Question 1	20	5	1	0	1
Question 2	4	7	6	8	2
Question 3	16	6	4	0	1

What did you find the most enjoyable in the lesson and why?

1. running (originality), team work (cooperation)
2. team work
3. the card game
4. group work, the card game
5. everything because we didn't have to learn anything and it was fun
6. that we got a dice
7. the level game in groups and also the card game because it was in groups as well
8. everything because it was something completely different and because it was team work
9. the game with levels, adrenaline + knowledge
10. the last game in groups – excellent combination of team work and swiftness in the form of competition
11. that we competed with other teams and we tried to be the best
12. competitions in teams
13. three dimensional solids, group work
14. the level game and cooperation in groups
15. the way how the lesson was managed
16. it was something completely different, it wasn't boring

What did you find the least enjoyable in the lesson and why?

1. nothing
2. competition (we were losers)
3. I don't know
4. I liked everything
5. the cube net – drawing
6. some problems were quite easy but at least we didn't have to work hard
7. drawing of the living room – I can't draw
8. nothing, I enjoyed everything
9. I don't know if there was something the least enjoyable but in my opinion there wasn't

10. maybe nothing was out
11. cards
12. maybe the living rooms because they were very primitive
13. that we have seen such problems several times before

I would like to find out more about:

- the way of solving problems
- the living room
- mathematics
- three dimensional solids
- more tasks on rotating solids
- when I don't know anything I can't write what I don't know
- new pedagogical methods
- I don't know
- nothing
- brain-teasers

Trainee teacher's answers

7. PROMOTE material is useful and helps to support the instruction 2
8. The delivery methods were suitably chosen 1
9. The pupils/students were captivated by the material 2
10. The delivery methods activated the pupils/students 1
11. The material suited me 2
12. The delivery methods suited me 1

9. What were the positive things about the chosen material and method?
   - The chosen methods took advantage of the pupils' competitiveness effectively, so there was no need to motivate them more.
10. What do you recommend to be changed about the chosen material and method?
    - To adapt the material better to the pupils' level of knowledge

CASE STUDY 11

Title of case study **Wave motion**
Origin of case study CZ Team

Description

This topics starts with a p**r**esentation of various types of wave motion

Target Audience Students in the age range 15-16 years
Key words Wave motion, mechanical and electromagnetic waves, longitudinal mechanical motion waves
Delivery method/s Work in groups, work in pairs, discussion, inquiry

Background

A teacher from a grammar school in Olomouc designed these lessons. Gymnázium Olomouc-Hejčín is renowned as one of the top secondary grammar schools in the Czech Republic. Through a rigorous study programmme, students are challenged to succeed academically and prepared to excel at university level.

The school is equipped with modern teaching and information technology facilities. It has 2 specialized Physics laboratories as well as other specialized laboratories (for Chemistry and Biology) and a number of specialized classrooms (for Physics x2, Chemistry, Mathematics, Geography, Arts and Music lessons). A recent innovation is the new multimedia classrooms where lessons of any subjects can be taught through the medium of computers. All the school computers are connected to the internet by high-speed optical cables.

Content

Various types of wave motion

Experiments and basic physical quantities

Evaluation

Most of the students enjoyed these lessons. Students preferred the learning activities, working in groups and doing experiments. Most of the students

prepared experiments at home. Presentations of experiments demonstrated that students are good thinkers and liked to present these experiments.

Recommendations for good practice

Let students summarise physical quantities; frequency, period, velocity of wave motion, wavelength and amplitude and the relationship between these quantities. Let them then repeat the conditions for stationary waves.

Let students in pairs, write down examples of waves and wave motion in everyday life. Then in groups (6 persons), put their ideas together and make one solution.

Let students discuss together various types of wave motion and write the kinds of motion on the board. Students can then make a table with the examples from everyday life.

Wave motion

Background

Jiri Kvapil designed these lessons**.** These topics were published in PROMOTE MSc materials. The teacher used the teaching methods that were described in MOTIVATE ME methods. Jiri started his teaching career at the grammar school in Olomouc a few years ago. It was his first teaching position. He is very satisfied with the teaching of physics and mathematics because students are talented and highly motivated there. He does not plan to change school at this time. Jiri wants to share his experience of how to teach wave motion with others. He divided this topic into 2 lessons (45 minutes each):

Lesson 1

Topic: Various types of wave motion

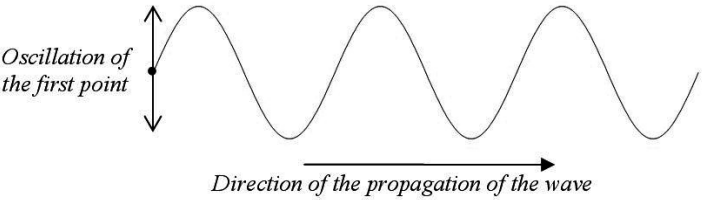
1 Presentation of various types of wave motion

The teacher **s**howed some examples of wave motion (show a short video, if possible).

a) Transverse mechanical and electromagnetic waves

E.g. switch the radio (or something similar) on, slinky (walking spring toy) on the floor (oscillates transversely related to the length of the spring), undulating

rope (one end is fixed, the oscillating hand holds the other one), play a stringed instrument.



b) Longitudinal mechanical motion waves

E.g. slinky on the floor (oscillates longitudinally related to the length of the spring).

2 Work in pairs

Students made pairs and wrote down examples of waves and wave motion in everyday life.

3 Work in groups

Students made groups (6 persons), put their ideas together and made one solution.

4 Discussion

Students discussed together various types of wave motion and wrote the kinds of motion on the board. They made a table with the examples from everyday life.

5 Group work

Students chose one or more suitable examples (e.g. wave motion on the elastic string). Groups were asked to design an experiment, which demonstrates a particular type of mechanical waves. They were asked to take cheap materials or a simple equipment and present it to the other groups (next lesson).

6 Discussion of projects

The groups chose together (or chose individually) the type of demonstration, which each group would prepare for the next lesson. They could prepare "The teacher's experiment" (It could be the same ☺).

The teacher's experiment (important for the next lessons) consisted of coloured elastic string (length 5 metres), an electric shaver or another source of oscillating movement, a stopwatch and a tape measure.

Lesson 2

Topic: Experiments and basic physical quantities

1 Experiments prepared at home

Presentations of experiments prepared at home. Students showed elementary phenomena connected with wave motion (e.g. reflection, interference).

2 Basic physical quantities and their measuring (and calculation)

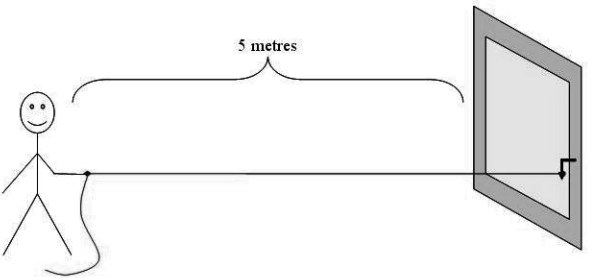
Students fastened one end of a coloured elastic string to the wall (or, for example, a window handle), then tightened the string and held it in their hand.

Then students vibrated the string with the other hand. Students could observe the speed of motion. They would also notice the reflection of the wave motion at the end of the string.

Students changed the tension in the string and then vibrated the string again; it changed the speed of the motion. Students could discover the relationship between the tension of the string (a bond between particles) and the speed of mechanical wave motion.

The teacher gave the students a chance to find out the velocity of the wave. When students had a source of oscillatory motion (e.g. an electric shaver), they could also find out the wavelength, the period and the frequency of the source.

Students held the tightened elastic string so that the distance between one end and the point in their hand was 5 metres. Students prepared a stopwatch. Now they vibrated the string and measured the time the impulse needed to go there and back, three times.



3 Summary

Students summarised the physical quantities; frequency, period, velocity of wave motion, wavelength and amplitude and relations between these quantities. Then they repeated the conditions for stationary waves. The following teaching methods were used: group work, discussion, students´ experiments, homework, inquiry, investigations, problem solving.

4 Analysis

All students received the questionnaires and filled them in immediately after these 2 lessons. Most of the students enjoyed the lessons. From the questionnaire, 32 % strongly agreed and 38 % agreed with this question. Some students were not sure (24 %) and 6 % of students disagreed. Students learnt some new things (27 % of students strongly agreed, 34 % agreed and 10 % disagreed). Students did interesting things in the lessons (68 % strongly agreed or agreed). Students found doing experiments the most interesting and enjoyable aspect and also to have the opportunity to demonstrate experiments that were prepared at home. They enjoyed the lessons (2) because no oral exams leading to marks were realized. Some students did not like to work in groups (3 students). Four students did not enjoy the topic because they did not like physics at all. They considered that this topic was boring and the knowledge would not be important when they left school.

CASE STUDY 12

Title of case study	**Phenomena connected with the wave motion – reflection and refraction**
Origin of case study	CZ Team

Description

When students know various types of wave motion, students can study phenomena connected with the wave motion.

Target Audience	Students in the age range 15-16 years
Key words	Reflection, refraction, law of reflection, Snell´s formula
Delivery method/s	Work in groups, discussion, students´ experiments, inquiry, demonstration, investigations, problem-based learning

Background

A teacher from a grammar school in Olomouc designed these lessons. Gymnázium Olomouc-Hejčín is renowned as one of the top secondary grammar schools in the Czech Republic. Through a rigorous study programmme, students are challenged to succeed academically and prepared to excel at university level.

The school is equipped with modern teaching and information technology facilities. It has 2 specialized Physics laboratories as well as other specialized laboratories (for Chemistry and Biology) and a number of specialized classrooms (Physics x2, Chemistry, Mathematics, Geography, Arts and Music). A recent innovation is new multimedia classrooms where lessons of any subjects can be taught through the medium of computers. All the school computers are connected to the internet by high-speed optical cables.

Content

Phenomena connected with the wave motion

Reflection and refraction

Snell´s formula

Evaluation

When students know various types of wave motion, students can study phenomena connected with the wave motion. The teacher planned this topic for one lesson. In this lesson students were able to understand applications of the reflection law and Snell´s law in their everyday life. The lesson was based on experiments.

Recommendations for good practice

The law of reflection can be shown with a little plane mirror and laser. Point a laser into the mirror and change the angle of incidence. Watch the track of the reflected beam. You can see that changes in the angle of reflection are the same as the changes in the angle of incidence.

ATTENTION!!! Keep the laser beam away from eyes!!!

Phenomena connected with the wave motion – Reflection and refraction

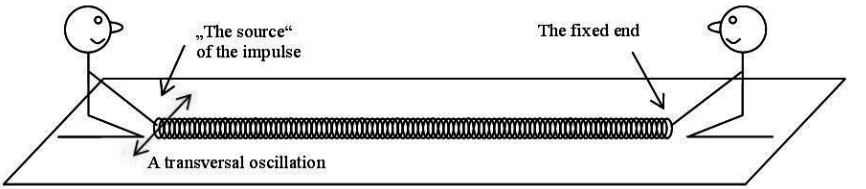
1 Introduction

The teacher motivated the students and explained to them that phenomena connected with wave motion are very important for all people and their everyday lives.

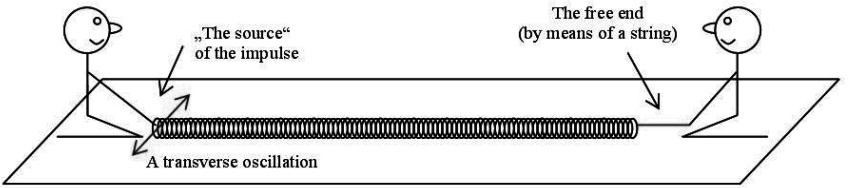
2 Reflection – mechanical wave motion

Students already knew this phenomenon from the previous lesson. The mechanical wave on the string was reflected with the **opposite** phase (in the case of reflection on the **fixed** end). Students repeated this experiment: vibrating the tightened string. Students observed the reflection.

Both kinds of reflection can be demonstrated easily by means of a ‘slinky’. Take the slinky and place it on a smooth floor.



The first part of the experiment is the reflection on the **fixed** end. One student holds the first end (fixed), another student holds the other end. It is the source of oscillation. The student tightens the slinky and then the second student makes one oscillation (transverse impulse). Here students can see the reflection with the **opposite** phase on the **fixed** end.



The second part of the experiment is reflection on the **free** end. Students tie up a piece of string (about 0.5 metre) to the first end. One student holds this end through the tightened string, the other one holds again the other end as a source of oscillation. Students tighten the slinky spring and then the other student makes one oscillation (transverse impulse). Here students could observe the reflection with the **same** phase on the **free** end.

3 Reflection of light

Very important applications of this wave phenomenon are seen in traffic. Everybody knows rear-view mirrors. These are convex mirrors (because the field of view is bigger) in which the situation behind the car is reflected. The law of reflection was shown with a little plane mirror and laser. The teacher pointed a laser into the mirror and changed the angle of incidence. Students

watched the track of the reflected beam. They observed that changes to the angle of reflection were the same as the changes to the angle of incidence.

4 Refraction

The next phenomenon connected with the wave motion is refraction. The best-known example is a rod in water. For example, place a drinking straw in a glass of water (but a small transparent aquarium is better). The teacher allowed students to observe this from various angles and think about what is an optical illusion and what is reality.

