Motivating and Exciting Methods in Mathematics and Science

GB

Lesson Plans

Lifelong Learning Programme

MOTIVATING AND EXCITING METHODS

IN MATHEMATICS AND SCIENCE

Lesson Plans

2014

1st edition

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http://www.msc4all-project.eu/

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Foreword

Many school children show a lack of motivation and interest in mathematics and science. This may be partly due to a lack of motivating material and partly due to the use of inappropriate pedagogical methods to present these materials.

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

The aim of this project was to address the problem of the shortage of young people attracted to study and enter teacher training in the mathematical and scientific subjects of the school curriculum.

With this project we want to make trainee teachers and their mentors aware of a wide range of appropriate pedagogical methods for the learning of mathematics and science, and specifically use materials produced in the Comenius 2.1 project PROMOTE MSc to develop appropriate methods aimed at increasing students' motivation.

The first activity of the project was to compile a list of pedagogical methods with a short outline of each one. To achieve this, the five partner institutions collected lists of methods used in their own countries in teaching mathematics and science. These lists were compared and condensed to a final list of methods that can be used across all countries. Each partner then took over the task of writing a short outline (including references) of several of these methods. The outlines were discussed and modified at a group meeting, and a final version was produced and published. All the project material can also be found at the webpage of the project:

http://www.MotivateMeMathsScience.eu/.

After almost 10 years, it was time to revisit the materials, to use the numerous feedbacks that we received from teachers, and to improve the materials. For this reason we planned the project "MSc4All – Motivating Methods and Materials in Maths and Science: Dissemination" in the framework of the Lifelong Learning Programme, which allowed the project team to collect suggestions for improvements and put them into practice, as well as to produce and disseminate a second edition of the project materials. By this, we hope to come even closer to our original goal to increase the motivation to learn mathematics and science. The second editions of the project materials can be found at the webpage of the project:

http://www.msc4all-project.eu/.

The booklet “Lesson plans” offers trainee teachers and teachers ready-to-use lesson plans, which leave enough space for teachers’ own creativity.

Project Team

The project participants are teacher training institutions in five European Countries: The University of Sunderland (United Kingdom), the University of Vienna (Austria), the Palacky University Olomouc (Czech Republic), the Constantine the Philosopher University Nitra (Slovakia), and the University of Palermo (Italy).

Lesson Plan 1: Variation

Date:	**Topic**: Variation	**Time**:	**Class**: Age 11 +

SEN pupils	**Gifted and Talented**	**Class Room Support**

Equipment needed for this activity

- Pupils will need a copy of the attached worksheet along with a ruler and the ability to measure height.

Health and Safety

Learning outcomes for this activity

All

- Pupils must be able to describe how certain characteristics can be influenced by environmental and genetic factors

Most

- Pupils may be able to explain how variation can be classified into continuous and discontinuous data

Some

- Pupils should be able to link the theory of variation and the results of the practical

Starter Activity (20 minutes)

At the start of the lesson pupils will be lined up outside and briefed that they are going to be placed into groups once within the lesson. Register will be taken. Pupils will be asked to create a spider diagram to show what they already know about the topic of variation. (This will be re-visited at the end of the lesson to show a progression of learning. (6 minutes)

Introduction of lesson content
Learning objectives will be shown to the class and read aloud by pupils. Pupils will also be introduced to the idea of '*key words'* for this lesson. This is done in an attempt to bring literacy into science through the use of spelling and familiarisation with specific, scientific terms. These key words will be called upon during the main activity and plenary. (4 minutes)

The class will be introduced to variation and how there are two distinct categories: Environmental and Genetic. A pupil will be chosen at random to ask what they think environmental variation is. This will be also be used to ask a pupil for an example, and again for genetic variation, with an example. This questioning will be followed with a short teacher explanation to confirm understanding. (5 minutes)

Moving on from environmental and genetic, the idea of continuous and discontinuous variation will be introduced. The definition will be given by the teacher; pupils will be chosen at random to give an example for each category. A whiteboard check will follow, as two graphs are shown. One is an example of a continuous data graph (A) and the other is a discontinuous data graph (B). Pupils will be asked to identify which one is which. (5 minutes)

Main Activity (30 minutes)

Building on from this, pupils will be given the opportunity to carry out their own research. Firstly is the use of discontinuous variation. Two volunteers will be chosen to be brought to the front of the class and count the number of boys and girls. Once the final numbers have been counted they will be wrote on the board for pupils to start plotting a bar graph to represent the data.

Whilst pupils are carrying out the gender graph, one table at a time will be asked to come to the front of the class to measure their height and represent it with a tally mark on in a pre-drawn table in the board. An extension worksheet will be provided for pupils to continue working whilst the rest of the class are having their height measured. The worksheets which will be provided are differentiated to suit each group's ability. Pupils will be given the opportunity to peer-assess these worksheets later in the lesson if time allows.

Once all of the class' height has been measured, and the data has been collected, pupils will be asked to finish the sentence that they are writing,

and put their pens down. Students will be introduced to the continuous data on the board and asked to attempt to draw the data on a graph. A further extension worksheet will be provided for pupils whom may finish before the allocated time.

Pupils will not re-visit their previously drawn spider diagram to add onto it what they now know about variation. They will be asked to either write in a different colour or place a start next to the ones which they are newly adding.

Plenary Activity

Each pupil will be given an 'Exit ticket', this will be a rectangular piece of paper where each student has to choose a key word from today's lesson and attempt to give a scientific definition . Underneath this they have to write something which they have learnt from this lesson. This then has to be swapped with a partner who will then expand on what is already written. All exit tickets will be given to the teacher whilst leaving the classroom.

Reflections on the lesson

Worksheet lower ability students

What do you think the word 'Variation' means?

_____

_____

_____

CONTINUOUS VARIATION:

Describes a f_____ that can have any v_____ from a r_____ of numbers. For example, the h_____ of everyone in this classroom.

DISCONTINUOUS VARIATION:

Describes a feature that can only have a c_____ value. For example, e____ c_____

feature certain eye colour value

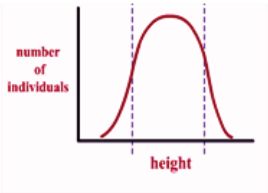
Remember to use CAPITAL LETTERS, full stops and always try to write in full, complete sentences.

VaRiation

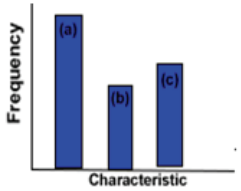
NAME: _____

CONTINUOUS or DISCONTINUOUS?

A



B



What are today's KEY WORDS?
Be careful with spelling.

1.
2.
3.
4.

ENVIRONMENTAL VARIATION	GENETIC VARATION

eye colour height freckles
dimples weight
piercings tattoos

H _ _ _ _ Ch _ _ _ _ _ _ _ _ _ _ _ c _

21 13 1 14 1 18 1 3 20 5 18 9 19 20 9 19

Which of these is an example of the above:

eye colour **taste in music** **how hungry you are**

Worksheet medium ability students

What does the word 'Variation' mean? Give an example.

_____

_____

_____

_____ **VARIATION:**

Describes a _____ that can have any _____ from a _____ of numbers. For example, the _____ of everyone in this classroom.

DISCONTINUOUS VARIATION:

Describes a feature that can only have a _____ value. For example, _____ _____.

Remember to use CAPITAL LETTERS, full stops and always try to write in full, complete sentences.

Draw examples of a CONTINUOUS an

VaRiation

NAME: _____

What are today's KEY WORDS?
Be careful with spelling.

1.
2.
3.
4.

ENVIRONMENTAL VARIATION	GENETIC VARATION

eye colour height freckles
dimples weight
piercings tattoos

Think of a different characteristic and add one

_ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

8 21 13 1 14 3 8 1 18 1 3 20 5 18 9 19 20 9 3 19

Which of these is an example of the above:

eye colour **taste in music** **how hungry you are**

Worksheet high ability students

What do you think the word 'Variation' means - Give an example and try to use one of today's key terms/words

____

____

____

Remember to use CAPITAL LETTERS, full stops and always

Remember to use CAPITAL LETTERS, full stops and always try to write in full, complete sentences.

Draw examples of a continuous graph and a discontinuous graph. Give an example of what each graph could stand for.

______________ **VARIATION:**

Describes a ________ that can have any __________ from a ________ of numbers.

For example: .... and ....

DISCONTINUOUS VARIATION:

Describes a feature that can only have a ________ value

For example: .... and ....

range feature certain value

VaRiation

NAME: ____________________________

What are today's KEY WORDS?
Be careful with spelling.

1.
2.
3.
4.

ENVIRONMENTAL VARIATION	**GENETIC VARIATION**

List three different characteristics for each type of variation

Write a definition for the term '**species**':

....

_ _ _ _ _   _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

8 21 13 1 14   3 8 1 18 1 3 20 5 18 9 19 20 9 3 19

Lesson Plan 2: Biomechanics

Date:	**Topic**: Biomechanics	**Time**: 120 minutes	Class: Age 16+

SEN **pupils**	**Gifted and Talented**	**Class Room Support**

Equipment needed for this activity

- Plastic model of Dinosaur, photographs of dinosaur model, sand pit, scales for measuring body mass, water trough, calculator and measuring tape

Health and Safety

- As students are required to walk through sand this should be checked prior to the activity

Learning outcomes for this activity

All

- Students will be able to estimate the volume and mass of a dinosaur model from its up thrust a tank of water

Most

- Students should be able to calculate the force of a bicep and relate that to the model of dinosaur chosen

Some

- Students should independently be able to use the McNeil Alexander equation to calculate the walking speed of their chosen dinosaur

Starter Activity (20 minutes)

Students should initially mass their model of dinosaur using scales then determine its volume from water displaced in a trough.

This can then be scaled up to full size approximations of real dinosaurs.

Main Activity 1 (40 minutes)

Students begin by weighing themselves and using Dempster's body segments data to ascertain the mass of their forearms, they make measurements of their own body and then calculate the force which their bicep might deploy.

Using the dinosaur model students then relate the data calculated to that of their chosen dinosaurs, discussing the implied force generated by each.

Main Activity 2 (40 minutes)

Students can determine the accuracy of calculations using a sand track, they are timed over a specific distance and their stride lengths recorded.

This can be related to their own force calculations for their legs, is there a correlation?

Plenary Activity (20 minutes)

Students are encouraged to discuss their findings, particularly any anomalous results. They are asked to consider differences in height and how the correlate to stride length. An ideal opportunity for discussion and evaluation.

Reflections on the lesson

Lesson Plan 3: Renewable energy resources

Date:	**Topic**: Renewable energy Resources	**Time**: 60 minutes	**Class**: 11+

SEN pupils	**Gifted and Talented**	**Class Room Support**

Equipment needed for this activity

- Pupils will need access to the work sheet in either electronic or hard copy version.
- The school caretaker to give a talk and answer questions.

Health and Safety

- None

Learning outcomes for this activity

All

- pupils should be able to identify key features of renewable energy sources by matching statements with types given in a list

Most

- Should be able to identify the main sources of energy lost from the school

Some

- Pupils will be able to suggest improvements to the schools functions or structure which would reduce energy consumption or suggest renewable energy sources which could replace those loses

Starter Activity (10 minutes) Pupils are asked to consider 10 statements and are then asked to match these with the type of renewable energy which they match with.
Main Activity (30 minutes) Pupils are given a talk by a member of the caretaking team and are encouraged to ask questions. The main focus of this talk is to identify the main areas of the school which lose energy. Students are encouraged to ask questions and perhaps tour the school recording their findings.
Plenary Activity (20 minutes) Pupils are encouraged to consider ways in which energy loss can be reduced by the school; they should also discuss possible renewable energy sources which the school can access.