5 Snell's formula

Snell's law of refraction describes this phenomenon. The teacher helped students to define a new physical quantity and to describe the speed of the wave in an optical medium.

6 Summary

Students repeated these two wave phenomena and their formulas. The following teaching methods were used: work in groups, discussion, students´ experiments, inquiry, demonstration, investigations, problem-based learning

7 Analysis

Most of the students enjoyed the lessons. From the questionnaire, 25 % strongly agreed and 35 % agreed with this question. Some students were not sure (14 %) and 6 % of students disagreed. Some students did not give a reply (20 %). Students learnt some new things (23 % of students strongly agreed, 46 % agreed and 10 % disagreed). Students did interesting things in the lessons (78 % strongly agreed or agreed). Students found the most interesting and enjoyable aspect was to do their experiments. They liked to do presentations. Some students (3) found that the tasks were interesting, for some of them (2) they were boring. Some students stated that this topic was not interesting and the knowledge they gained would not be important when they left school. They did not like to study old fashioned information (Snell´s formula).

CASE STUDY 13

Title of case study	**Consecutive Numbers**
Origin of case study	IT Team

Description

Activity about the relationship between consecutive numbers.

Target Audience	3rd Lower Secondary School
Key words	Consecutive numbers, problem based learning, discussion and debate
Delivery methods	problem based learning, discussion and debate

Background

The activity was carried out with 19 students of 3rd Lower Secondary School "Publio Virgilio Marone" in Palermo, they were 12-13 years old. The work was done in non-curricular time. The Mathematics teacher was present during the entire activity. This class was one of the best classes in the school.

Content

Examining and proving a relationship between consecutive numbers: *Take three consecutive numbers, square the middle term and multiply the first and last together and compare. Extend to five consecutive numbers, …,* n *consecutive numbers.*

Evaluation

The teacher adopted the methodology of *problem based learning* to develop students' skills about finding relationships among consecutive numbers. The students worked individually to accomplish the task. Later they had a discussion and debate about their solution, in which the guidance role of the teacher was fundamental. At the end of the discussion the general rule was found. The teaching method was well balanced, between individual and cooperative work. During the individual work, students reached various levels of understanding, using different strategies. This activity proved to be very motivating for students. They were involved in a challenge in which they used

familiar quantities like *natural numbers.* They also enjoyed discovering themselves a rule instead of the simple application of it.

Recommendations for good practice

Many students found it very surprising to obtain relations beetween numbers, but they were not sure about the general validity. It stresses that students are not used to discover relations between numbers and, in general, between variables of a problem. It is due to low attention paid to using their own knowledge in dynamic way. It is suggested individual work by students and subsequent discussion and debate in which the guidance role of the teacher is fundamental.

Consecutive numbers

Topic

The teaching activity was concerned with the examining and proving of a relationship between consecutive numbers. It was conducted and analyzed by the Italian team

Target and background

The activity was carried out in a 19 students class of 3rd Lower Secondary School "Publio Virgilio Marone" in Palermo, 12-13 years old. This class was one of the best classes in the school. In the course of studies the pupils attended Mathematics for three hours a week. In their Mathematics curriculum they studied: Arithmetic, Geometry (2 and 3 dimensions), first approach to algebraic concepts (variables, simple equations).

Contents, Methodology and Results

The teacher adopted the methodology of *problem based learning* to develop students' skills about finding relationships among consecutive numbers.

First, the students worked individually to accomplish the following task: *Take three consecutive numbers, square the middle term and multiply the first and last together and compare. Extend to five consecutive numbers, …,* n *consecutive numbers.*

They worked in a very serious way, demonstrating engagement and interest. Students reached various levels of understanding, using different strategies to accomplish the task.

An a priori analysis of the expected students' behaviours was carried out. In the appendix we report the related table and graphs

(http://www.motivatememathsscience.eu/)

From these data it is notable that all the students knew consecutive numbers and how to operate on natural numbers. They knew how to operate on polynomials (binomial square and the product of polynomials). Just two students did not know how to operate on exponents.

In the first step of the task all students proceeded numerically on terns of numbers and 7 of them argued in natural language their procedures. Also 15 students formalized on terns of consecutive numbers: $n(n + 1)(n + 2)$. This is a noticeable result, considering the age of students.

In the second step of the task, 15 students proceeded numerically on finite *n*-ple of numbers and formalized the rule, but nobody used natural language to explain it. 10 students recognized the patterns of first level, that is terms of numbers, formalizing this case. They used simple forms of algebraic thought, using variables. Only 4 students recognized the patterns of second level, that is *n*-ple of numbers, trying to define a general case. Just one girl found the parametric form of the general case. 2 students did not accomplish the task at all.

After the individual test, the students had a discussion and debate about the topic of the test. During the discussion, in which the guidance role of the teacher was fundamental, they compared the various strategies adopted and solutions found.

Any contributions to the conversation was accepted from anyone involved in the discussion and various ideas emerged and evolved in ways which have not been predetermined by the teacher, who influenced the discussion in a conclusive way, inserting himself with interventions planned in preparation.

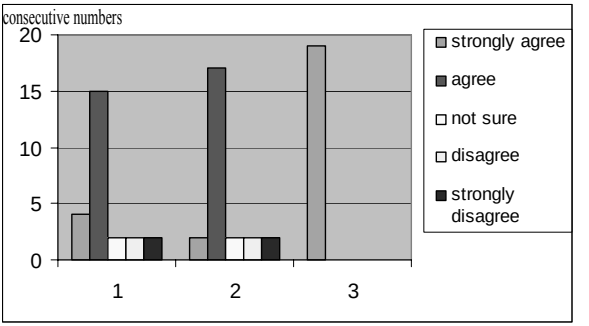
At the end of the discussion the general rule was shown.

Evaluation

This activity proved to be very motivating for students. They were involved in a challenge in which they used familiar quantities like *natural numbers.* They

also enjoyed discovering for themselves a rule instead of simple application of it, as normally happens in a classroom.

The standard MOTIVATE ME's questionnaire about students' motivation was submitted to pupils. The following graph points the results of first 3 questions (closed-type answers):



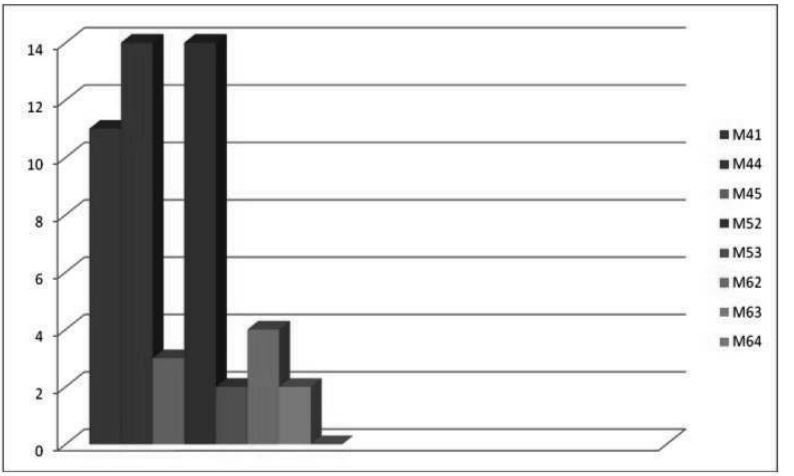
1. I enjoyed the lesson,
2. I learnt some new things
3. I did interesting things in the lesson

The graph shows that in questions n. 1 and 2 the majority of the students chose the option "agree". All students were strongly agreed about the interest of the lesson. This result confirms that the students were motivated and involved in this activity. This way of working resulted innovative with respect to the usual didactical method. It is confirmed also by the answers to the remaining questions.

About the questions n. 4, 5 and 6 an analysis of the more significant answers was carried out as follows:

	Question n. 4: What did you find the most interesting and enjoyable in the lesson, and why?
M4.1	*I never made this kind of exercise before*
M4.4	*It is very surprising to find these relations beetween numbers. But I'm not sure that it is always true*
M4.5	*I read a book before including this relationship but I never made an*

	exercise on it.
	Question n. 5: What did you find the least interesting and enjoyable in the lesson, and why?
M5.2	*I didn't understand the problem.*
M5.3	*I found the activity not very interesting*
	Question n. 6: I would like to find out more about
M6.2	*Could I do the same with all numbers?*
M6.3	*Algebra*
M6.4	*Mathematical games*



The question 4 graph shows that 11 students had never carried out this kind of exercise before. It confirms the innovative aspect of the activity.

Many students found it very surprising to obtain relations between numbers, but they were not sure about the general validity. It stresses that students are not used to discover relations between numbers and, in general, between variables of a problem. It is due to low attention paid to using their own knowledge in a dynamic way. Instead the *problem based learning* method adopted in this activity prepares students to think critically and analytically.

During the discussion students found it interesting and enjoyable to compare their own ideas and opinions with schoolmates. It supports the validity of the teaching method of discussion and debate in which any contributions to the conversation are accepted from anyone involved in the discussion.

The answer *I used some of the known rules* stresses out that a student feels interesting and enjoyable applying own knowledges and cognitive resources to solve new problems. This is one of the strength points of the *problem based learning*

The occurences of answers like *Relation beetween numbers* of the question n. 6 show that this activity gave the students new interest and motivation in working about relations between numbers and stimulates their curiosity.

Recommendations for good practice

Many students found it very surprising to obtain relations beetween numbers, but they were not sure about general validity. It stresses that students are not used to discover relations between numbers and, in general, between variables of a problem. It is due to low attention paid in using their own knowledge in a dynamic way in curricular courses. On the contrary, the activity has innovative aspects with respect to the normal didactical practice. Also the method adopted by the teacher is recommended because the students have the possibility to reflect individually upon the problem and then to compare their own result with schoolmates. It stimulates students' curiosity and using their cognitive resources. It also prepares students to think critically and analytically.

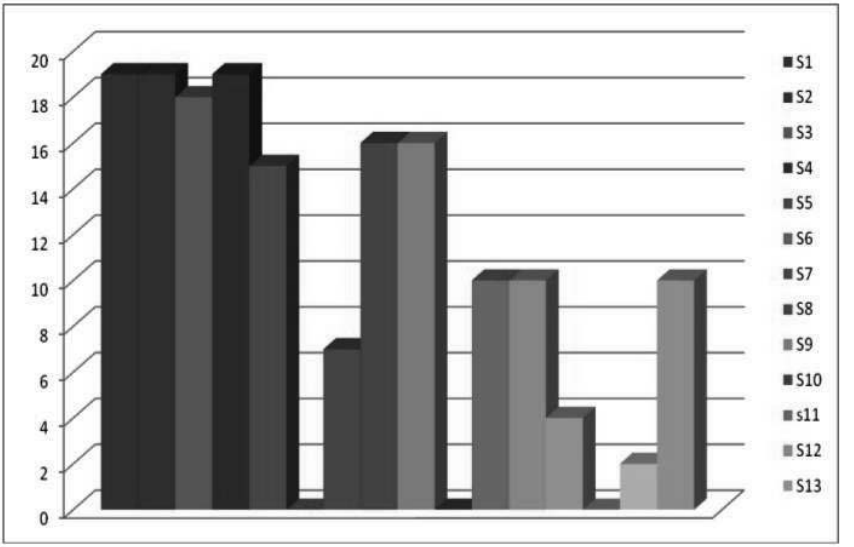
The activity is also easily repliable. In fact, the requested background and didactical tools are elementary. It is a noticeable point of strength.

APPENDIX

An a priori analysis of expected behaviours of students during the activity was carried out. In the following table the related variables are noted.

	A priori analysis ***Consecutive Numbers***
S1	He/she knows how to operate on natural numbers
S2	He/she knows consecutive numbers
S3	He/she knows how to operate on exponents
S4	He/She numerically proceeds on terns
S5	He/She formalizes on terns of consecutive numbers: $n(n + 1)(n + 2)$
S6	He/She formalizes on terns of numbers: $a\ b\ c$
S7	He/she argues in natural language the performed numerical procedures
S8	He/She numerically proceeds on finite *n*-ple
S9	He/She formalizes on finite *n*-ple
S10	He/she argues in natural language the performed numerical procedures on *n*-ple
S11	He/she correctly "develops" the binomial square and the product of polynomials
S12	He/she recognizes the patterns of first level (terns) and argues or formalizes this case.
S13	He/she recognizes the patterns of second level (*n*-ple) and argues or formalizes the general case
S14	He/she works only with terns starting from number 1
S15	He/she doesn't accomplish the task
S16	He/she uses simple forms of algebraic thought, using variables

In the following graph are showed the occurrences of the variables as emerged from the students' protocols



CASE STUDY 14

Title of case study	**Painted Cube**
Origin of case study	*ITALY*

Description

Activity about the relationship between shape and space and algebraic generalisation..

Target Audience	3rd Lower Secondary School
Key words	Shape and space and algebraic generalisation, problem based learning, discussion and debate
Delivery methods	problem based learning, discussion and debate

Background

The activity was carried out with 19 students of 3rd Lower Secondary School "Publio Virgilio Marone" in Palermo, 12-13 years old. The work was done in non-curricular time. The Mathematics teacher was present during the entire activity. This class was one of the best classes in the school. In their Mathematics curriculum they studied: Geometry (2 and 3 dimensions), first approach to algebraic thinking.

Content

Examining and proving relationship between shape, space and relative volumes, to identify patterns and to generalise and justify their findings.

A cube with sides of 4 cm is made up of smaller cubes with sides of 1 cm. The $4 \times 4 \times 4$ cube is dipped into a paint tin and covered in red paint. How many of the smaller cubes have: 3 faces painted red?; 2 faces painted red?; 1 face painted red?; 0 faces painted red?

Investigate the problem and extend your enquiry to other sized cubes for example a $5 \times 5 \times 5$ cube.

Generalise your results for an $n \times n \times n$ sized cube and try to justify your findings.

Evaluation

The teacher adopted the methodology of *problem based learning* to develop students' skills about finding relationships between shape, space and relative generalization on the case of volumes. The students worked individually to accomplish the task. Later they had a discussion and debate about their solution, in which the guidance role of the teacher was fundamental. At the end of the discussion the general rule was found even though there were difficulties related to the phase of generalization. The teaching method was well balanced, between individual and cooperative work. During the individual work, students reached various levels of understanding, using different strategies. This activity proved motivating for students. They enjoyed discovering for themselves possible different rules on the single steps of the activity.

Recommendations for good practice

This activity is a good practice because it develops students' skills in shape and space problems and algebraic thinking, adapted to a particular geometrical context. Also because it resulted in being motivating and very interesting for students. It is suggested that individual work is carried out by students with subsequent discussion and debate with the guide of the teacher. It is recommended using Multilink cubes to allow pupils to accomplish the task with an experiential approach.

Painted cube

Topic

The activity is concerned with the investigating and proving of a relationship between shape, space and relative volumes, to identify patterns and to generalise and justify their findings. It was conducted and analyzed by Italian team.

Target and background

The activity was carried out in a class of 19 students of 3rd Lower Secondary School "Publio Virgilio Marone" in Palermo, 12-13 years old. This class was

one of the best classes in the school. In the course of studies the pupils attended Mathematics for three hours a week. In their Mathematics curriculum they studied: Geometry (2 and 3 dimensions), first approach to algebraic concepts (variables, simple equations), application of the algebraic thinking to different mathematical context (ex. Geometry).

Contents, Methodology and Results

The teacher adopted the methodology of *problem based learning* to develop students' skills about finding relationships between shape and space referred to in the case study.

First, the students worked individually to accomplish the following task: *A cube with sides of 4 cm is made up of smaller cubes with sides of 1 cm. The* $4 \times 4 \times 4$ *cube is dipped into a paint tin and covered in red paint. How many of the smaller cubes have: 3 faces painted red?; 2 faces painted red?; 1 face painted red?; 0 faces painted red? Investigate the problem and extend your enquiry to other sized cubes for example a* $5 \times 5 \times 5$ *cube. Generalise your results for an* $n \times n \times n$ *sized cube and try to justify your findings.*

They worked in a very serious way, demonstrating engagement and interest. Students reached various levels of understanding, using different strategies to accomplish the task.

An a priori analysis of the expected students' behaviours was carried out. In the appendix we report a related table and graphs

(http://www.motivatemathsscience.eu/)

From the data it is notable that all the students discerned how to operate with the presented geometrical shape, through a graphic approach. They knew how to find the relationship between shape and space on the $4 \times 4 \times 4$ cube. Just a very few students did not know how to operate on the presented cube (they declare misunderstanding of the text as the problem). The graphical approach is the preferred strategy to "investigate" the $4 \times 4 \times 4$ cube. This strategy is almost absent in the phase of generalization to the $5 \times 5 \times 5$ cube and to $n \times n \times n$ cube.

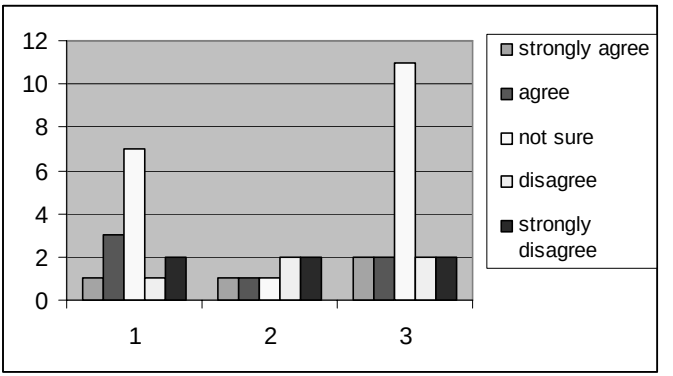
In the second step of the task, not one of the students proceeded algebraically for the generalization of the process on the different cubes. They seem to use as a first approach the idea of a variable but they put in as evidence the same difficulty in the passage from the graphical presentation (used in the case of $4 \times 4 \times 4$ cube) to the general one expressed in a algebraic form.

After the individual test, the students had a *discussion and debate* about the topic of the test. During the discussion they compared the various strategies adopted and solutions found. Every contribution to the conversation was accepted from anyone involved in the discussion and various ideas emerged and evolved in ways which have not been predetermined by the teacher. In this phase the guidance role of the teacher was fundamental in maintaining equilibrium inside the class and in influencing the discussion towards a conclusive way. So he inserted himself with interventions planned in his preparation. At the end of the discussion the general graphical/algebraic rule was shown.

Evaluation

This activity resulted in motivating the students. They enjoyed discovering for themselves possible different rule on the single steps of the game and the use of the multilink cubes for the phase of generalization and justification, instead of simple geometrical application of "formulas", as normally happens in a class.

The standard MOTIVATE ME's questionnaire about students' motivation was submitted to pupils. The following graph give the results of first 3 questions (closed-type answers):

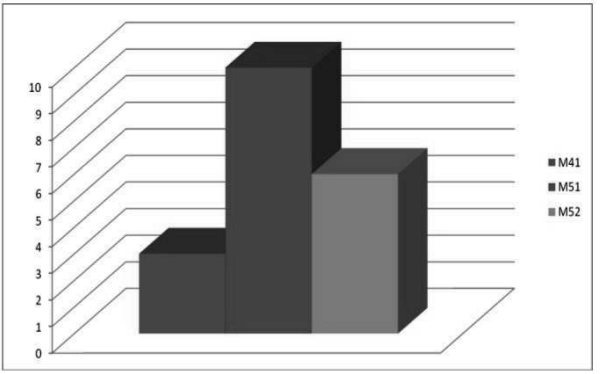


1. I enjoyed the lesson
2. I learnt some new things
3. I did interesting things in the lesson

The graph shows that not many students answered these questions, especially to question n. 2. The majority of the class chose, for questions n. 1 and 3, the answer "not sure". It could be justifiable in relation to the particular mathematical context, the geometrical one, which is always problematic for the Italian students. As told above, some students did not know how to operate on the $4 \times 4 \times 4$ cube. This difficulty could be overcome using Multilink cubes. However students had difficulty in the phase of generalization to the $5 \times 5 \times 5$ cube and to the $n \times n \times n$ cube, related to algebraic thinking. These difficulties could have caused a decrease of enjoyment and interest, that students showed when they operated graphically with $4 \times 4 \times 4$ cube. The small number of answers to question n. 2 could be due to a difficulty of student in doing a metacognition process on their knowledge. Students effectively worked and had the impression of not learning new things.

For the questions n. 4 and 5 of the standard MOTIVATE ME's questionnaire, an analysis of the more significant answers was carried out as follows:

	Question n. 4: What did you find the most interesting and enjoyable in the lesson, and why?
4.1	*I never made this kind of exercise before*
	Question n. 5: What did you find the least interesting and enjoyable in the lesson, and why?
5.1	*The language is difficolut for me. I'm not able to see the 3D of the cube. Also for the generic one*
5.2	*I didn't understand the problem.*



The graph shows that only 3 students had never carried out this kind of exercise before but 10/19 confirm their difficoluties with the translation of the problem from Naltural language to the geometrical one, declaring difficoluties on the understanding of the problem (M52).

From a verbal evaluation of the activity, it emerged that students found it interesting and enjoyable to compare their own ideas and opinions with schoolmates. It supports the validity of the teaching method of discussion and debate in which any contributions to the conversation are accepted from anyone involved in the discussion.

Recommendations for good practice

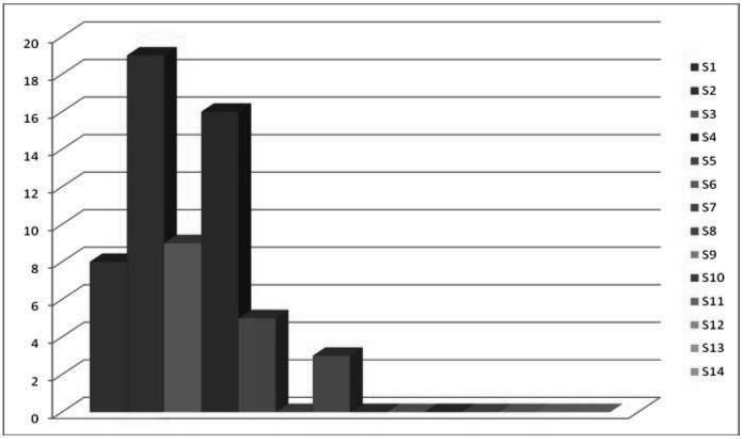
This activity can be considered good practice because it is quite motivating for students. It also develops students' skills in geometrical problems and algebraic thinking in an unusual context. The activity has innovative aspects with respect to the normal didactical practice. In fact the students are involved in using their own knowledge in dynamic way. Also the method adopted by the teacher was found to be valid because the students have the possibility to reflect individually upon the problem and afterwards compare their own results with classmates. So the method adopted is strongly recommended. The argument stimulates students' curiosity and induces students to use their cognitive resources. It also prepares students to think critically and analytically. The activity is also easily replicable. In fact, the requested background and didactical tools are elementary. It is recommended to use Multilink cubes to allow pupils to accomplish the task with an experiential approach.

Appendix

An a priori analysis of expected behaviours of students during the activity was carried out. In the following table the related variables are noted

	A priori analysis ***Painted Cube***
S1	He/she understands the text of the problem (verbally discussion on it)
S2	He/she analyzes the problem $4 \times 4 \times 4$ through a graphic approach on "Vertexes", "Faces"...
S3	He/she arguments with natural language the performed procedures
S4	He/She tries to find some relation between the different cubes and the respective positions in the space
S5	He/she underlines, even though without formalizing, a first approach to the generalization
S6	He/she formalizes in algebraic language even though with errors on the control of the used variables
S7	Calculated the demanded results for the $4 \times 4 \times 4$ cube, He/She tries to generalize on $5 \times 5 \times 5$ cub, graphically proceeding.
S8	Calculated the demanded results for the $4 \times 4 \times 4$ cube, He/She tries to generalize on $5 \times 5 \times 5$ cub, algebraically proceeding.
S9	Calculated the demanded results for the $4 \times 4 \times 4$ cube, He/She tries to generalize on $5 \times 5 \times 5$ cub, proceeding in a inductive way on the first case
S10	Calculated the demanded results for the $4 \times 4 \times 4$ cube, He/She tries to generalize, graphically proceeding.
S11	Calculated the demanded results for the $4 \times 4 \times 4$ cube, He/She tries to generalize, algebraically proceeding.
S12	Calculated the demanded results for the $4 \times 4 \times 4$ cube, He/She tries to generalize, proceeding in a inductive way on the first cases
S13	He/she underlines and an algebraic translation formalized for the general case.
S14	He/she underlines a good tridimensional view of the problem

In the following graph are showed the occurrence of the variables emerging from the students' protocols:



CASE STUDY 15

Title of case study	**The Enhanced Greenhouse Effect and Global Warming**
Origin of case study	IT Team

Description

Activity about The Enhanced Greenhouse Effect and Global Warming.

Target Audience	Upper Secondary School students, 15 years old
Key words	Greenhouse Effect, Global Warming, Computer Aided Learning, Discussion and Debate
Delivery methods	Computer Aided Learning, Discussion and Debate, Worksheets

Background

The activity was carried out with 41 students of two classes of an Upper Secondary School, students were 15 years old. The work was done in curricular time. The Physics teacher was present during the entire activity. The class involved was a mid-level class with respect to the normal Italian scholastic level

Content

The students had to go to navigate the website:

www.epa.gov/globalwarming/kids/global_warming_version2.html. It consists of a cartoon which represents a dialogue between a curious boy and a pedantic girl about an enhanced greenhouse effect and global warming. Their dialogue, in the English language, was supported by moving images that represented their discussion. The same website offers the possibility to verify the acquisition of new knowledge by an on-line test.

Evaluation

The adopted methodology was: *Computer Aided Learning*. A website constitutes the learning environment of the topic of the lesson. During the navigation, the students' curiosity was enhanced by this new tool and it increased their motivation in learning the subject. Afterwards, the students were

involved in a *Discussion and Debate* about the argument of the navigation. It was very useful for the students' learning because they focused and pointed out the main aspects of the Greenhouse Effect and Global Warming. It allowed students to share their knowledge and to bridge gaps. Every contribution to the conversation was accepted. The coordination role of the teacher was fundamental to manage the interventions and to help students during the navigation.