Reflections on the lesson

Lesson Plan 4: Build a space dictionary

Date:	**Topic**: Build a space dictionary	**Time**: 1 hour	**Class**: 11+

SEN pupils	**Gifted and Talented**	**Class Room Support**

Equipment needed for this activity

- All pupils will need access to the original document in either hard copy or electronic form
- They should also have access to the internet and or a good range of text books or encyclopaedias relating to space

Health and Safety

- There are no health and safety issues involved with this activity

Learning outcomes for this activity

All

- pupils should be able to define the key words given or identify the key words from the definition given

Most

- pupils should be able to identify a range of important terms and find definitions for them

Some

- pupils will be able to discover the deliberate errors and offer corrections to them

Starter Activity (10minutes) Pupils are asked to discuss the features of a glossary. They consider the layout and the definitions used. They are also asked to consider the needs of the reader.
Main Activity (40 minutes) Pupils are given a structured table which is partially filled in with key word and definitions. They are asked to complete the table and add other words or terms which are relevant to the topic. If available this would be ideally suited to an IT suite. Pupils are then asked to comment of inaccurate statements and correct them.
Plenary Activity (10 minutes) Pupils are asked to look at each other's work and peer assess, they will be encouraged to make helpful suggestions and praise good work.

Reflections on the lesson

Lesson Plan 5: Vectors

Date:	**Topic**: Vectors	**Time**: 60 Minutes	**Class**:

SEN pupils	**Gifted and Talented**	**Class Room Support**
Need responsible group-peers	Can form own group and get special tasks on certain positions	

Equipment needed for this activity

- Map of school campus (one per student group)
- Task sheets in various positions across the campus/school

Health and Safety

- Outdoor activity

Learning outcomes for this activity

All

- See the use of vectors in mapping and positioning

Most

- Experience different learning situation in fieldwork

Some

- See vectors as useful tools for various outdoor and real-life activities

Starter Activity

5 minutes exposition, repetition of basic concepts of vectors, already known to students

Main Activity

The students were 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 http://www.promotemsc.org/results/AT/Materialien_fuer_Vektoren.pdf
- 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.

Plenary Activity

At the end all students were instructed to come back to the classroom and hand in their calculation sheets and the solution sheet. It was planned

to use discussion and debate on the solutions in classroom within the lesson after all students were back.
Reflections on the lesson (students) **Answers to "what did you find most interesting and enjoyable" included** • It was great to be outdoors, and working outside • Leaving the classroom • 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? **Detailed results of the questionnaire (16 students):** • I enjoyed the lesson: 2.0 • I learnt something new: 2.2 • I did interesting things in the lesson: 1.0 • Most interesting: Work outside the classroom (8 students) • Least interesting: Lengthy introduction on organisation (3 students) • Would like to find out more about: How to use fieldwork in elementary mathematics

Lesson Plan 6: 3-D geometry (1)

Date:	**Topic**: 3-D geometry	**Time**: 50 minutes	**Class**: age 15-16

SEN pupils	**Gifted and Talented**	**Class Room Support**

Equipment needed for this activity

- Materials for posters

Health and Safety

Learning outcomes for this activity

All

- Repeating knowledge of vectors in 3-D space

Most

- Improving competence to solve word problems with 3-D vectors

Some

- Improving competence to critically analyse context of word problems

Starter Activity

At the beginning of the lesson, the teacher checked homework, and then gave five minutes exposition (repetition of last lesson's content) on elementary 3D-vector properties and vector operations.

Main Activity

The students were 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:
http://www.promotemsc.org/results/CZ/Pruvodce_trojrozmernym_prostorem.zip

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.

Plenary Activity

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.

Reflections on the lesson (teacher)

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.

Reflections on the lesson (students)

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):

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

Lesson Plan 7: 3-D geometry (2)

Date:	**Topic**: 3-D geometry	**Time**: 100 minutes	**Class**: age 15-16

SEN pupils	**Gifted and Talented**	**Class Room Support**

Equipment needed for this activity

- Map of school campus (one per group)
- Digital camera (one per group)

Health and Safety

- Outdoor activity

Learning outcomes for this activity

All

- Strengthening knowledge of 3-D space.
- Presenting results of mathematical tasks in PowerPoint.

Most

- Improving competence to solve word problems with solids.

Some

- Improving competence to critically analyse context of word problems.

Starter Activity

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" http://www.promotemsc.org/results/CZ/Pruvodce_trojrozmernym_prostorem.zip
- A worksheet with space for writing down the solution
- Several empty sheets for calculations
- A digital camera

Main Activity

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.

Plenary Activity

In the second lesson (three days later), as a plenary activity, 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.

Reflections on the lesson (students)

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

- Using tools, had fun working with my hands
- Leaving the class, be outdoors
- 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):

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

Lesson Plan 8: 2-D geometry

Date:	**Topic**: 2-D Geometry	**Time**: 50 minutes	**Class**: age 13

SEN pupils	**Gifted and Talented**	**Class Room Support**
Work with manipulatives and using the own body to demonstrate concepts supports SEN pupils' learning	More complex concepts can be done by these students, and to be explained to whole class	Gym hall needed for this lesson

Equipment needed for this activity

- Digital camera (one per group)

Health and Safety

- Activity in the Gym Hall, including sports articles

Learning outcomes for this activity

All

- Improve understanding of geometry in the plane by using manipulatives and own body

Most

- Improving social skills by group work

Some

- Improving ability to explain concepts to peers

Starter Activity 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), see http://www.promotemsc.org/results/AT/Mathematik_im_Turnsaal.pdf, several sheets of empty paper to take notes, and a digital camera per group.
Main Activity 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.
Plenary Activity 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.

Reflections on the lesson (teacher)

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.

Reflections on the lesson (students)

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 PE.

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):

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

Lesson Plan 9: Problems of roofs

Date:	**Topic**: Problems of Roofs	**Time**: 3 – 5 Lessons	**Age**: 14+ year

SEN pupils	**Gifted and Talented**	**Class Room Support**
	Inquiry-based learning	Work in groups

Equipment needed for this activity

- Worksheets, drawing tools

Learning outcomes for this activity

All

- developing space imagination, application of mathematical knowledge in technical practice, solution of easy problems of roofs from the worksheets

Most

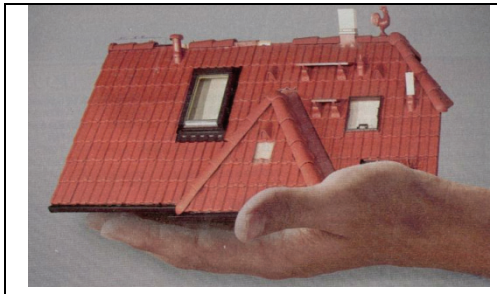
- complicated exercises

Some

- forbidden eaves

Starter Activity

Interesting examples of classic and modern roofs of different types, the usefulness of mathematics in the construction of houses.









Main activities

For all students:

Problems of Roofs

1.General knowledge, types of the roofs

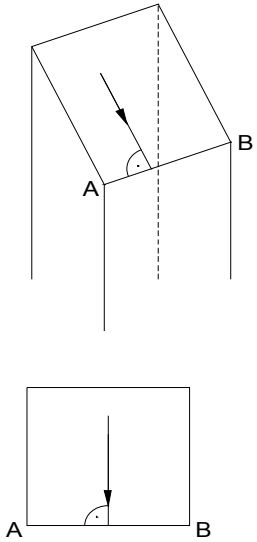
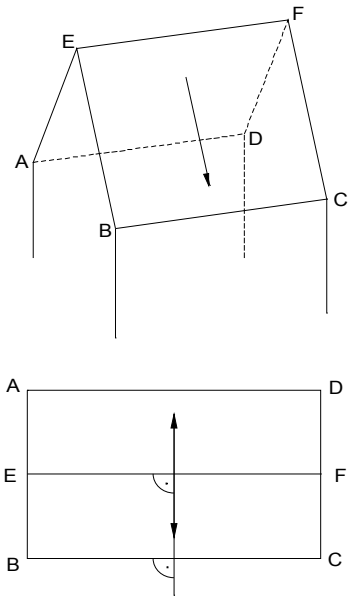
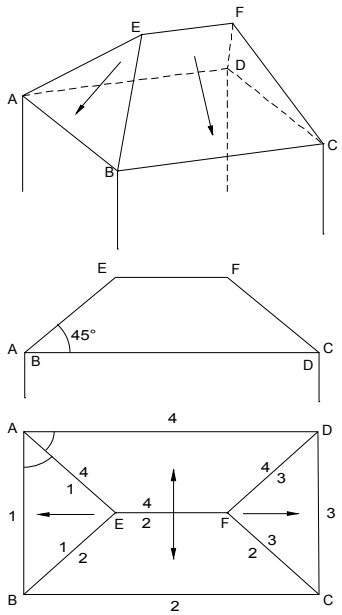
We want to build a roof over the building. The roof is determined by the pattern of the eaves.

We need to know:

1. All eaves of the building are in the same horizontal plane.
2. The planes of the roof and the plane of the horizontal plane make the same angle.
3. There is one plane of roof going each eaves.
4. We use red colour or double line for edge, where water is not flowing out.

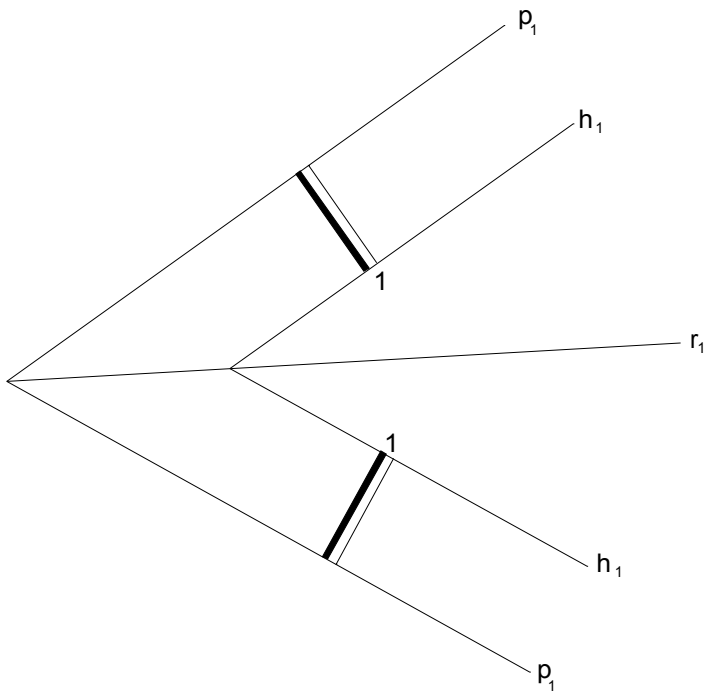
The horizontal plane is the plane of rectangular projection. Intersection of two roof planes halves angle of tracks of these planes in rectangular projection. Two trails of planes can by parallel. These planes we call antiparallel. Rectangular projection of two antiparallel planes halves distance between their tracks. If we have three planes, which do not have the same bisector, they meet in one point. Their intersections have to meet in this point.