The activities above ware preceded and followed by the same worksheet, which consisted of eight open answer questions about topic of the lesson. So the teacher and the students also had the possibility to develop confrontation between their previous knowledge and after the navigation of the website. This lesson was found to quite motivating for students, as they were involved in a stimulating and multimedia learning environment. Also students enjoyed the possibility of studying an interesting and present-day argument like *environmental pollution.*

Recommendations for good practice

This activity is a good teaching resource because it allows students to learn present-day arguments in a pleasing and innovative way. Much more, the learning times are shortened by the multimedia approach of this lesson. It is recommended to involve the students in Discussion and Debate to share the knowledge.

The enhanced greenhouse effect and global warming

Topic

The students had to navigate the website:

www.epa.gov/globalwarming/kids/global_warming_version2.html. It consists in a cartoon which represents a dialogue between a curious boy and a pedantic girl about enhanced greenhouse effect and global warming. Their dialogue, written and recited in English language, was supported by moving images that represented the subject of their discussion. The website offers also the possibility to verify the acquisition of new knowledge by an on-line test.

The activity was conducted and analyzed by IT team.

Target and background

The activity was carried out with 41 students of two classes of the Upper Secondary School (Liceo Classico) "F. Scaduto" in Bagheria (PA). In the Lower Secondary School pupils study general Science subjects and, in particular, environmental phenomena, thermal phenomena, gasses and radiations.

Contents, Methodology and Results

In this activity, the methodology of *Computer Aided Learning* is adopted. In fact, a website constitutes the learning environment of the topic of the lesson.

During the navigation, the students were curious about the new tool and it increased their motivation in learning. The main contents of the website are: greenhouse gasses, deforestation, pollution and global warming.

Afterwards, the students were involved in a *Discussion and Debate* about the argument of the navigation. It was very useful for students' learning because they focused and pointed out the main aspects of the Greenhouse Effect and Global Warming. It allowed students to share their knowledge and to reduce gaps. Every contribution to the conversation was accepted. The coordination role of the teacher was fundamental to manage the interventions and to help students to reach the main arguments of the navigation. During the discussion the observation about what greenhouse gasses are, were very significant. In fact students did not know them exactly.

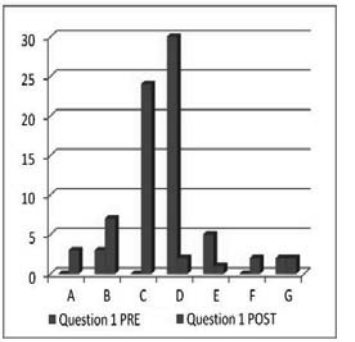
The activities above were preceded and then followed by the same worksheet, which consisted of nine open answer questions about the topic of the lesson. So the teacher and the students also had the possibility to compare the knowledge before and after the navigation.

The students worked seriously and individually on the questionnaire. In the following session the questions and the different answers of the students are shown. The blue bars are related to the pre-test, while the red ones are related to the post-test.

1. Explain two things that happen to the Sun's solar rays

ANSWERS

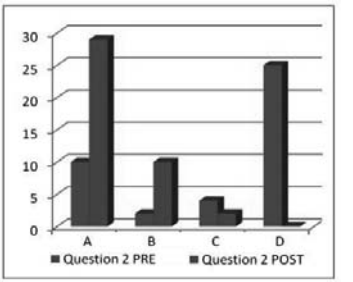
A They are reflected
B They are absorbed
C In part reflected, in part absorbed
D They warm up the Earth and its atmosphere
E They hit the Earth and then immediately reflected
F They are refracted
G No answer



2. Name the rays radiated by the Earth:

ANSWERS

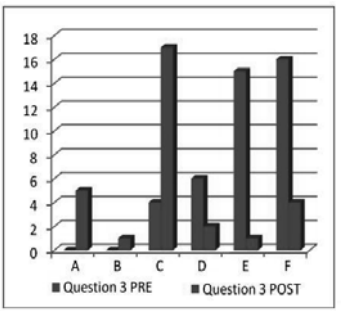
A Infrared
B Ultraviolet
C X-rays
D Heat



3. Explain two things that happen to the rays radiated by the Earth:

ANSWERS

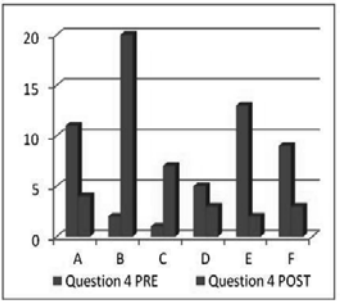
A They are reflected and are absorbed by the atmospheric water
B They make the water evaporating to the atmosphere
C They are absorbed by green house-gasses and again irradiated
D they are transformed in CO_3
E They favorite the ozone hole
F They warm up the air



4. Explain why having the right amount of 'greenhouse gases' is important:

ANSWERS

A Because they make life possible
B Because they keep Earth temperature stabile
C Because they filter solar rays/ultraviolet rays
D Because they protect Earth
E Because they warm up Earth
F Because they protect the ozone in the atmosphere



5. Explain two ways humans affect the amount of 'greenhouse-gases' in the atmosphere:

ANSWERS

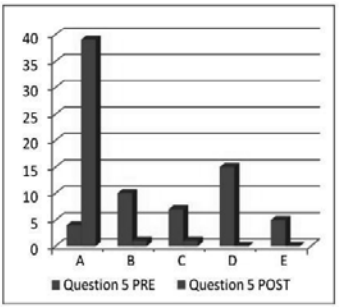
A By means of deforestation/ pollution gasses

B By means of polluting gasses

C By means of deforestation

D Heating/pollution

E No answer



6. Name and explain the origins of three fossil fuels:

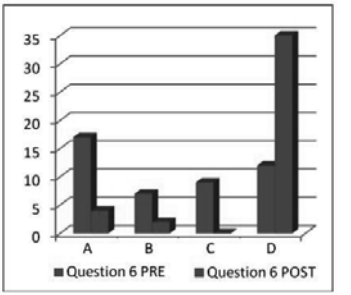
ANSWERS

A cars' exhaust gas

B Factories' exhaust gas

C CO_2

D Oil, methane, coal



7. Describe two things that raising global temperatures by even 10C could cause:

ANSWERS

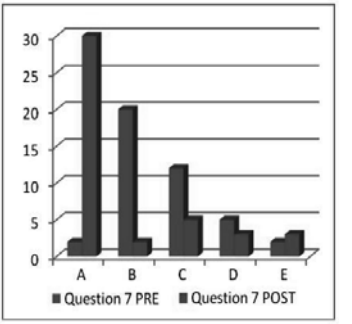
A The water cycle is enhanced, with all its consequences

B Melting of glaciers

C Damage to the ecosystem

D Rising seas

E desertification



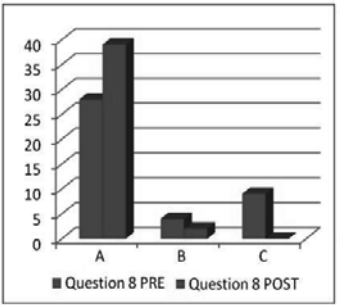
8. Describe two actions governments and people can take to reduce the impact of global warming:

ANSWERS

A Reduce pollution and deforestation

B Reduce deforestation

C Reduce pollution

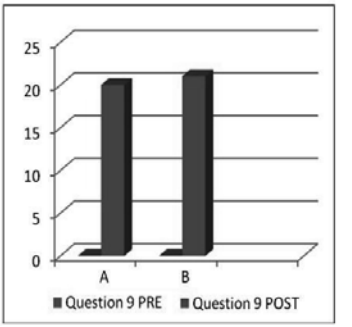


9. Explain what you learned from visiting this site:

ANSWERS

A Better understanding of already known subjects

B Learning of new concepts and ideas



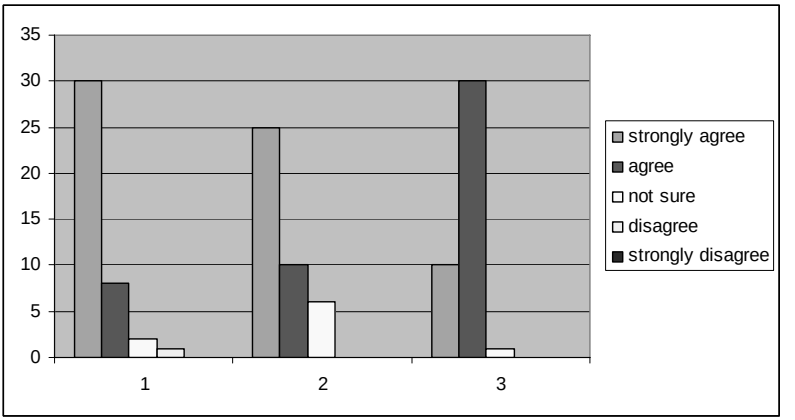
The previous graphs show the strong improvements in the conceptions and knowledge of the students about the contents of the lesson. For example, in the first graph the occurrences of answer C is significant.

Evaluation

This lesson proved to be quite motivating for students, as they were involved in a stimulating and multimedia learning environment. Also students enjoyed the possibility of studying an interesting and present-day argument like *environmental pollution.*

They showed their enthusiasm for learning during the *Discussion and Debate.* In fact, in this phase the students were strongly involved in discussion . They enjoyed proving their new knowledge.

The standard MOTIVATE ME's questionnaire about students' motivation was submitted to pupils. The following graph points the results of first 3 questions (closed-type answers):



1. I enjoyed the lesson
2. I learnt some new things
3. I did interesting things in the lesson

These results show that the majority of the students enjoyed the lesson, learnt new things and did interesting things in the lesson.

About question n. 4. *What did you find the most interesting and enjoyable in the lesson, and why*? the more significant answers were:

- Knowing more about pollution and deforestation
- The approach used (video presentation)
- Information about gasses and pollution

About question n. 5. *What did you find the least interesting and enjoyable in the lesson, and why?* the more significant answers were :

- Language used
- Poor interactivity

In the last sentence question *I would like to find out more* the more significant affermations were:

- Pollution and energy
- Ways to save environment
- Ways to present science with a motivating approach

These answers confirm that students enjoyed the lesson's argument and they would like to know much more about it. But they had some difficulties with the use of the English language, in fact the teacher had to translate the dialogue during the viewing.

Recommendations for good practice

This activity can be described as good teaching practice, as it allows students to learn present-day arguments in a pleasing and innovative way. In fact, students are involved in learning new knowledge using a multimedia environment. Much more, the learning times are shortened by the multimedia approach of this lesson. It is recommended to involve the students in Discussion and Debate to share the knowledge. The activity is also easily reproducible. In fact, the requested background and didactical tools are elementary for High Schools and the tutorial is readily available. This is a noticeable point of strength. The methods here adopted, are strongly recommended, because of very good results in terms of content and motivation of the presented activity. For non English students, it is recommended to help pupils in the correct translation of the website. Students would not be able to know all scientific terms without this help.

CASE STUDY 16

Title of case study	**Capacitor Discharge**
Origin of case study	IT Team

Description

An activity about Capacitor discharge.

Target Audience	High School students, 17-18 years old
Key words	Capacitor, discharge, problem based learning, discussion and debate
Delivery methods	problem based learning, discussion and debate

Background:

The activity was carried out with 30 students in the final class of a High School, 17-18 years old. The work was done in normal curricular time. The Physics teacher was present during the entire activity. The class involved was a mid level class with respect to normal the Italian scholastic level

Content:

The students had to consider three diagrams reproducing the oscilloscope screen, concerning three different discharge processes of the same capacitor, in which the initial voltage is different. Working on screens and on data that can be collected, students had to find a value for the time constant of the circuit, calculating the value of C (Capacity) of the capacitor.

Evaluation:

The teacher adopted the methodology of *problem based learning* , in order to develop students' skills about working on graphs and data using their previous theoretical knowledge. The students first worked individually to accomplish the task. Later, they discussed in small groups, debating about the task. At the end there was a whole class discussion, in which the coordination role of the teacher was fundamental, this was used in order to come to a consensus model about data interpretation.

The teaching method was a balanced one between individual and cooperative work. During the individual work, students reached various levels of understanding, using different strategies. This activity was found to be quite

motivating for students, as they were involved in an active way, first collecting data, then searching for data interpretation. We also point out that students seemed to enjoy the possibility of discovering by themselves results and data interpretation from a graph instead of normal school practice, in which the experiment results and the interpretations of a graph are presented by the teacher only.

Recommendations for good practice

The students encounter difficulties in applying their theoretical knowledge in real contexts. They also showed difficulties with scale and measuring units. So, the activity needs more support in reading and interpreting data from a graph. The method suggested is based on individual and group work by students and subsequent whole class discussion and debate, in which the guidance role of the teacher is fundamental.

Capacitor discharge

Topic

The students had to consider three diagrams reproducing the oscilloscope screen concerning three different discharge processes of the same capacitor, in which the initial voltage is different. Working on screens and on data that can be collected, students had to find a value for the time constant of the circuit, calculating the value of C (Capacity) of the capacitor.

The activity was conducted and analyzed by IT team.

Target and background

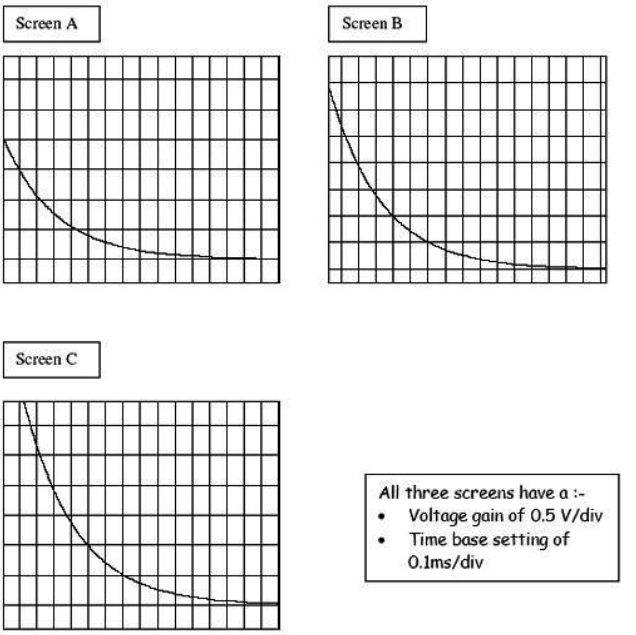
The activity was carried out with 30 students of the final class of the High School "Margherita" in Palermo. The Physics teacher was present during the entire activity. The class involved was a mid-level class with respect to normal Italian scholastic level. In their Physics curriculum student had lessons on: Electrostatics, Electric charge, Capacitors, Voltage, Electric Current. During their Physics course they have sometimes dealt with the use of an oscilloscope and related data collection, but only by watching the teacher doing that. They also used to build and analyse graphs in their mathematics course, adapting mathematical functions to experimentally collected data.

Contents, Methodology and Results

The teacher adopted the methodology of *problem based learning* , in order to develop students' skills about working on graphs and data using their previous theoretical knowledge.

First, the students worked individually on the following task:

This experiment has already been done for you, so just have to analyse the results. A capacitor, surprisingly called C, has been repeatedly discharged through a resistor, of value 297Ω, called R, using a signal generator with a square wave output. The charging voltage was set initially to a nominal 2 V, then increased twice, each time by about 1.5 V. The p.d. across the capacitor during the discharge was monitored on an oscilloscope and here are three diagrams of the oscilloscope screens:



You are to analyse the three screens and:

- find a value for the time constant for the circuit
- find the value of C the capacitor

Students worked seriously, demonstrating engagement and interest in the task. From our analysis we can infer that students reached various levels of understanding, using different strategies to accomplish the task.

From the analysis of the protocols and of the outcomes of subsequent discussion and debate, five typical students' difficulties in accomplishing the task emerged:

A: 12 students out of 30 showed difficulties concerning understanding of scale on graphs.

This is due to two principal factors:

- Low confidence with actual experimental work and data/graphs interpretation;
- Low confidence with the effective use of the measuring units they have studied before.

B: 25 students out of 30 showed difficulties concerning understanding of the meaning of RC circuit time constant, i.e. τ as the time the discharging capacitor takes to vary its voltage of about 2/3 of the initial voltage(in the approximation 1/e about equal to 1/3).

This is due to a lack of a critical and deeper approach to topics, expecially referreing to the scientific field. Besides, it means also that students have low confidence with dimensional analysis.

C: 18 students out of 30 had difficulties in finding actual values of τ from graphs in the three cases.

This is a consequence of the difficulties mentioned above; It is not so easy to reach correct results without a clear understanding of the physics laws involved.

D: 13 students out of 30 had difficulties about understanding τ values have to be the same (within experimental uncertainties) as the circuit is always the same

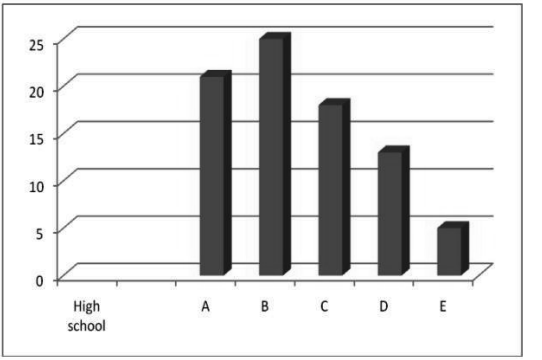
As in B, these kind of difficulties emerge because of a *non-scientific thinking*. Students are not used to work using a rigorous and coherent scientific approach to the topic.

E: 5 students out of 30 had problems in calculation.

The low percentage shows a good mean level of the mathematical skill in the classroom; when considering the five students, probably this is due to a lack in

mathematics skill and maybe also to a weak connection between theoretical knowledge and practical application.

A general view of the students'difficulties is presented in the following histogram.



After an individual test, the students had a discussion and debate about the topic of the test. During the discussion, in which the guidance role of the teacher was fundamental, they compared the individual work with their schoolmates'work and also compared results. All difficulties mentioned emerged earlier during the discussion and were stressed by the teacher in a very clear way.

Any contributions to the conversation was accepted from anyone involved in the discussion and various ideas emerged and evolved in ways which have not been predetermined by the teacher, who influenced the discussion in a conclusive way, inserting himself with interventions planned in preparation.

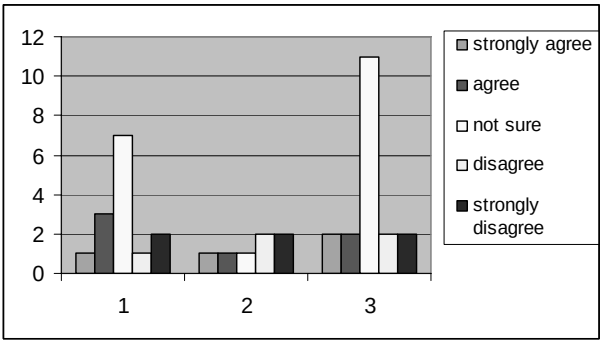
At the end of the discussion, some fundamental points were well defined, that is:

1) The role and meaning of the time constant τ in the analysis of the phenomenon.
2) The interpretation of the diagrams as three different situations of the same physical apparatus, in which the difference is due to different initial conditions.
3) The role of experimental uncertaintes.
4) The connection between the mathematical law of discharge and calculation of τ.

Evaluation

The teacher adopted the methodology of *problem based learning* , in order to develop students' skills about working on graphs and data using their previous theoretical knowledge. The students first worked individually to accomplish the task. Later, they could discuss in small groups, debating about the task. At last, a whole class discussion, in which the coordination role of the teacher was fundamental, was used in order to come to a consensus model about data interpretation. The teaching method was a balanced one between individual and cooperative work. During the individual work, students reached various levels of understanding, using different strategies. This activity proved quite motivating for students, as they were involved in an active way, first collecting data, then searching for data interpretation. We also point out that students seemed to enjoy the possibility to discover by themselves results and data interpretation from a graph instead of normal scholastic practice, in which the experiment results and the interpretations of a graph are presented by the teacher only.

The standard MOTIVATE ME's questionnaire about students' motivation was submitted to pupils. The following graph points the results of first 3 questions (closed-type answers):



The graph shows that in question n. 1 all the students chose the option "strongly agree" or "agree" . It means that they were motivated and involved in this activity. This way of working proved to be innovative with respect to the usual didactical method. However in question 2, the majority of students "are not sure" to have learnt new things, that is they stressed the fact that there were no

"novelties" in the activity. They maybe didn't appreciate the deepening in understanding of physics by experimental data and graphs. In question 3, the majority chose "agree". Like in question 1, they showed interest in the activity. The other questions are open-answer type

About question n. 4, *What did you find the most interesting and enjoyable in the lesson, and why* ? the more significant answers were :

- Obtaining data from graphs
- To calculate circuit values from data

The students found it interesting to work on data and graphs, deducting physical parameters. Like in question 1, they showed they like a school activity in which they are actively involved.

Question 5 is: *What did you find the least interesting and enjoyable in the lesson, and why*?

The more relevant answers were:

- To perform calculation
- Understanding scales
- To Extract data from graphs

It is normal for a student to consider calculations boring, while understanding scales in diagrams and extracting data implies good handling of measure units; students showed difficulties about it.

Question 6 is: *I would like to find out more* , and the more significant and quite common answer was:

- To perform experiments in electricity

The students showed clearly their interest in experimental work.

The students found it interesting and enjoyable to work on data and graphs. Frequently at school too little attention is paid to using their own knowledge in a dynamic way. Instead, a *problem based learning* method , as adopted in this activity, prepares students to critically and analytically think. During the discussion students found it interesting and enjoyable to compare their own ideas and opinions with schoolmates. This fact supports the validity of the teaching method of discussion and debate, in which any contributions to the

conversation are accepted from anyone involved in the discussion, on a peer to peer basis.

The answers to questions 4 and 6 show that students feel interesting and enjoyable applying their knowledge and cognitive resources to solve new problems. This is one of the strength points of the *problem based learning*

This kind of activity gives to students new interest and motivation in working on a topic like capacitors, which is otherwise not so stimulating for them.

Conclusions

This activity can be described as a good teaching practice, as it helps in developing students' skill in discussing and interpreting experimental data and in solving problems and also because it proved to be motivating and very interesting for students. The activity has quite innovative aspects with respect to the normal didactical practice. In fact, students are involved in using their own knowledge in a dynamic way. Moreover, the method adopted by the teacher appeared to be valid, because the students have had the possibility to individually reflect upon the problem and then compare their own result with schoolmates. It stimulates students' curiosity and brings them to use their cognitive resources in a constructive way, training students to work analytically and think critically.

The activity is also easily reproducible. In fact, the requested background and didactical tools are elementary for a final class of High School. This is a noticeable point of strength.

The methods here adopted are strongly recommended, because of very good results in terms of content and motivation of the presented activity.

CASE STUDY 17

Title of case study	**Games with fractions**
Origin of case study	SK Team

Description

The case study describes one lesson where three different activities were performed: these used individual work and two games suggested by the project PROMOTE MSc.

Target Audience	Lower secondary grammar school pupils, 13-14 years old
Key words	Motivation, competences, case study, fractions, unintentional learning, whole classroom work, pair work, motivating materials
Delivery method/s	classroom, class discussion, posing questions to the class, games, group work

Background

The lessons were promoted by PaedDr. Lubica Korenekova at Gymnázium Levice (Secondary Grammar School, town Levice). She taught two identical lessons with two different classes.

Content

1. Introduction
2. Study
3. Questionnaires evaluation.
4. Conclusions and recommendations

Evaluation

According to the analysis of the case study *Games with fractions,* we can say that the use of motivating materials on the mathematics lessons, positively influenced pupils' interest in the activities that were carried out during lessons. Furthermore, pupils were motivated to get more information and knowledge. They were learning and developing their mathematical skills and the ability to think quickly, tactically and correctly, even though not everyone realised it. So their learning was unintentional. They also had to communicate and cooperate in order to play the games.

Recommendation for good practice

The materials that were used in this case study can be changed and adapted to any level of the group of pupils. They are also suitable for mathematics seminars for future teachers.

Introduction

The topic of the two identical lessons, which were carried out in two different classes, was of fractions and mathematical operations with fractions. The aim of the lesson was to practise and strengthen the pupils' knowledge of fractions by comparing them and doing different mathematical operations with them. The pupils were supposed to:

- Change fractions to their lowest forms,
- Change fractions to a decimal number,
- Add fractions to 1,
- Compare fractions,
- Work with mathematical operations with fractions: addition, subtraction, multiplication, division.

Study

At the beginning, the lesson was not very different from **traditional mathematics lessons**. After checking homework, the pupils were asked to copy and solve simple exercises written on the board. These exercises focused on mathematical operations with fractions: multiplication, division, addition, subtraction.

The next part of the lesson was more active and playful because pupils practised the topic through two mathematical games. These games were chosen from a range of motivating materials for teaching mathematics collected in the Comenius project: **Promote MSc**. They were realised by activating some of the teaching methods from the Comenius project: Motivate Me in Mathematics and Science.

A game was used, called ***Mathematical bingo.*** When the rules of **the game** are explained, the class is divided into two **groups.** Pupils do not change their places; they stay at their desks as they sit in pairs. One of the pair belongs to group A, the other to group B. Each pupil is given a **worksheet** for the game. It consists of tables, usually divided into four lines and four columns. The tables contain certain values, which are the results of the exercises to be solved in the next stage of the game. The game starts when a teacher reads particular

mathematical operations and pupils are supposed to count by heart, find and cross out the correct result in their table. Step by step, pupils will get to the point when they have crossed four consequential squares horizontally, vertically or diagonally. This is "*bingo"*, and the moment when they are allowed to shout out this word. Mathematical operations practised by Mathematical bingo in the case study were: adding to 1; changing a fraction to its lowest form; changing a fraction to a decimal number.