We can use these types of the roofs:

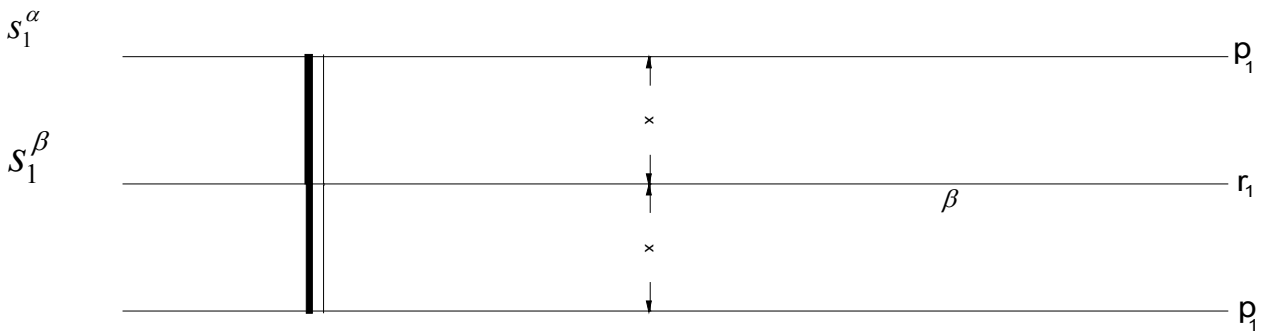
Aisle roof	Saddle roof	Hip roof
		
		

2. **First steps, easy exercises.**

a) Eaves are non-parallel



b) eaves are parallel

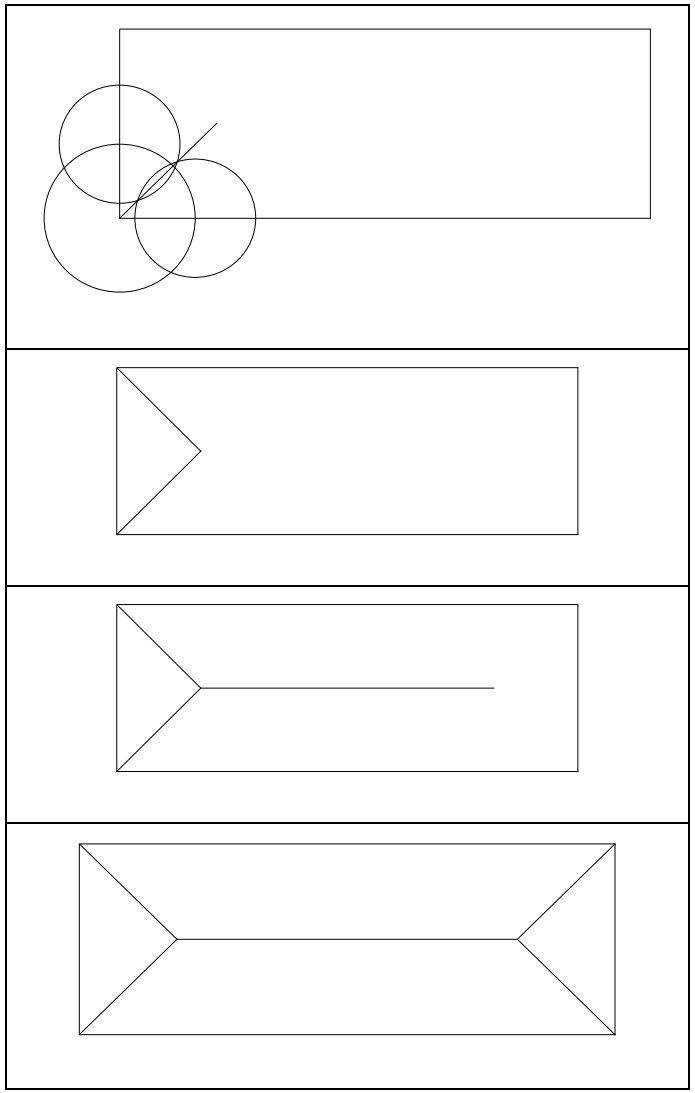


Example 1:

Problem:

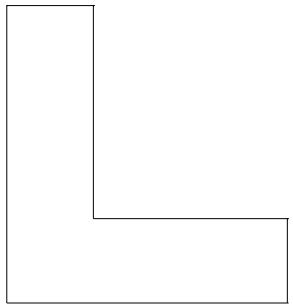
There is one decision procedure: First we choose two planes of the roof and we find the bisectrix or axis of zone. Than we choose other two and continue in the similar manner.

Solution:



Exercise 1. (worksheet)

1.



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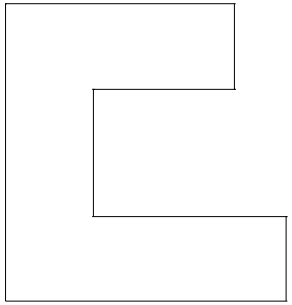

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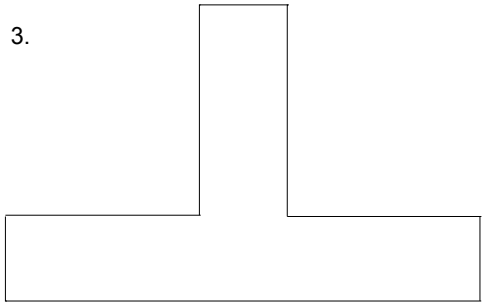

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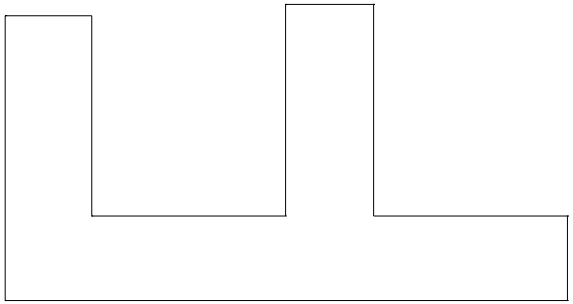
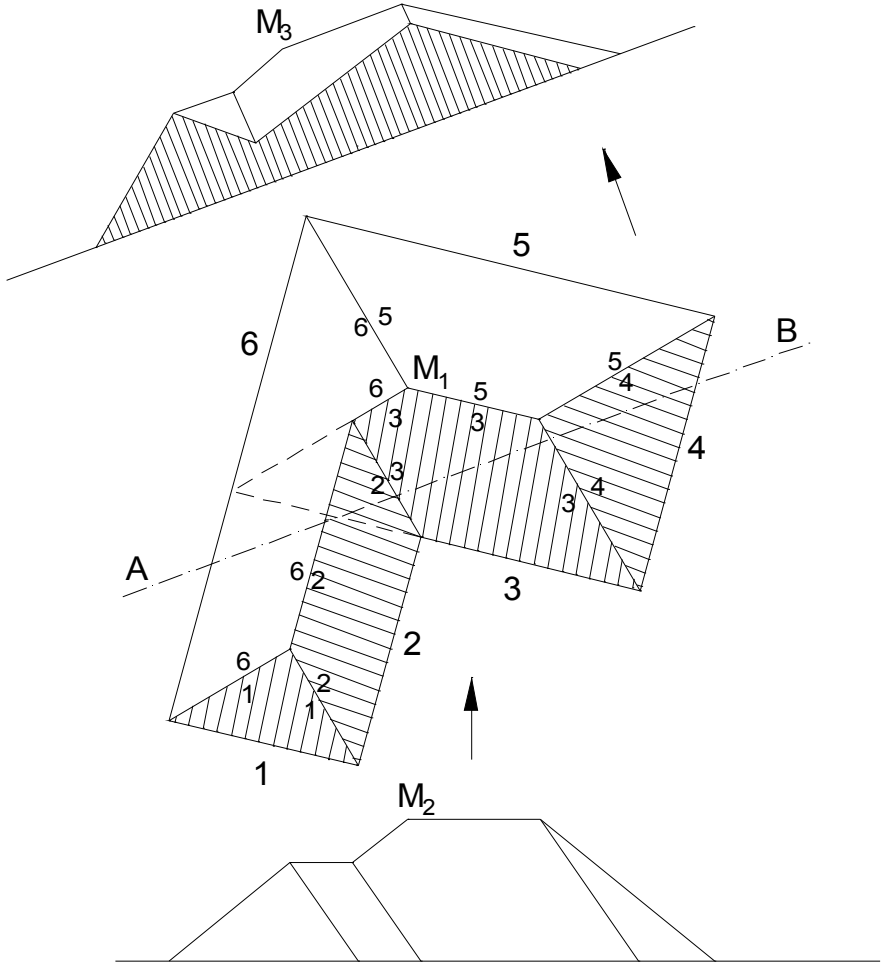
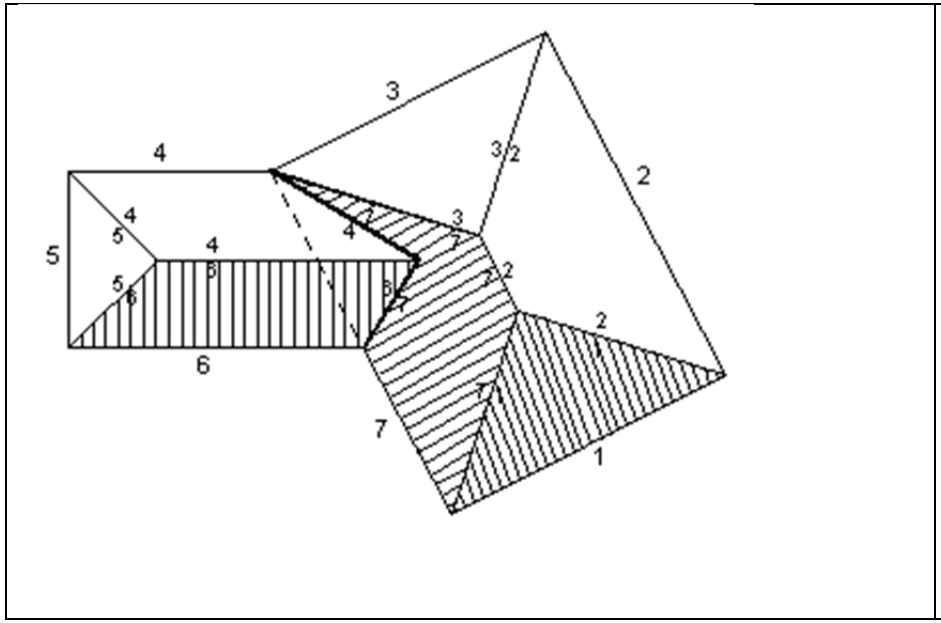
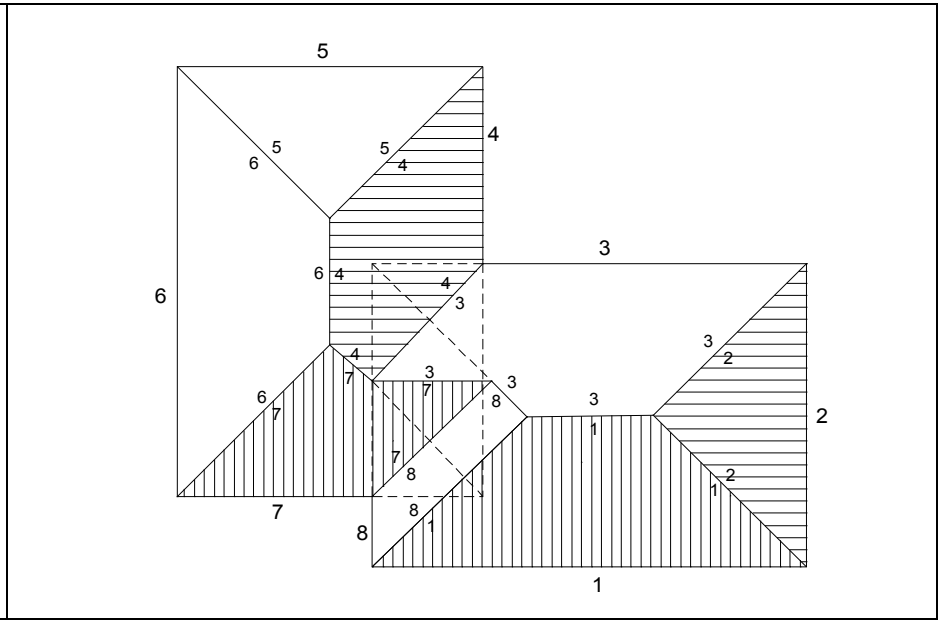


3a) Rectangular projection



3b) Methods of solution

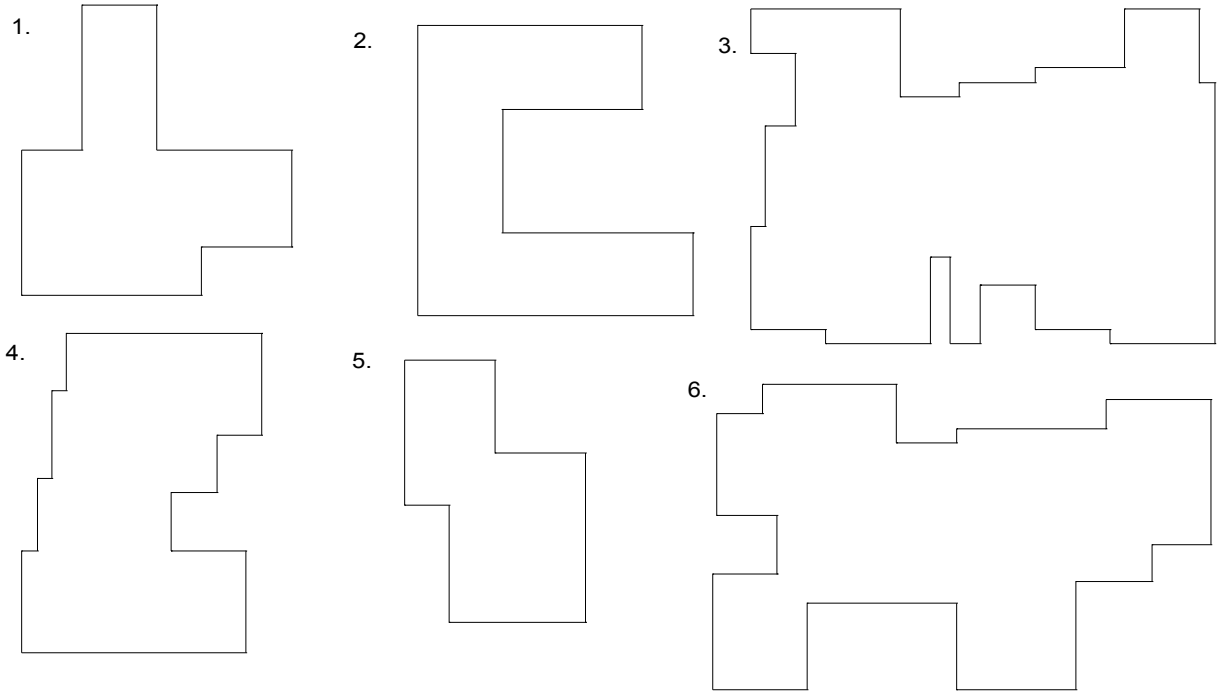




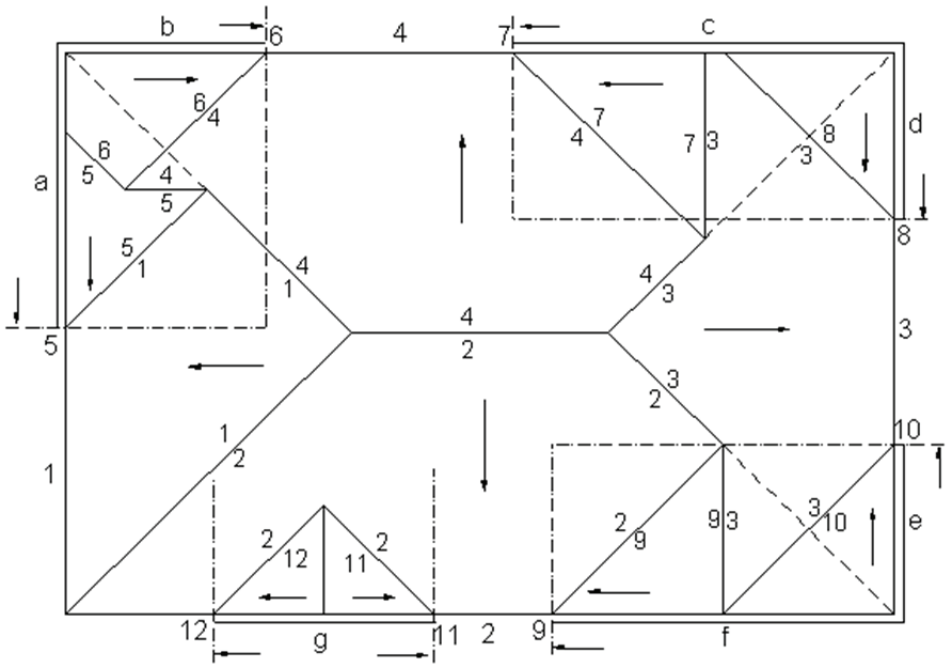
Work in groups

4) Complicated exercises

Exercise 2: (worksheet)



5) Forbidden eaves



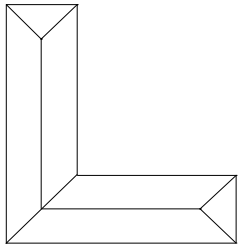
The final activity

1. Check the correctness of the solution and the assessment of pupils

Solutions:

Exercises 1

1.



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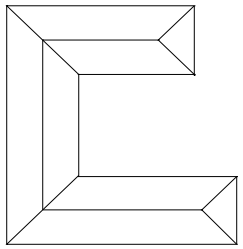

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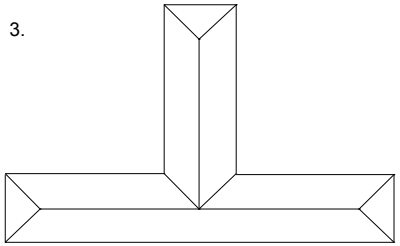

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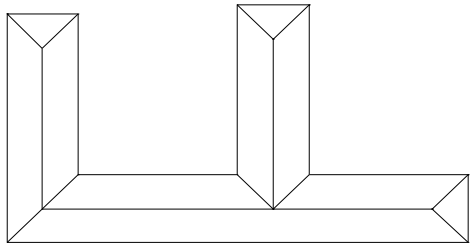
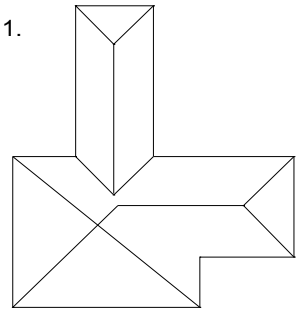


Exercise 2

1.



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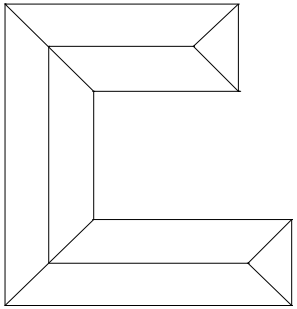

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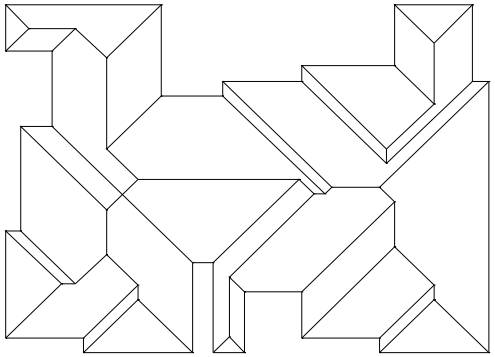

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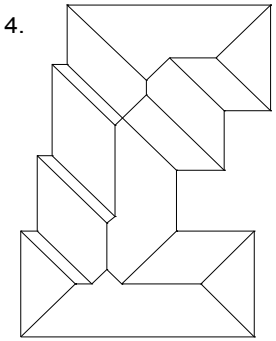

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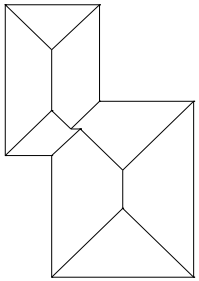

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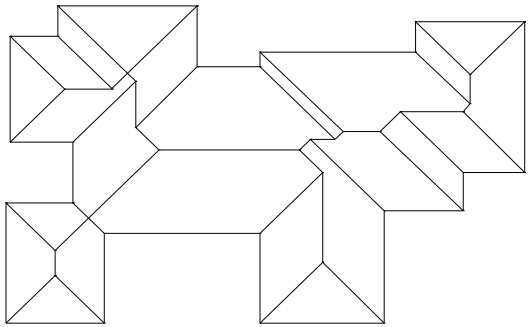


2. Reflections on the lesson

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.

Pupils were given a questionnaire, the questions were:

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

Table: Answers in questionnaire

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

From questionnaire for teacher

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. The method of worksheets suited me, the material was chosen well.

Lesson Plan 10: Activities developing the spatial imagination

Date:	**Topic**: Activities Developing the Spatial Imagination	**Time**: 3 Lessons	Class: 14+

SEN pupils	**Gifted and Talented**	**Class Room Support**
	Solution of hard problems Inquiry-based learning	

Equipment needed for this activity

- Models, wire, drawing instruments (ruler, compass, protractor), cardboard, scissors, glue.

Learning outcomes for this aktivity

All

- developing of space imagination

Most

- solution of problems

Some

- solution of hard problems, inquiry-based learning

Starter Activity, motivation

Card game Black Peter

The main activity

Frontal instruction:

1) repetition of basic knowledge from 3 D geometry

Group work:

2) solving various tasks, developing spatial imagination

Programme:

Lesson 1: Problems are posed, and some revision can be done in case of need. Solving of the problems is set for homework.

Lesson 2: Students take turns in demonstrating their own solutions to the problems. Different methods, the number of possible solutions, and the modifications of the problems are discussed. Students are asked to make up their own problems.

Lesson 3: Problems made up by the students are solved by the whole class together. We recommend that the teacher has prepared some more problems in case students do not manage to make up enough problems themselves.

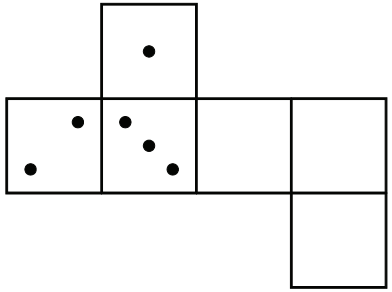
The final activities

1. Check the correctness of the solution
2. Reflection

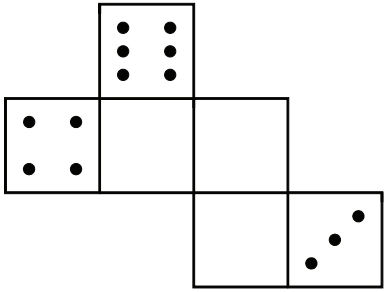
Problems:

1. Complete the net of a die with points so that there are seven of them on each two opposite faces.

a)

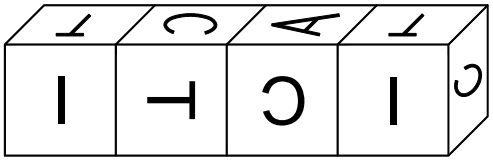


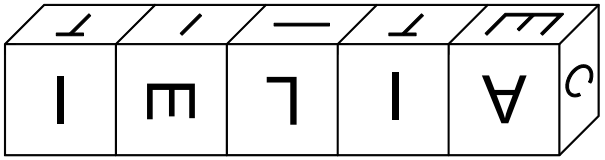
b)



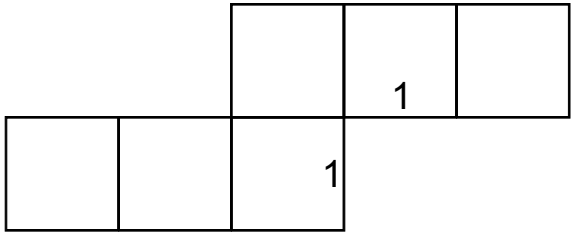
2. Find and sketch as many nets of a cube as you can. There are 11 of them. (Two nets are considered congruent if you can transform one onto the other so that they coincide.)