A second game: ***Just a fraction more*** was also used. In the first stage, pupils are divided into pairs. Each pair is given a pack of cards. These cards are special; there is a fraction written on each of them. Numerators and denominators of fractions contain only numbers 1 to 5. Each player has 5 cards. The rest of the pack is put in the middle, so that the fractions written there can not be seen. The younger player starts by putting a card on the desk. The other player tries to choose a card with a higher value and compares his card with the one on the table. If the card he puts on the desk has a fraction of higher value, he wins both cards. Otherwise, they belong to the first player. If the values are equal, they take another round and compare their cards. The card with a fraction of a higher value wins the round and the player can take all the cards. Each round of the game should be played with 5 cards in the hand, so players take the missing cards from the pile in the middle. When there are no cards left in the middle, players finish the game with the ones they have in their hands. After the first game, players change their order and the second player starts. At the end of each game, players count their cards. The number of cards is the number of points for the game. The winner has the biggest number.

When two games in pairs are finished, two **pairs** join and create a **group** with double number of players and cards. At the end of the lesson, pupils and a teacher evaluate the activities that were done during the lesson and fill in the questionnaire.

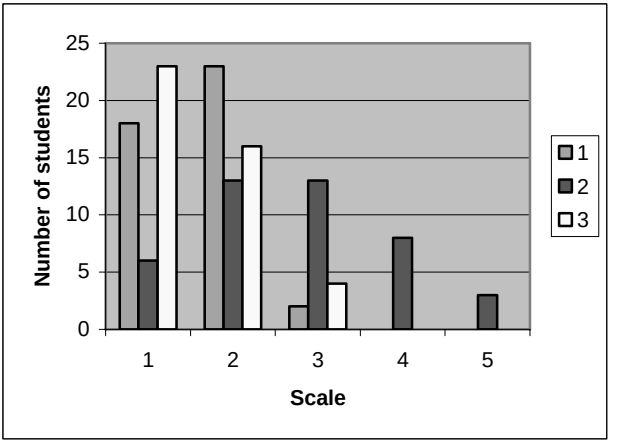
Questionnaires evaluation

The case study was carried out as the activity of the **project Motivate Me**, which has developed a questionnaire to check on pupils' motivation during the lesson. In the first part of the questionnaire, pupils were supposed to evaluate the following statements using the scale below:

1. I enjoyed the lesson.
2. I learnt some new things.
3. I did interesting things in the lesson

1 I strongly agree 2 I agree 3 I don't know 4 I disagree 5 I strongly disagree

The following graph shows the results of pupils' evaluation. There were 43 students evaluating.



According to the results that can be seen in the graph, the majority of pupils agreed with the first statement. That means they enjoyed the lesson. Despite the fact that during the lesson the topic was revised and practised, almost half of the students stated that they learnt something new. Moreover, nobody disagreed with the third statement, so each pupil thought that activities of the lesson were interesting.

In the second part of the questionnaire, pupils should answer the following open questions:

4. What did you find the most interesting and enjoyable in the lesson, and why?

5. What did you find the least interesting and enjoyable in the lesson, and why?

6. I would like to find out more about …

The evaluation of the second part of the questionnaire.

The answers of pupils to the fourth question can be divided into 3 groups.

The first group is the answers of pupils who realised that the aim of the lesson was to learn something in a different, more active and playful way. Here are some quotations:

- ✓ *„I liked that we were playing games and at the same time we have learnt something."*
- ✓ *„Bingo and a card game. It was a lesson which was special, different from the usual one, and it was connected with the topic as well."*
- ✓ *„I didn't know that mathematics can also be done in such a funny way. I have never experienced it before. I liked the fact that we had to think but it was also funny."*

In the second group are the students who thought it was a lesson when they just didn't study:

- ✓ *„Bingo – because we didn't have to study."*
- ✓ *„Bingo was the most interesting because we didn't study."*
- ✓ *„I liked playing a card game because we didn't have to study*."

The third are pupils who liked that the lesson was more amusing and relaxed:

- ✓ *„The card game because the atmosphere was relaxed and we were laughing."*
- ✓ *„When we were playing bingo because it was fun."*
- ✓ *„Bingo because we could shout out a word anytime."*

According to the analysis of pupils' answers to question No. 5, we can say that the majority of them considered the first part of the lesson to be the least interesting. In this part, the topic was revised and pupils were dealing with traditional exercises on the topic. A few of them stated that everything was interesting.

- ✓ *„Those 10 minutes that we were studying."*
- ✓ *„There wasn't anything like that."*
- ✓ *„I liked whole lesson, so I liked everything."*

There were various answers to the last question of the questionnaire. They were influenced by the mood, character or hobbies of pupils as well as the topic of the lesson.

- ✓ *„I don't know, maybe about fractions."*
- ✓ *„About everything that I could."*
- ✓ *„About quadratic and cubic equations."*
- ✓ *„I want to know whether there will be more lessons like this also in other subjects."*
- ✓ *„About the use of **expressions** in everyday life."*

Conclusions and Recommendations

According to the analysis of the case study *Games with fractions,* we can say that the use of **motivating materials** on the mathematics lessons, where the case study was realised, positively influenced pupils' interest in the activities that were carried out during lessons. Furthermore, pupils were motivated to get more information and knowledge. They were learning and developing their mathematical skills and the ability to think quickly, tactically and correctly, even though not everyone realised it. So their learning was unintentional. They also had to communicate and cooperate in order to play the games.

The materials that were used in this case study can be changed and adapted to any level of the group of pupils. They are also suitable for mathematics seminars for future teachers. A case study is a kind of lesson which is alternative and different way of teaching mathematics. It is based on **unintentional learning,** which is realised in a playful and amusing way.

CASE STUDY 18

Title of case study	**Teaching and learning basic functions using interactive spreadsheet models (EXCEL)**
Origin of case study	SK Team

Description

The case study describes two identical mathematics lessons promoted in two different classrooms at secondary grammar schools in Nové Zámky and Nitra by the author of interactive spreadsheets models PaedDr. Ján Beňačka, PhD.

Target Audience	18 -19 years old students,
Key words	interactive spreadsheet models, elementary functions, visualization, motivation
Delivery method/s	Computer aided learning, demonstration, debate, posing questions to the class

Background

The experimental lessons were carried out in two different Slovak towns (Nitra, ordinary class, and Nové Zámky mathematically oriented class). Both lessons took part in the standard classroom with one computer linked to a PC projector.

Content

1. Introduction
2. Interactive spreadsheet model
3. Questionnaires evaluation
4. Further experimentation

Evaluation

The answers to the first three questions were about the scale "*agree*" which shows increased motivation and interest to the lesson atmosphere (question 1), obtaining new or revising existing knowledge (question 2) and evaluating own activity during the lesson (question 3). The answers to the question 4 affirm interest of students to the method, application and teacher's style of teaching or

performing knowledge. Some answers to the fifth question express student's satisfaction with the lesson. To sum up the answers to the last, sixth question, we imagine that student's cannot be active in creating the content of the lesson. Student's involvement is not typical for students at secondary schools. Teaching maths is still mostly rigorous without active student's involvement in the majority of Slovak secondary schools.

Recommendation for good practice

Demonstration using one computer is not suitable for big classrooms because of low visibility of presentation from the distance places of the classroom.

Having the special classroom for CAL learning-teaching mathematics with working places for students is recommended.

Worksheets with problems of different level of achievement.

Introduction

A dynamic computerized environment during mathematics lessons at secondary schools is under development in Slovakia. The most common approach is using a computer as a tool for demonstration, explanation, and illustrating mathematical elements. **Interactive spreadsheet models** for teaching/learning have been developed by Ján Beňačka as an **exciting material** for **CAL mathematics lessons**.

Interactive spreadsheet model

The idea is to **visualize** how the graph of the particular elementary function has been changed by changing the function parameters and **making more dynamic** the process of study of graphs of particular elementary function. It allows **studying** the graph's motions **instantly**, **observing** the changes **immediately**, and **controlling** the graph shape prediction derived from the changes of its parameters very quickly. The interactive spreadsheets model is ready to draw enormous number of graphs in several minutes so, that students could **understand and remember** the typical shapes, recognize changes and keep them in their visual memory. Students have the opportunity to approach the concept of elementary functions graphs by using the features of interactive spreadsheet model in an **intuitive and dynamic way**. Such an approach is impossible using just paper and pencil.

Two experimental lessons were realized, one in the third and one in the fourth (the final) year of higher secondary school, within math knowledge revision. The lessons aimed to have **ready-to-use knowledge** for the school leaving

examination. The experimental lessons were realized in two different Slovak towns (Nitra, ordinary class, and Nové Zámky mathematically oriented class). Both lessons took part in the standard classroom with one **computer linked to a PC projector**.

During the first part of the lessons, each student was given three sheets with basic graphs of functions as their **handout.** The graphs were also **projected**. The shapes of the graphs were putting "nice" values for *x* into the formulas and the value *y* was **calculated by heart**. The resulting points were pointed out on the projected graphs. The aim of this revision was to get the shapes of the graphs into the **visual memory** to be able to recall it in a few seconds.

In the second part of the lesson, interactive spreadsheet applications were **projected** with the challenge to students **to experiment** with the formula's parameters and find their meaning.

Then, the students were given the **work sheet** with the graphs, and they had to write down the equations, which determinated the particular graph. When finished, the results were checked publicly using the model.

The lesson continued by exercising phase: sketching graphs given in the second handout – the table with different types of non-elementary functions created as graduated tasks. Students were invited to sketch the graph by hand.

Students were called up to **solve the tasks** on the whiteboard. Having completed the graph, they were **invited to open the respective application and adjust the data** to show the precise graph and **check the result** (we remark that students were surprised how precise a hand made graph can be if using the presented method). In the last part of the lesson, the graphs via the spreadsheet applications were drawn with **student's active participation**. Drawing graphs by hand was set for **homework**.

Questionnaires evaluation

Students were asked to fill the questionnaire of the Comenius project MOTIVATE Me distributed after each lesson. **The personality of the teacher and his enthusiasm were the most motivating factors during the both lessons**. The teacher's narrative language has played the important role as well e.g.: "*the most beautiful point all over the world*"," *chimney shape"," V-shape", "the nice point*". The Table 1 shows obtained results. Questions 1-3 are scaled by scale: 1(strongly agree) to 5 (strongly disagree).

	Question	Nitra	*n*	%	Nové Zámky	*n*	%
			12	**100**		**27**	**100**
4	What did you find the most interesting and enjoyable in the lesson, and why?	the method	7	**58**	the method	12	**44**
		the applications	5	**42**	teacher's style	11	**41**
		precise graphs	1	**8**	the applications	2	**7**
5	What did you find the least interesting and enjoyable in the lesson, and why?	no answer	9	**75**	all was OK	13	**48**
		that I already know	2	**17**	no answer	8	**30**
		boredom	1	**8**	be in the last row, can't see the graphs	3	**11**
6	I would like to find out more about	no answer	9	**75**	no answer	11	**41**
		not basic functions	2	**17**	logarithms	3	**11**
		the applications	1	**8**	combinatory	3	**11**
					derivatives	3	**11**
					not basic functions	1	**4**
1	I enjoyed the lesson	2,00	average of 1 - 5		1,74	average of 1 - 5	
2	I learnt some new things	2,33			1,96		
3	I did interesting things in this lesson	2,17			1,81		

Table 1 Outcomes of secondary school experimental lessons

The answers to the first three questions were about the scale "*agree*" which shows **increased motivation** and **interest** to the lesson atmosphere (question 1), **obtaining new or revising existing knowledge** (question 2) and **evaluating** their own activity during the lesson (question 3). The answers to the question 4 **affirm interest** of students to the method, application and teacher's style of teaching or performing knowledge. Some answers to the fifth question express student's **satisfaction** with the lesson. To sum up the answers to the last, sixth question, we suppose student's helplessness in being active in creating the content of the lesson. Student's involving is not typical for students at secondary schools. Teaching maths is still mostly rigorous, without active student's involving in the most of Slovak secondary schools.

Further experimentation

The experimentation continues with student teachers and focuses on presentation spreadsheets model and motivation them to teach using described developed teaching materials.

The main idea of the experimentation with student teachers is:

- to introduce student teachers the spreadsheets model as useful material for their future practice in schools,
- to make them familiar how a spreadsheet works and how it is possible to use them during the particular maths lesson,
- to ask them for preparing a part of maths lesson using the spreadsheets elementary function models and perform it to their schoolmates,
- to ask them for preparing a maths lesson using the spreadsheets elementary function models and perform it to their students during their practice at schools,
- to obtain results given in questionnaire for student teachers as students and for student teachers as teachers (part II) and compare the results – elements of motivation.

CASE STUDY 19

Title of case study	**How it is being a physics teacher?**
Origin of case study	Slovakia team

Description

Pupils trying to be a physics teacher, This situation increase their motivation to study physics and also the interest in physic topics – meteorology in this case.

Target Audience	Primary school pupils, 12 – 13 years old
Key words	Motivation, meteorology, individual work, independent learning
Delivery method/s	classroom presentation after individual and independent learning

Background

The Case study was performed by PaedDr. Ľubomíra Valovičová, Ph.D. Assistant of the physics department who regularly teaches at primary school in Nitra. She and pupils used PROMOTE MSc materials – Meteorology. There were 2 lessons videotaped by PaedDr. Ján Šunderlík, doctoral student.