3. A writing (the first two words of a famous quotation) is made of nine equal cubes. You can see it from the reverse side. Find the words. Do you know which famous quotation it is?

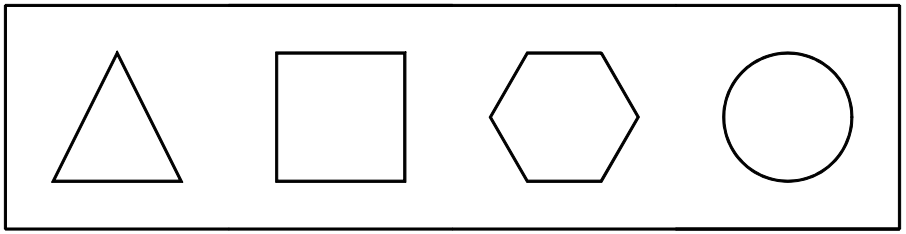


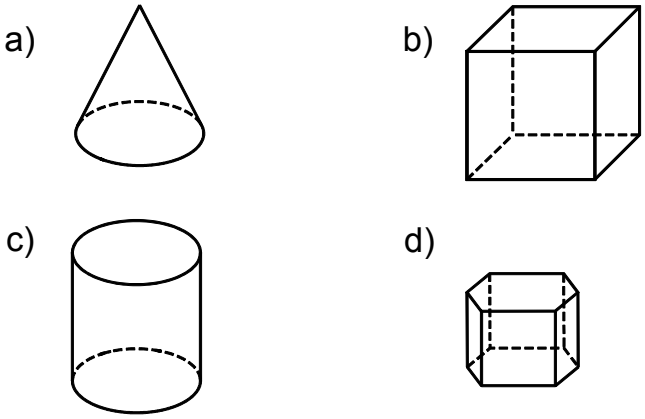


4. In the given net of a cube, mark by the same number the sides of squares which form the same edge of the cube (see the figure). Try also to do that in other nets of a cube, as well as in the nets of other solids.



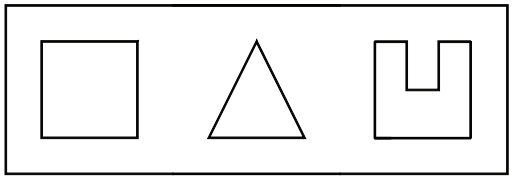
5. Match each of the given solids to all the "holes" through which it can be tightly (without gaps) pushed to the other side. (It becomes a bung at one moment.)





6. In oblique projection, draw a solid which can be tightly (without gaps) pushed through all three given “holes”.

a)



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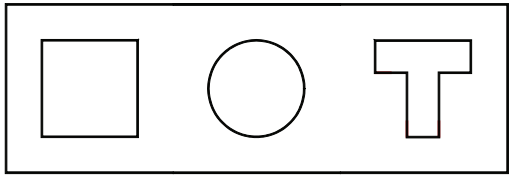
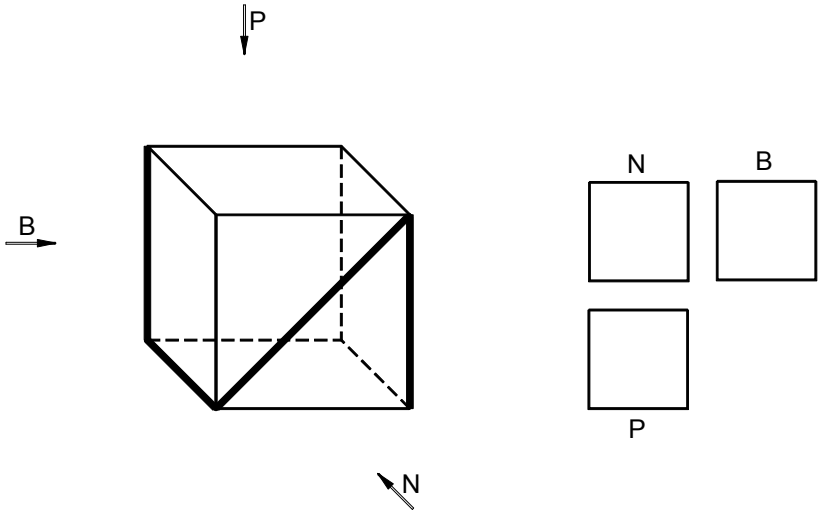
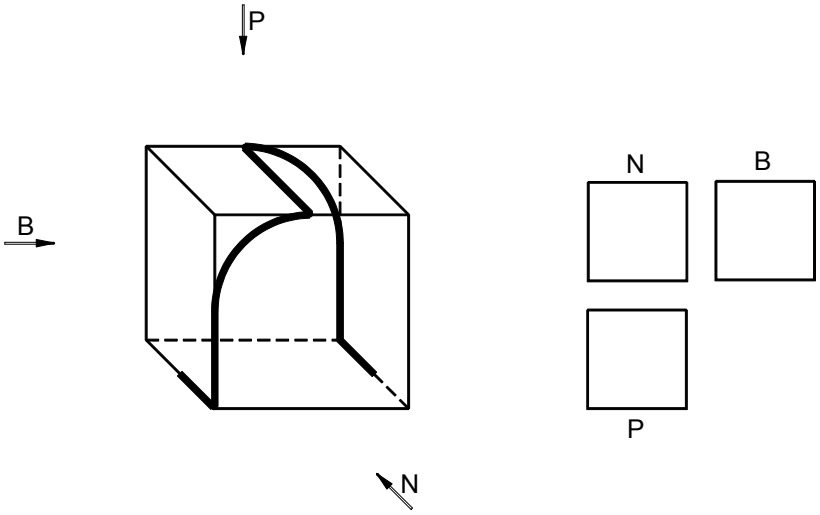


7. Construct the front view N, the top view P and the lateral view B of the wire drawn in oblique projection.

a)

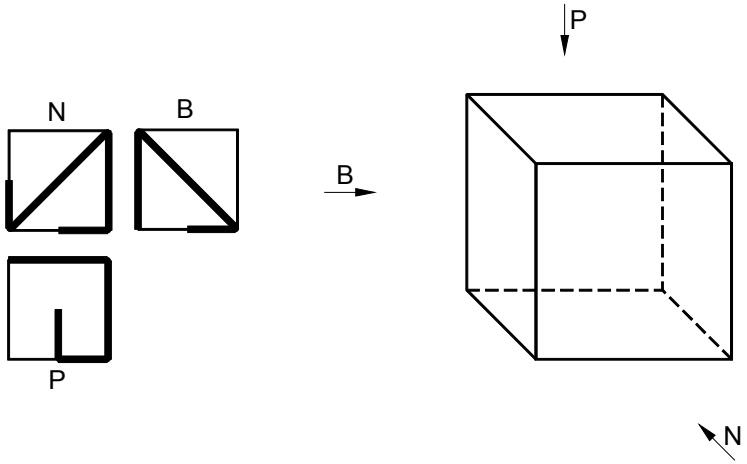


b)



8. Draw the wire (it does not tee) into the cube given in oblique projection using its front view, top view and lateral view.

a)



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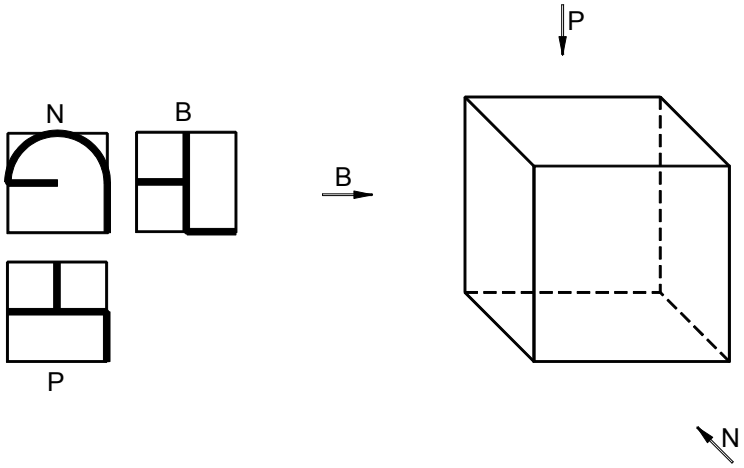
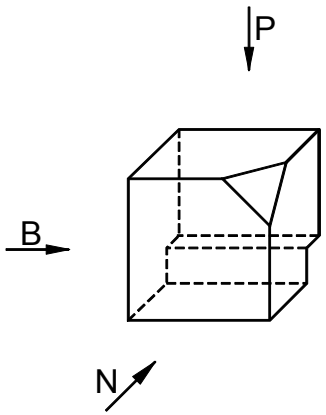


9. Construct the front view, the top view and the lateral view of the solid in oblique projection.

a)



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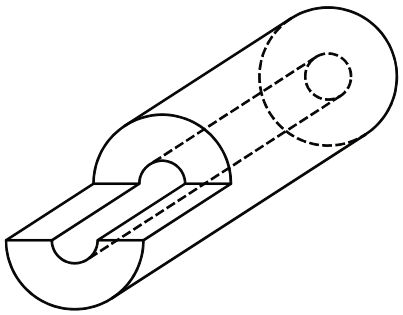
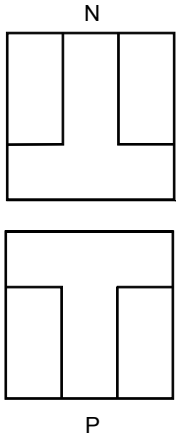
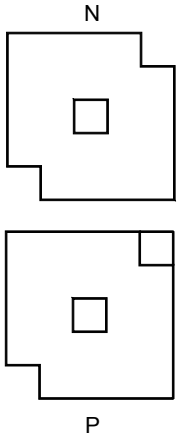


10. Sketch the lateral view and the oblique projection of the solid using its front and lateral views. (There are more solutions.)

a)



b)



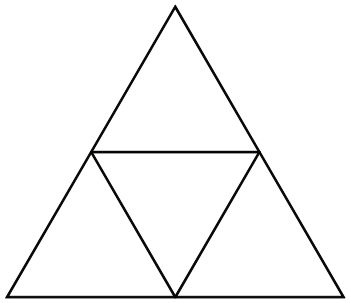
11. What is the shape of the perpendicular projection of:

a) a regular tetrahedron whose two edges are parallel to the plane of projection?

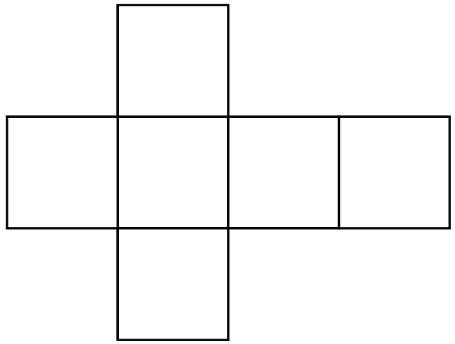
b) a cube whose solid diagonal is perpendicular to the plane of projection?