Content

1. Introduction
2. Study with detail description of methodology and time-table
3. Evaluation
4. Conclusions and recommendations
5. Appendix: Video

Evaluation

Having pupils in the role of the teacher strongly motivated them to teach and to learn. Pupils chose different types of lessons – demonstration, group work, individual work. This was done intuitively, very often they imitated the style of teaching of their real teachers not only of physics. The idea of being teacher causes very strong motivation for those, who play the role of teacher – they are able to prepare interesting material using different sources – not only textbooks.

The MOTIVATE ME questionnaire was not used.

Recommendation for good practice

One topic should be shared by 2 pupils, if one pupil presentation is not longer than 20 minutes.

Time for preparation the pupils' lesson should be one month.

Consultancy with the teacher about the methods and topics or materials before the lesson is necessary.

The teacher should only be an observer, he/she influences lesson only in emergency situations.

Control test after the topic is recommended.

Introduction

One of important factors influencing the pupils'attitude towards physics is motivation. For good motivation, it is necessary to let students enjoy the physics and give them the chance to understand every particular topic. Pupils will lose interest if they cannot be active in obtaining the knowledge and, very frequently, they take refuge to memorising the facts.

Because of this reason we were trying to find the suitable and interesting form of motivation. We found the **role-play game**, where the pupil becomes a teacher, a prospective motivator.

We had chosen the topic of **meteorology** for this study. It is the topic easily divisible into separate parts not necessary connected one to another in comparison with other curricula topics. Another important issue is the wide range of study materials pupils can use, e.g. book or huge number of web pages dealing with meteorology. Pupils have the opportunity to use **different sources**. The topic of meteorology is applicable also for the time allocation. The teacher can spend approximately a month with it, so almost all the pupils of the classroom get a chance to express themselves in **individual presentations**..

Study with detail description of methodology and timetable

The main source for creating the particular topics for separate lessons was the curriculum for grade 7 within the Slovakian school system.

Lesson 1: Essential concepts of meteorology. Climate and weather.

Lesson 2: Levels of atmosphere.

Lesson 3: Condensation of water steam.

Lesson 4: (Air) humidity.

Lesson 5: Clouds and downfall.

Lesson 6: Wind and wind directions.

Lesson 7: Meteorological map.

Lesson 8: Meteorological station.

Lesson 9: (Air) pollution.

Lesson 10: Different calamities caused by weather.

Distribution of particular topics to particular pupil

The teacher can choose from two ways:

Way 1: Teacher uses two urns with cards and decides about pupils and topics **randomly**. In the first urn, there are names of pupils and in the second one, the titles of particular lessons (see the list above). Teacher can play at cast lots of Master League or other sport lot. He picks out the names of pupils from the first urn and the title of the lesson from the second urn.

Way 2: Teacher lets pupils create the groups and then they can **bid** (give the offers as at auction) the lessons. Teacher announces the title of the first lesson. The group interested in the topic will claim it. If several groups are interested in the topic, there is time for duel. Pupils answer the teacher's questions connected to the actual curriculum topic.

After the assignment of titles and pupils responsible to prepare them, each group of students obtains a card with the title and with a question that could be answered by other classmates after the lesson.

Cards

Lesson 1: Climate and weather. (Explain what the weather is, what is covered by this word. What climate is and what kinds of climate we can meet).

Lesson 2: Levels of atmosphere. (Explain the particular levels of atmosphere – you can find something interesting a about it.

Lesson 3: (Air) humidity. (What is the (air) humidity? How can it be measured? Explain the concept of dew-point, absolute and relative humidity).

Lesson 4: Condensation of water steam. (How the cloud does originate? What is the cloudiness?)

Lesson 5: Clouds and downfall. (Name the basic types of clouds. What is the dew and the fog? What is the downfall and how it does originate? How is the downfall measured?)

Lesson 6: Changes in atmospheric pressure. Wind and wind directions. (How the changes of pressure do originate? Differentiate between pressure-height and pressure-depression. What is the wind and how does it originate? What is the direction and speed of the wind?)

Lesson 7: Meteorological map. (What is the meteorological map – front (cold and warm). What is the weather forecast?)

Lesson 8: Meteorological station. (What are meteorological stations good for? What equipment is there in the meteorological station?)

Lesson 9: (Air) pollution. (Natural and artificial air pollution (greenhouse effect, ozone hole))

Lesson 10: Different calamities caused by weather. (Mention some natural calamities – tornadoes, hurricanes, snow calamities, deluges).

After the distribution of the topics to pupils, the teacher can advise students by addresses of different web pages containing information about given topics. It is suitable to provide addresses which the teacher is familiar with to simplify the control of student (teacher needs to push them to use several sources). If there is still some time, teacher can answer pupils' questions.

The time between the topic distribution and their tuition

In the period between distribution and tuition of particular topics, the teacher should have **individual consultations** or in some another way **cooperate with students** at preparation of their lessons.

In the same period, pupils should provide the teacher with their prepared lessons. The Teacher should remind them not to forget the repetition (he/she can suggest them preparation of crosswords or similar forms). It is suitable to make pupils aware to prepare notes for classmates with conclusions from the lessons. It is emphasized that they have to be careful and not organise the

lesson only as dictation of notes. Teacher can notice **other methods** applicable for lessons e.g. **practical experiment** or **situation methods**.

Lessons of pupils

It is extremely important for the teacher to realise he/she is the pupil and regulate their own behaviour according to it. During the lesson of the pupil, the teacher sits at the back desk in the classroom and observes the lesson. For better nature in the classroom, he/she behaves as a pupil. He/she write down the notes, answer the "teacher's" questions, or he/she does not pay attention (it is good to have the same behaviour as the pupil usually has during lessons). Pupils can experience and **play the role** of how it is to be a teacher, how it can be uncomfortable and difficult to teach something not only this particular class. The teacher does not need to intervene when pupils are disturbing during the explanation every time, but only in kind of emergent situations.

Teacher's taking notes has one important outcome. He/she knows what was explained, what was missing. The only task the teacher has at a lesson like this is to evaluate it at the end.

Teacher should evaluate whether pupil teachers:

- have covered all the curricula for particular lesson;
- have done something more (interesting activities like crosswords);
- have used any experiment or pictures;
- have created the notes for pupil;
- have been able to make the discipline in the classroom;
- have been responsible while preparing the lesson.

Evaluation

From realized analyses, we can assume that pupils used methods they had seen before at lesson of several teachers. We recognised the elements of teaching styles not only of the physics teacher, but also of other teachers teaching other subjects from that particular school.

Students were motivated mainly by appreciating the possibility of being a teacher for the while. They had teacher's competences: to examine, caution, suggest the rebukes or praises.

There was a large variety of used methods. The usage depended mostly on the chosen form of lesson. This choice of forms and method was rather intuitive.

We assume that this form of tuition is suitable mainly because the pupil **learn non-intentionally** and according to preparation for own lesson they learn more than usual (using notes or textbook).

Conclusions and recommendations

We can conclude several facts from this case study.

- It is appropriate to give one topic to at least two pupils – to avoid one pupil speaking more than 20 minutes;
- Teacher has to give students enough time for preparing their lesson, appropriate time is approximately one month. The long period is important because of the consultations and potential improvement of the lesson;
- During the pupil-lead lesson, the teacher should sit in the back of the classroom and observe the lesson (this place is advantageous because of the good view and relative tranquillity);
- It is good for the classroom atmosphere if the teacher is behaving like a pupil: taking notes, answering the teacher's question, copying the usual behaviour of the presenting pupil;
- The Teacher should not affect the preparation and the process of pupils' teaching very much. He should take notes to know what was explained in the class;
- It is advisable to alert the test after the whole meteorology topic, because pupils have to realize they are the only teachers, there is nobody to explain it again and they have to explain the topics in the way the classmates will catch it and remember the required facts and skills.

CASE STUDY 20

Title of case study	**ICT in new topics in chemistry and motivation primary school pupils and secondary grammar school students**
Origin of case study	SK Team

Description

The study describes innovative methods of teaching chemistry – using ICT: power-point presentation, applets and worksheets during one lesson of chemistry.

Target Audience	pupils of primary schools 8-th, 9-th grade, secondary schools students age: 14-16 years, teachers in practice, chemistry student teachers.
Key words	motivation, competencies, presentation, demonstration using ICT, worksheets,
Delivery method/s	active learning – demonstration, class discussion, debate, short written exercises, role play, worksheets

Background

The instruction has been done by PaedDr. Zita Jenisová and prof. Martin Bílek for pupils and teachers form Nitra and Trenčín region and for university students of Constantine the Philosopher University in Nitra.

Content

1. Introduction
2. Topic of the case study lesson
3. Description of the lesson
4. Conclusions and recommendations
5. Appendix: Questionnaires evaluation

Evaluation

Pupils and students liked the lesson, they liked power point presentation and the lesson was evaluated as very interesting.

Teachers missed using live chemical experiments.

Student teachers were satisfied with the content and the methods.

Recommendation for good practice

Demonstration using one computer is not suitable for big classrooms because of low visibility of presentation from the distance places of the classroom.

Having the special classroom for CAL learning-teaching sciences with working places for students.

More problems for gifted students in the worksheet.

Introduction

The case study was carried out on primary and secondary schools in Slovakia in 2008 and 2009. Pupils and students who took part in the case study were at the age of 14 to 16. After each case study lesson, questionnaires were filled in, step by step, by 408 pupils and 384 students. The second questionnaire for teachers was filled in by 42 in-service teachers. Out of these, 17 teachers taught the case study lesson and to the rest of them, the lesson was shown during an annual course for in-service teachers. The third questionnaire was filled in by future teachers of chemistry who could experience this lesson on their didactics seminars. 77 students of Faculty of Natural Sciences of CPU in Nitra were involved. All of them are studying to become teachers of chemistry, either in their third year of study for Bachelor's degree or in the first, fourth and fifth year of study for Master's degree.

Topic of the case study lesson

The lesson was focused on the topic „Chemical action". The teachers could choose one of the following topics: „Chemical reactions", „Protolytic reactions", „Chemical kinetics".

The following teaching methods were used in the course of the lesson:

- **Exposition** - to make students understand the topic by using the MS PowerPoint presentation. During the exposition, motivational introduction with **discussion** and **demonstration** were used.

- **Reinforcement** and **revision** of the presented topic. **Worksheets** based on the presented topic were used in this part of the lesson.

A teacher's computer and a digital projector were used to present the topic not only during the exposition, but also during the revision stage while working with worksheets. 25 % of worksheets were electronic and the majority, 75 %

was printed. The printed form was especially appreciated by pupils in primary schools because they could use it as additional notes to the topic and a source of information for their **self-study** and **homework**.

This kind of presentation of the topic enabled teachers to include different forms of motivation:

- **Motivational exposition** – with the use of a computer; it was engaging, varied and more dynamic.
- **Motivational introduction**– taking advantage of the knowledge those students have to access new knowledge; the theory was connected with the applications from real life.
- **Motivational demonstration** – there was at least one slide in the presentation with interesting facts about the topic and a suggestion how to carry out an experiment with photo evidence. When the classroom had access to the **Internet**, the links to **websites** with dynamic chemical reactions or actions as **video** and **flash** animations were displayed in the instructions.

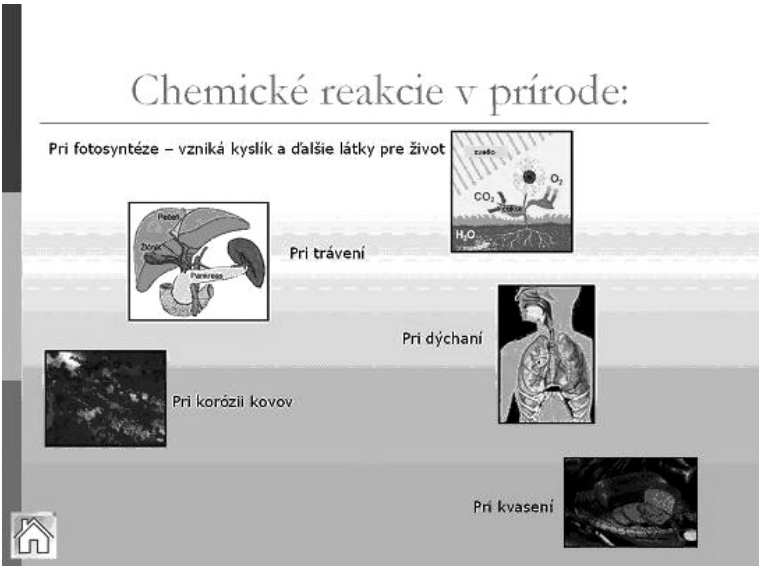
Using the **worksheets**, teachers could make use of „continuous motivation while revising the topic, in the form of: updating the content, motivational challenge, praise, encouragement, criticism, **didactic games** (gap- filling and puzzle) and **problem solving**, **drama** methods, **feedback** on the results of the work.

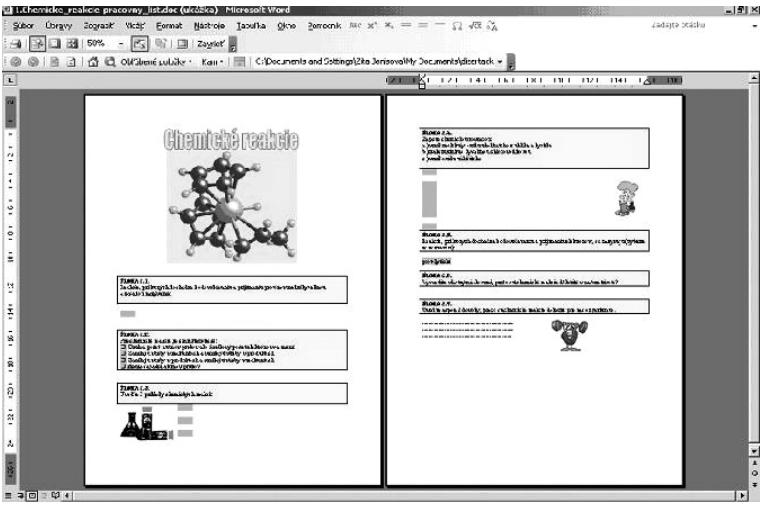
The lesson focused on the topic of Chemical reactions was taught by in-service teachers in 17 schools that were chosen.

The aim of the lesson was to develop students' ability to distinguish different types of chemical reactions, to define basic concepts like: reactant, product, initial substance, oxidation-reduction, and protolytic reactions and so on. Chemical experiments will help them to understand chemical reactions and their influence on our everyday life.

Description of the lesson

The lesson started with typical administrative duties of a teacher. Then, 80% of the teachers revised the previous topic with whole class, 20% of teachers examined the knowledge of students individually, and finally, students were given marks. In the second part of the lesson, the new topic was presented. This part was not taught traditionally because **computer, digital projector, laser pointer and projection screen** were used instead of blackboard, chalk, books and exercise books. Each teacher familiarised himself with the presentation and adapted his exposition to his own ideas and requirements.


Chemické reakcie v prírode:
Pri fotosyntéze – vzniká kyslík a ďalšie látky pre život
Pri trávení
Pri dýchaní
Pri korózii kovov
Pri kvasení


Chemické reakcie

The **worksheet** was prepared in MS Word. Some teachers used it in **electronic form** but the majority of teachers in a **printed form**. Students found it useful for making notes, and in some cases, students were given a task from the worksheet to finish for **homework**.

Conclusions and recommendations

According to the results of analysis of case study lesson when chemistry was taught with information technologies, we can say that the „PROMOTE" material and suggested teaching methods were **motivating** for pupils and students and they were positively evaluated by teachers in service and future teachers, too.

In conclusion, we can say that there is a wide range of possibilities of how to use IT in teaching. In the lessons that were analysed, the computer was used as a mean of presentation of a new topic. Teachers agreed on the fact that there is a lack of accessible materials of this type and they would appreciate its distribution, e.g. via the Internet. Pupils and students appreciated a change from typical lesson to a lesson that is more **creative**, lively and varied. They especially liked the worksheets as they replaced traditional making and taking notes.

Interesting but not surprising was the fact that students missed a chemical **experiment** the most. On the other hand, teachers and future teachers did not miss it and none of them mentioned it in the questionnaire. Some of in-service teachers said that there is a lack of possibilities to teach with IT because of insufficient equipment and inadequate classrooms. Specialised classrooms are usually small, so only a half of class can work there. When a notebook and a digital projector are used in a common classroom, the quality of projection is not very good, especially the visibility and readability, so it is not possible to work with worksheets in their electronic form.

Appendix

Questionnaire evaluation

This research was carried out as an activity of the Motivate Me project which has developed three basic types of questionnaires. One of them is for students who are supposed to evaluate the lesson, the second one for teachers and the third questionnaire is for teacher trainees, university students of chemistry (future teachers).

The aim of the questionnaires is to evaluate the motivation of pupils and students to learning, particular chemistry topics with the use of information technologies (IT) - from the point of view of students, teachers and future teachers.

The evaluation of pupils (students):

In the first part of the questionnaire, pupils were supposed to evaluate the following statements using the scale below:

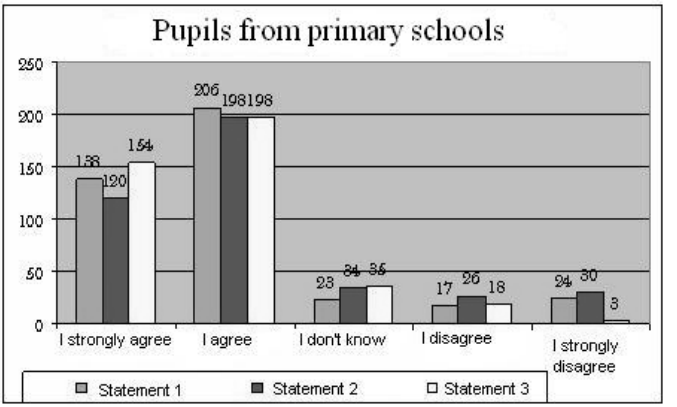
1. I enjoyed the lesson.

2. I learnt some new things.

3. I did interesting things in the lesson

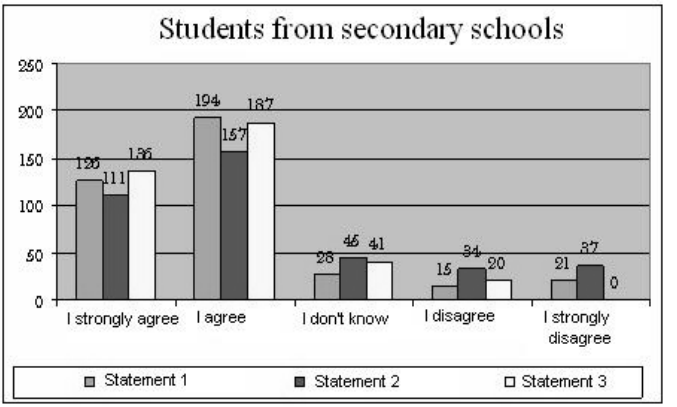
1 I strongly agree 2 I agree 3 I don't know 4 I disagree 5 I strongly disagree

The following graph (Picture 3) shows the results of pupils' evaluation of these statements. 408 pupils of 8th and 9th classes of primary schools were evaluating.



Picture 3 Pupils' evaluation of the first three statements

The same statements were evaluated by the first year students of secondary grammar school or fourth and fifth class students of 8-year secondary grammar school. The graph in the Picture 4 shows the results of evaluation of 384 students.



Picture 4 Students' evaluation of the first three statements

According to the results shown in both graphs, it can be said that the Promote material positively supported and influenced pupils'and students'motivation. When we sum up the results into three categories: I agree, I don't know, I don't agree, we can summarise the evaluation of 792 pupils and students in the following way:

- I agree - about 85 % agreed with all the statements
- I don't know - about 6,5 to 10 % evaluated all the three statements in this way
- I don't agree - about 5,2 (third statement) to 16 % (second statement).

In the second part of the questionnaire, pupils were supposed to answer the following open questions:

4. What was the most interesting and amusing for you and why?

5. What was the least interesting and amusing and why?

6. I would like to know more about:

The answers of pupils from primary schools and secondary schools were the same. Here are their most frequent and interesting answers.

Question No. 4. The most interesting and amusing was:

- Presentation (26 %)
- I don't know (13 %)
- Worksheets (11 %)
- Pictures in the presentation (10 %)
- Nothing (9 %)
- Interesting facts (7 %)
- That I don't have to make notes; we got worksheets (6 %)
- The teacher could explain the topic perfectly (4 %)
- Experiment, even though it was only in the photographs (3 %)

Some opinions were repeated in more answers to questions, so their total percentage is not 100. In 5% of the questionnaires, this question was not answered. The rest of the answers did not fit to the scale mentioned above or it was meaningless.

Question No. 5. The least interesting and amusing was:

- Nothing (34 %)
- Everything was interesting (11 %)
- Much theory (6 %)
- Things I have already known (6 %)
- Theorems (4 %)
- Exposition (3 %)
- Videos of experiments (3 %)
- There were more things (2 %)
- Topic (2 %)

About 7 % of students did not answer this question. 2 % of them answered "differently", e.g. “this questionnaire was the least interesting“ or some of them said: everything, ringing of the bell, interruptions by classmates or some chemical film.

Question No. 6. I would like to know more about:

Experiments (31 %)

Chemistry in real life (14 %)

The latest chemical researches and interesting facts (6 %)

History (4 %)

Everything I could (3 %)

Explosives (3 %)

Also this question was not answered by 5% of students. About 7% of students wrote „Nothing“ and 9 % „I don’t know“. This question proved that there is a lack of school experiments in chemistry in primary and secondary schools.

The evaluation of teachers and teacher trainees:

In the first part of the questionnaire, respondents should evaluate the following statements using the scale below:

1. PROMOTE material is useful and supports teaching process.

2. Teaching methods were suitable.

3. Students were interested by the material.

4. Teaching methods were activating for students.

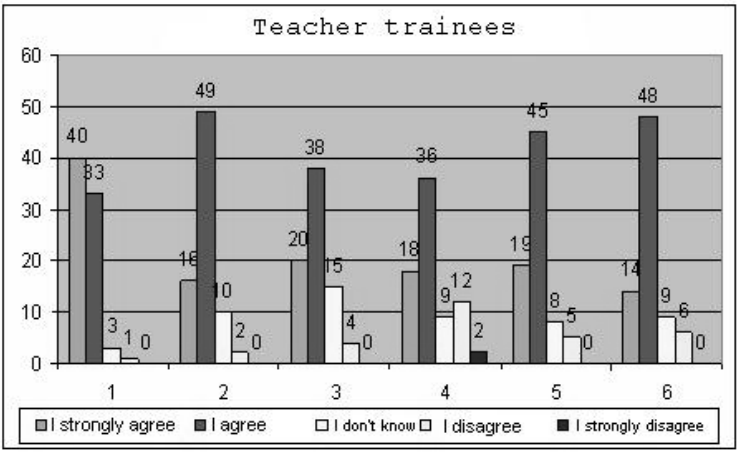
5. The material would fit me.

6. Teaching methods would fit me.

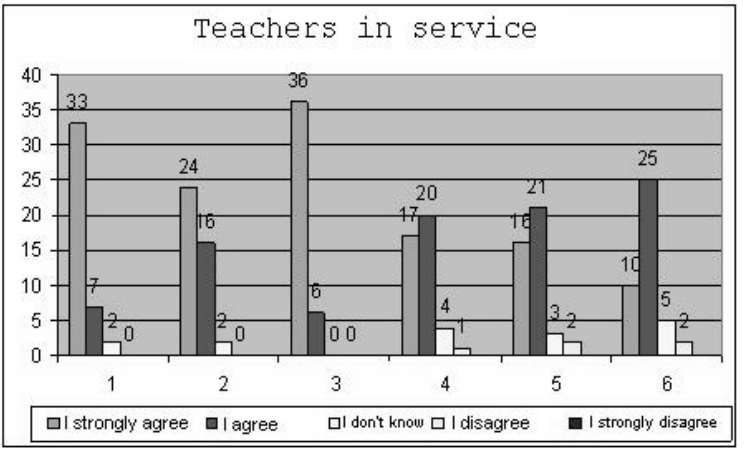
Scale from 1 to 5:

1 I strongly agree 2 I agree 3 I don’t know 4 I disagree 5 I strongly disagree

The Picture 5 shows the results of evaluation of statements by teacher trainees and the Picture 6 by teachers in service.



Picture 5 Evaluation of teacher trainees



Picture 6 Evaluation of teachers in service

According to the results of questionnaires' evaluation, we can say that 90% of in-service teachers and teacher trainees agree with these statements. They think

that the material is highly motivational and they agree with the use of motivational methods.

In the second part of the questionnaire, they were supposed to answer these two open questions:

- 7. What was positive about the choice of material and teaching methods?
- 8. What should be changed? (in materials and teaching methods)

Question No. 7 The choice of material and methods was positive because:

There was a wide range of answers. They can be summed up as follows:

- They enable to show more pictures.
- They support imagination.
- The better concentration of students, the bigger chance that they will remember the topic.
- They activate and stimulate students.
- Reinforcement and revision is more effective by using worksheets.
- More visualisation, I appreciate the possibility to use video and flash animations.
- While working with worksheets, pupils can check on the presentation again. (If E-learning is used, they can do it at home as well).

The majority agreed on some of basic advantages of IT in teaching ,during explanation: visualisation of phenomena, simplicity and motivation. In the second part of the lesson, the when worksheets were used, they appreciated their simplicity, explicitness of questions, variety of problems, as well as the fact that this way of revising and learning was more interesting for students and their activity and concentration was on a higher level.

Question No. 8. It would be good to change:

Here are some interesting answers:

- To use it more in schools.
- Nothing.

- To have a variety of materials in order to avoid the passivity of students.
- To have a specialised classroom focused on teaching science by information technologies.
- Sufficient equipment needed for teaching by using IT at schools.
- Enough materials of this type and their good accessibility.
- More tasks in worksheets focused on gifted students.
- It would be fine for me.
- Problem solving tasks.

Motivating and Exciting Methods in Mathematics and Science – Case Studies

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