12. Add the folds and make your own models of all five regular polyhedra (Platonic solids).

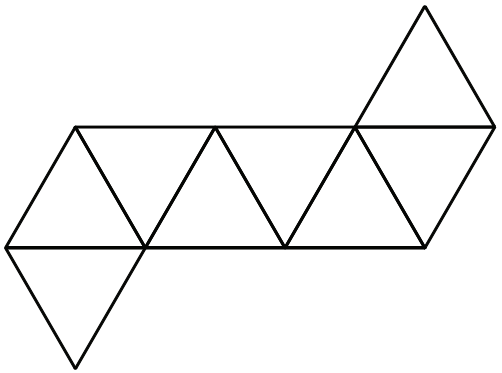
a) tetrahedron



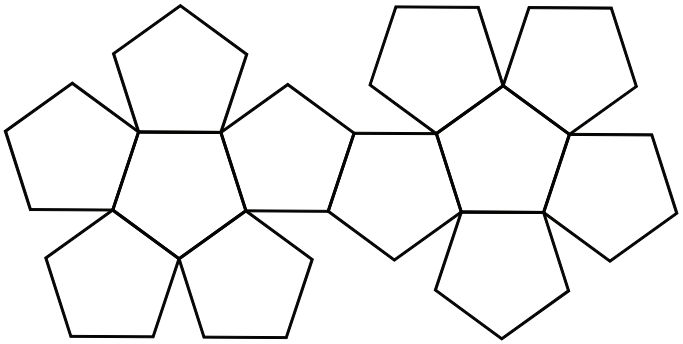
b) cube



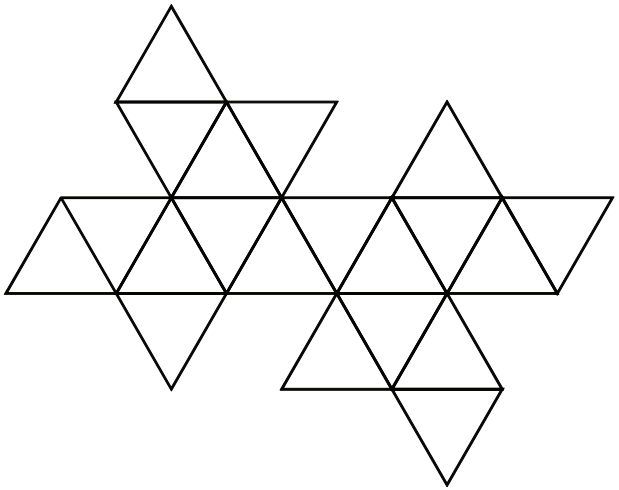
c) octahedron



d) dodecahedron



e) icosahedron



13. Given a triangular pyramid *ABCV* with the vertex *V*. The plane ρ intersects its edges *AB, BC, CV*, and does not pass through any of its vertices. Which other edges of the pyramid does the plane intersect?

14. Is it possible to construct a section of a cube which is:

a) an equilateral triangle,
b) an isosceles triangle ,
c) a scalene triangle,
d) an acute-angled triangle,
e) a right-angled triangle
f) an obtuse- angled triangle,
g) a square,
h) a rectangle,
i) a rhombus,
j) a trapezium,
k) a pentagon,
l) a hexagon,
m) a regular hexagon?

15. Given a regular tetrahedron *ABCD*. Points *P, Q, L, K* are the mid-points of the edges *AD, BD, CB, CD*, respectively. Find the angle between the lines *PQ* and *KL*.

16. Show that if we "go" on the edges of a cube (and dodecahedron), we can make an unbroken line through all vertices so that there is no double line on any of the edges. Try it also for other solids.

17. We will colour the faces of a cube white or black. They can be all white, all black or some white and some black. How many different cubes can we make?

18. How many unit cubes (= cubes with the edge length 1 unit) can be intersected by the solid diagonal of a cuboid with the edge lengths 5, 4 and 3?

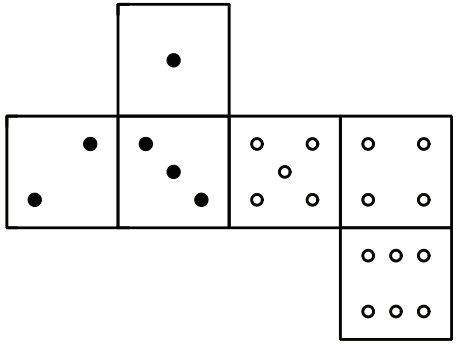
19. How many planes of symmetry are there in each Platonic solid?

20. Six different planes intersect a regular tetrahedron. Each of them passes through one edge of the tetrahedron and the mid-point of the opposite edge. How many solids will we get provided that we make all six sections at the same time?

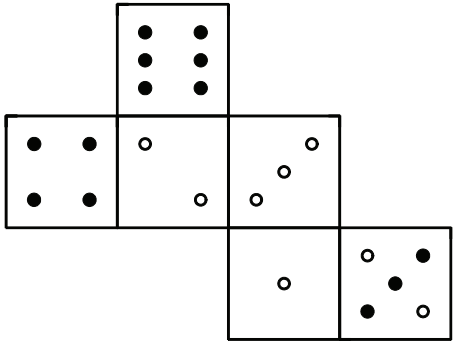
21. Given six different planes and a line p. The given line p is a part of three of the given planes. Two of the given planes are parallel, and intersect the line p. How many lines of intersection are there?

Answers:

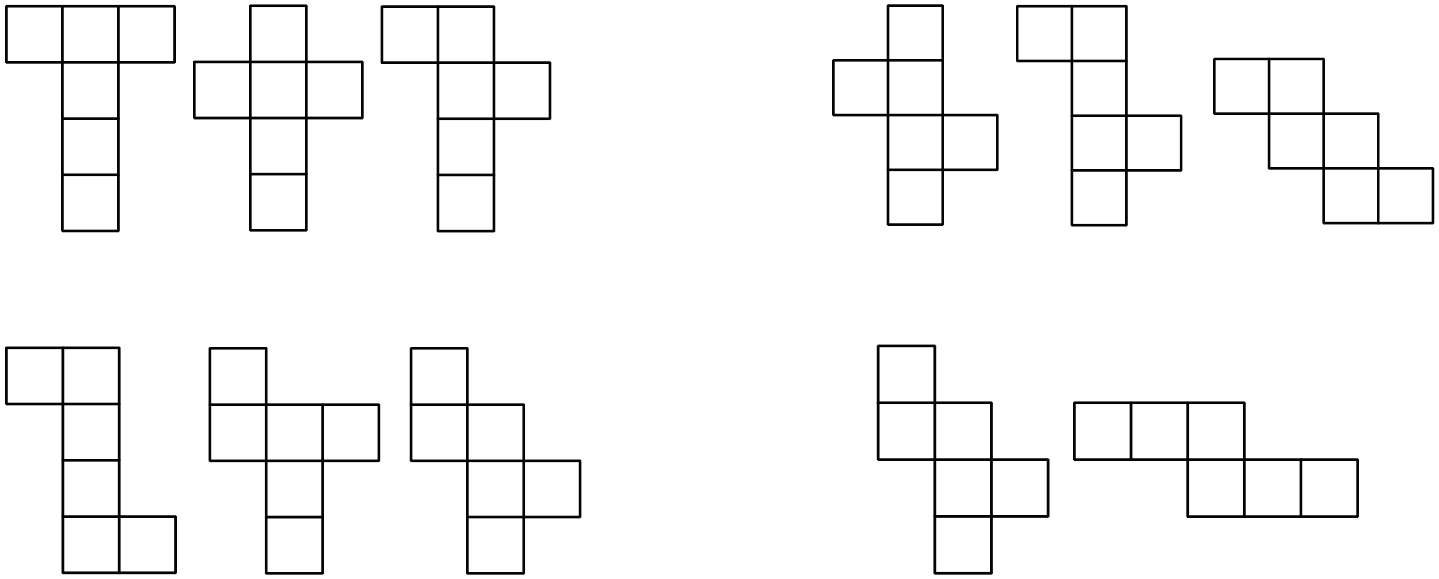
1. a)



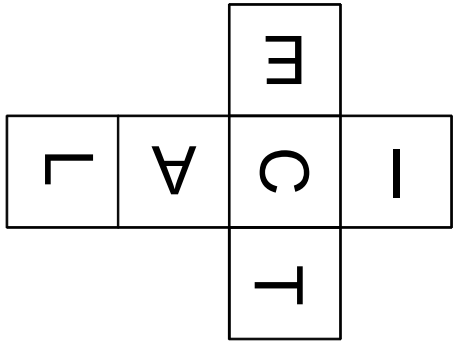
b)



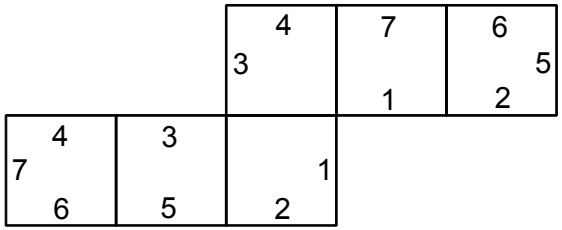
2.



3. ALEA IACTA (EST)

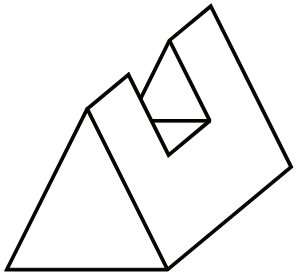


4.



5. a-1, a-4, b-2, c-2, c-4, d-3

6. a)



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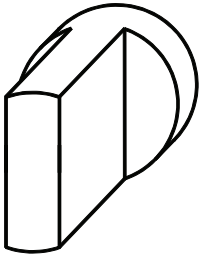
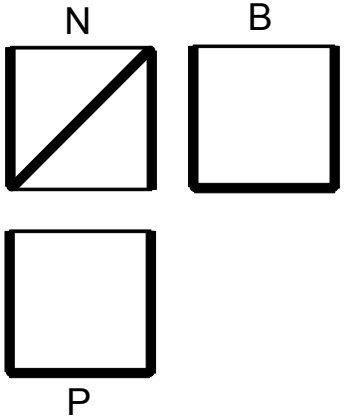


7. a)



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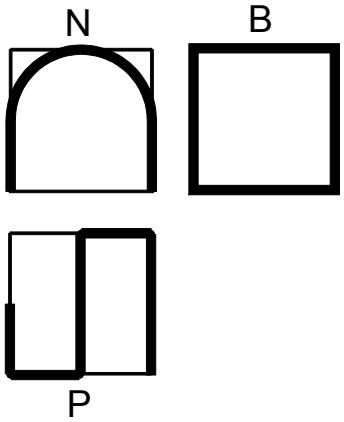
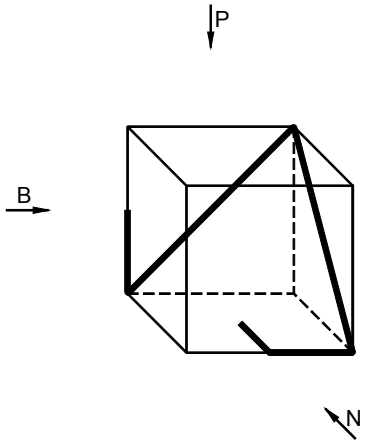


8. a)



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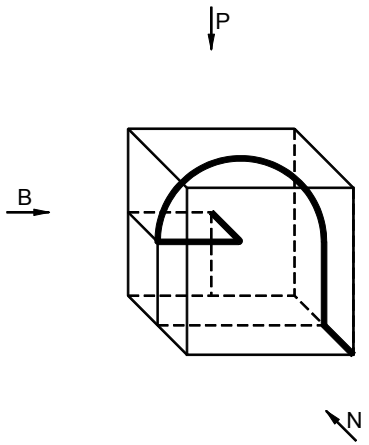
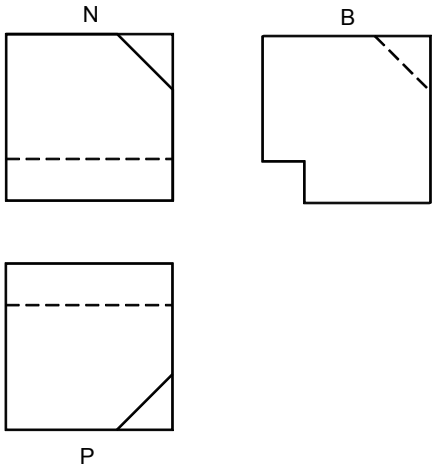


9. a)



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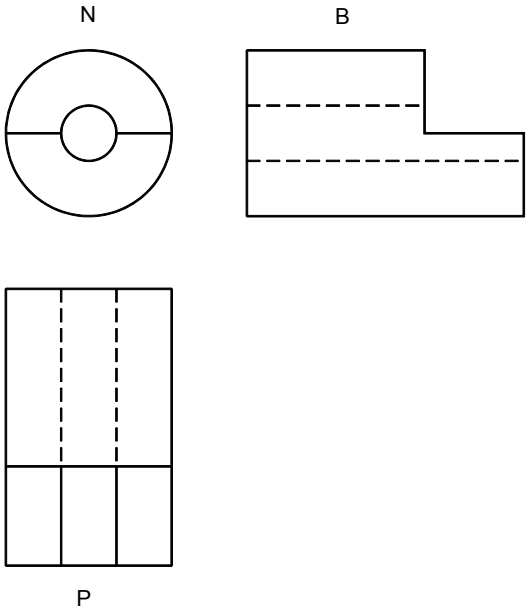
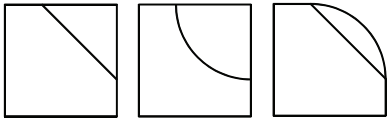
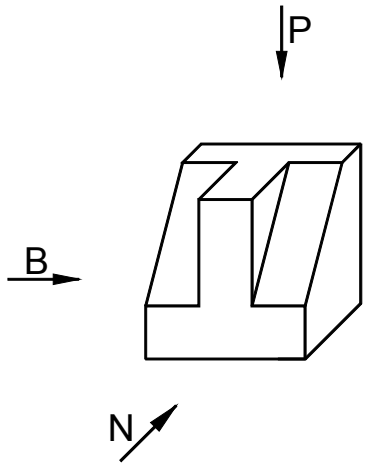
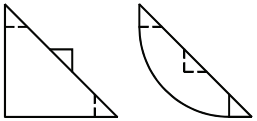


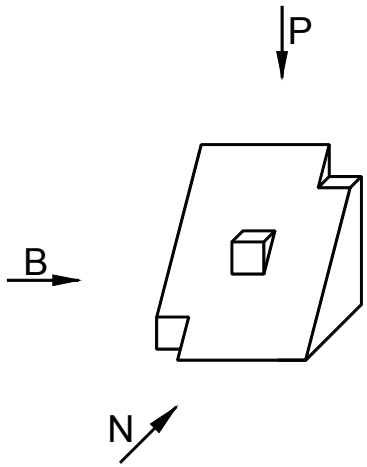
10. a) *Sample solutions:*



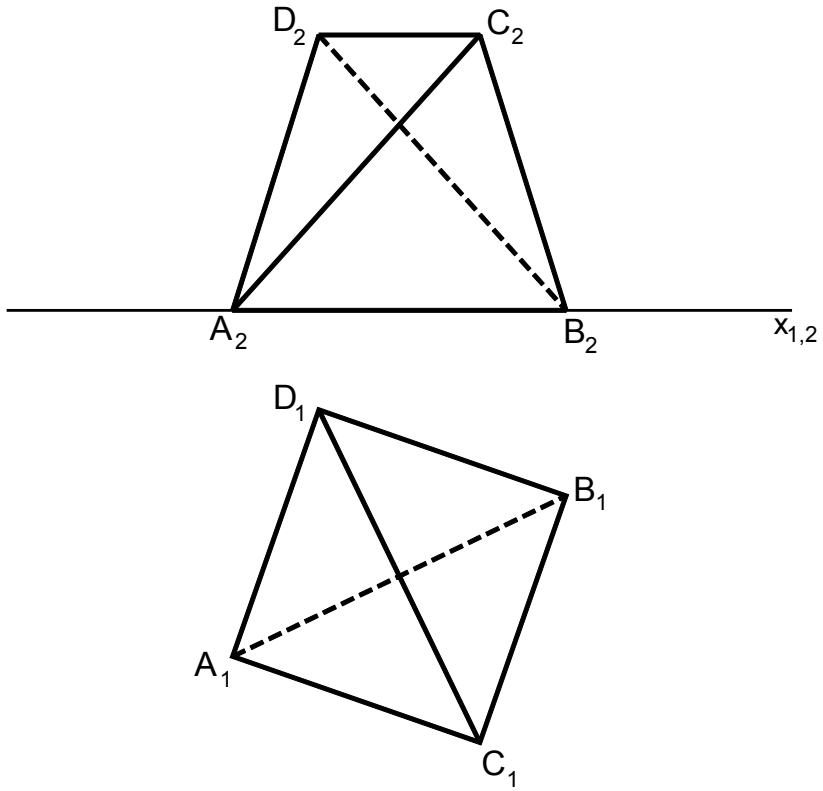


10. b) *Sample solutions:*

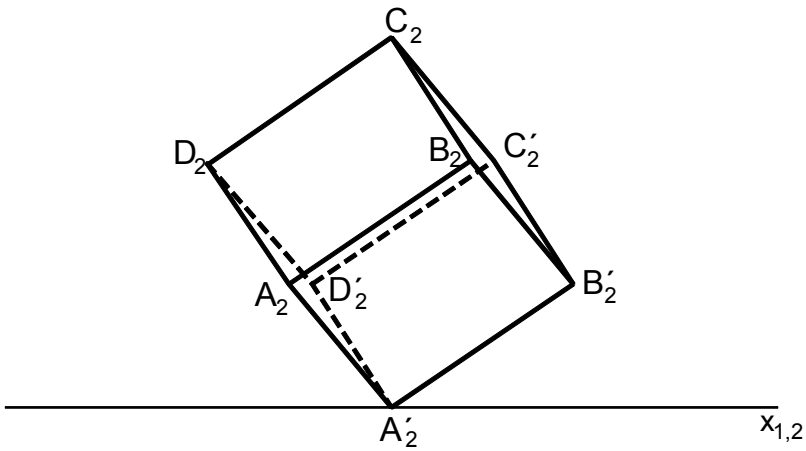


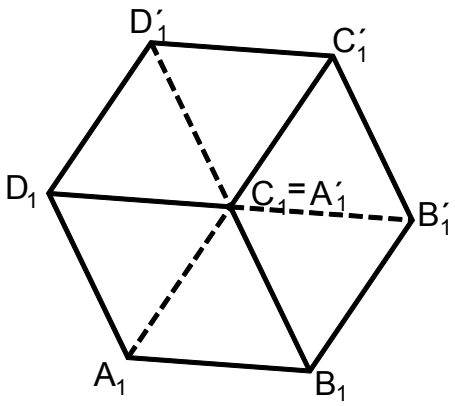


11. a)



11. b)





13. *AV*

14. *a), b), c), d), g), h), i), j), k), l), m) and n) are;* *e) and f) are not*

15. *60°*

17. *10*

18. *10*

19. *tetrahedron 6, cube 9, octahedron 9, dodecahedron 15, and icosahedron 15.*

20. *24*

21. *11*

Other problems and ideas like Tangram, Origami, the cube Soma etc., can be studied eg. in Steinhaus (1958), Pugačov (1960), Gardner (1968, 1988), Barr (1987), Kuřina (1976), Hejný (1980), Molnár (1986), Opava (1989), Hejný a kol. (1990), Molnár a Kobza (1990 a 1991), Adam a Wyss (1994), Máca a Macků (1996), Šarounová (1998), Leischner (2003), Perný (2004); you can also use the teaching aid of Stopenová (1999), various puzzles and building blocks (eg. Žídek, 1997); and computer games or other programmes can also help.

Reflection:

Teaching proved to be very time consuming, showed various levels of spatial imagination of individual pupils. Pupils should like to group lessons.

Lesson Plan 11: Waves

Date:	**Topic**: Waves	**Time**: 90 Minutes	**Class**: 15-16 year

SEN pupils	**Gifted and Talented**	**Class Room Support**
	Prepare and explain the experiment, which will use, for example, an electrical shaver	

Equipment needed for this activity

- Radio, computer with projector, spring (slinky), rope, musical instrument (monochord), stopwatch

Health and Safety

- Discipline during experiments

Learning outcomes for this activity

All

- Student recognizes the transverse waves and longitudal waves
- Student knows the concepts of frequency, period, wavelength, wave velocity, amplitude

Most

- Relationships between these variables
- Demonstration of different types of waves

Some

- Able to design an experiment which demonstrates the given type of waves

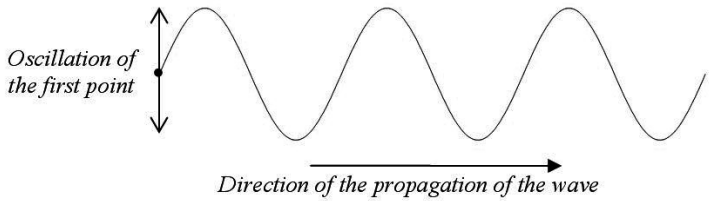
Starter Activity

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).

Main Activity

Work in pairs

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

Work in groups

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

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.

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).

Experiments and basic physical quantities

Experiments prepared at home

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

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.

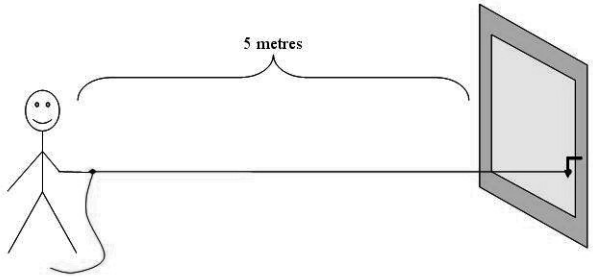
Then students vibrated the string with the other hand. Students could observe the speed of motion. They would also notice the reflection of the wave motion at the end of the string.

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.



Plenary Activity

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.

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.

Reflections on the lesson (students)

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.

Lesson Plan 12: Phenomena regarding reflection and refraction of waves

Date:	**Topic**: Phenomena regarding reflection and refraction of waves	**Time**: 90 Minutes	**Class**: 15-16 year

SEN pupils	**Gifted and Talented**	**Class Room Support**
	Mathematical expression of Snell´s law, solving problematic tasks	

Equipment needed for this activity

- Flat mirror, laser, spring (slinky), straw, transparent glass, water

Health and Safety

- Laser safety, keep the laser beam away from eyes!!!

Learning outcomes for this activity

All

- Student can demonstrate reflection and refraction of waves
- Student can express Snell´s law

Most

- Student can calculate the speed of the wave
- Student can apply knowledge about waves on everyday life phenomena

Some

- Student solve problematic tasks regarding reflection and refraction of waves

Starter Activity

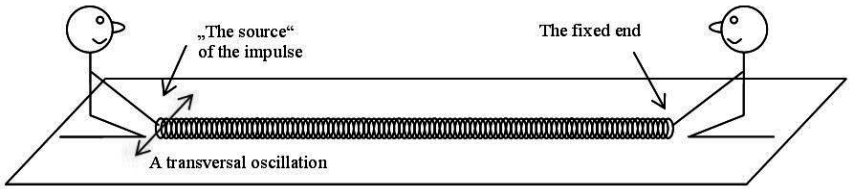
The teacher motivated the students and explained to them that phenomena connected with wave motion are very important for all people and their everyday lives.
The law of reflection was shown with a little plane mirror and laser. The teacher pointed a laser into the mirror and changed the angle of incidence. 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.

Main Activity

Reflection – mechanical wave motion

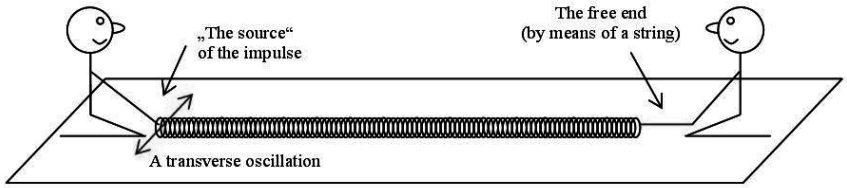
Students already knew this phenomenon from the previous lesson. The mechanical wave on the string was reflected with the **opposite** phase (in the case of reflection on the **fixed** end). Students repeated this experiment: vibrating the tightened string. Students observed the reflection.

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.

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.

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.

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.

Plenary Activity 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
Reflections on the lesson (students) 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).

Lesson Plan 13: Consecutive numbers

Date:	**Topic**: Consecutive Numbers	**Time**: 60 min	**Class**: 3rd Lower Secondary School

SEN pupils	**Gifted and Talented**	**Class Room Support**
Need responsible group-peers		

Class Room Support

- Task sheets

Health and Safety

Learning outcomes for this activity

- Examining and proving a relationship between consecutive numbers

Starter Activity Some minutes exposition by teacher
Main Activity 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 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*. In a second phase they gave to discuss and debate about their solution, in which the guidance role of the teacher is fundamental. This activity was very motivating for students. They were involved in a challenge in which they used familiar quantities like natural numbers. They enjoyed discovering themselves a rule instead of the simple application of it.
Plenary Activity At the end of the discussion the general rule is founded. The teaching method was well balanced, between individual and cooperative work. During the individual work, students reached various levels of understanding, using different strategies.

Reflections on the lesson (teachers) Teacher underlined as this activity proved to be very motivating for students. Reflections on the lesson (students) About 90% of the students were strongly agreed about the interest of the lesson, the said that "it was not a typical math lesson" and it " to work together was very motivating".

Lesson Plan 14: Painted cube

Date:	**Topic:** Painted cube	**Time:** 90 min	**Class:** 3rd Lower Secondary School

SEN pupils	**Gifted and Talented**	**Class Room Support**
• Need responsible group-peers		

Equipment needed for this activity	**Learning outcomes for this activity**
• Task sheets **Health and Safety**	Examining and proving relationship between shape, space and relative volumes, to identify patterns and to generalize and justify their findings.

Starter Activity Some minutes exposition by teacher
Main Activity The students worked individually to accomplish the task. 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 × 4 × 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 × 5 × 5 cube. Generalise your results for an n × n × n sized cube and try to justify your findings*. 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.
Plenary Activity At the end of the discussion the general rule is founded. 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. The teaching method was well balanced, between individual and cooperative work. During the individual work, students reached various levels of understanding, using different strategies.

Reflections on the lesson (teachers) Teacher noticed that 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.

Reflections on the lesson (students)
Student underlined that the following teaching methods were very exiting: they had the opportunity to have group work, discussion, students´ experiments, inquiry, investigations, problem solving.

Lesson Plan 15: The enhanced greenhouse effect and global warming

Date:	**Topic**: The Enhanced Greenhouse Effect and Global Warming	**Time:** 60 min	**Class:** 2rd Upper Secondary School

SEN pupils	**Gifted and Talented**	**Class Room Support**
• Need responsible group-peers		

Class Room Support	**Learning outcomes for this activity**
• Task sheets	• Activity about The Enhanced Greenhouse Effect and Global Warming

Starter Activity Some minutes exposition by teacher
Main Activity 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. 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. 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. This activity could be very motivating for students.
Plenary Activity

Reflections on the lesson (teachers)

Teacher underlined as this activity proved to be very motivating for students.

Reflections on the lesson (students)

About 98% of the students were strongly agreed about the interest of the lesson, the said that “it seems not a typical Science lesson” and it and “the topic seems very interesting”.

Lesson Plan 16: Capacitor discharge

Date:	**Topic:** Capacitor Discharge	**Time:** 90 min	**Class:** High School students, 17-18 years old

SEN pupils	**Gifted and Talented**	**Class Room Support**
Need responsible group-peers		Computer and video-projector

Equipment needed for this activity

- Task sheets
- Diagrams

Health and Safety

Learning outcomes for this activity

- 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

Starter Activity

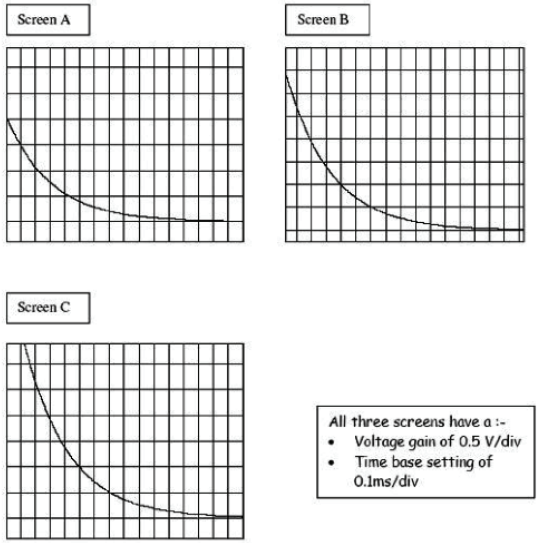
A brief introduction to the topic of the activity

Main Activity

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

Plenary Activity

At the end of the discussion the general "rule" is founded. 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.

The teaching method was well balanced, between individual and cooperative work. During the individual work, students reached various levels of understanding, using different strategies.

Reflections on the lesson (students)

From the analysis of the feedback and the outcomes of subsequent discussion and debate, is it possible to notice

- Low confidence with actual experimental work and data/graphs interpretation;

- Low confidence with the effective use of the measuring units they have studied before.

- A lack of a critical and deeper approach to topics, especially referring to the scientific field. Besides, it means also that students have low confidence with dimensional analysis.

Answers to "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.

The students showed clearly their interest in experimental work.

Lesson Plan 17: Games with fractions

Date:	**Topic**: Games with fractions	**Time**: 45 minutes	**Class**: 13-14 years old pupils

SEN pupils	**Gifted and Talented**	**Class Room Support**
• Need responsible group-peers	• Can form own group and get special more demanding tasks	

Equipment needed for this activity

- Worksheet for the game *Mathematical bingo*
- Pack of cards for the game *Just a fraction more*

Health and Safety

Learning outcomes for this activity

All

- Practice knowledge of fractions using non traditional activities

Most

- Strengthen knowledge of fractions

Some

- Understand fractions as not only part of the whole, but also as an operator.

Starter Activity

5 minutes mental mathematics with fractions, simple arithmetic tasks with fractions written on the blackboard

Main Activity

The pupils sit on their places in the classroom in pairs. The class is divided into two groups, one pupil of the pair belongs to group A, the other to group B.

The first game is *Mathematical bingo.* Rules of the game are explained to pupils. Each pupil is given a worksheet for the game. It usually consists of table of four rows and four columns. Each elementary cell of the table contains one fraction, which represents result 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 cells in their tables (horizontally, vertically or diagonally. This is "*bingo*"., and the moment when pupils are allowed to shout out this word. Mathematical operations, which are usually practiced by Mathematics bingo are:

- Change fraction to their lowest form.
- Change fraction to decimal number.
- Add fraction to 1.
- Compare fractions.
- Practice fraction arithmetic: addition, subtraction, division.

The second game is *Just a fraction more*. Pupils work in pairs. Each pair is given a pack of special cards. On each card is a fraction written, but numerators and denominators of fractions contain only numbers 1 to 5. Each player has 5 cards, the rest of the pack is placed to the middle, and the value of tha card is not visible. Pupils display consequently their cards one by one and compare the values on pairs of the cards. The pupil, who displayed the card with higher value win the both cards. When the value of both cards is equal, next displaying decides about the winner of the round. After each round pupils complete the number of their card in hand to five, using cards in the middle. When there are no cards in the middle, game ends. Each pupil counts number of collected cards. The winner has the biggest number.

Plenary Activity

Pupils and teacher evaluate both activities at the end of the lesson.

Reflections on the lesson by two classes, 43 pupils.

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

- I liked that we were playing games and the same time we have learnt something
- Bingo and the card game. It was a lesson which was special, different from 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 liked the fact that we had to think but it was also funny
- I liked playing a card game and bingo because we didn´t study
- I liked bingo because we could shout out a word anytime

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

- Repetition during the first part of the lesson

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

- …maybe about fractions.
- …about everything that I could.
- …about quadratic and cubic equations.
- …about the use of expressions in everyday life

Details about answers of 43 pupils:

- I enjoyed the lesson: 1.47
- I learnt something new: 2.33
- I did interesting things in the lesson: 1.56
- Most interesting: both games
- Least interesting: classical repetition at the beginning of the lesson
- Would like to find out more about: fractions, arithmetic, algebra…

Lesson Plan 18: Teaching and learning basic functions using spreadsheet models (EXCEL)

Date:	**Topic**: Teaching and learning basic functions using spreadsheet models (EXCEL)	**Time**: 45 minutes	**Class**: 18-19 years old pupils

SEN pupils	**Gifted and Talented**	**Class Room Support**
Need responsible group-peers	Can get special more demanding tasks	

Equipment needed for this activity

- Computer for teacher
- Beamer
- Handouts for pupils
- Computers for pupils (eventually)

Health and Safety

- Activity suitable for computer laboratory

Learning outcomes for this activity

All

- Practice knowledge of graphs of functions

Most

- Strengthen knowledge of graphs of functions

Some

- Understand special characteristics of functions and their graphs

Starter Activity 5 minutes general repetition (naming) basic functions (linear, absolute value, quadratic, trigonometry)
Main Activity During the first part of the lesson each pupil is given three handouts with basic graphs of functions. The graphs are also projected. The shapes of the graphs are putting “nice” values for x into the particular formula and the value y is counted by heart. The resulting points are pointed out on the projected graphs. The aim of this revision is to get the shapes of the graphs into the visual memory of pupils. The expected result is that pupils will be able to recall the shape of the graph of function in a few seconds. In the second part of the lesson, interactive spreadsheet applications are projected with the challenge to pupils to experiment with the formula´s parameters and find their meanings for the shape of the graph of particular function. Than during the third part of the lesson, the pupils are given the work sheet with the graphs, and they have to write down the equations, which determinate the particular graph. When finished, the results are checked and discussed publicly, using the model. The fourth and the last phase of the lesson is exercising phase: sketching graphs of the functions. The exercises are given on the handout. It contains the table with different types of non-elementary functions equations. The equations are created as graduated tasks. Pupils are invited to sketch the graphs by hand. Pupils work in pairs, share and discuss their knowledge. Pupils display their solutions on papers or draw the results on the whiteboard. They open the spreadsheet application afterword and adjust the data to show the precise graph and check their results.
Plenary Activity Pupils and teacher evaluate activities at the end of the lesson. Drawing graphs of some functions can be set for homework.

Reflections on the lesson by two classes, 25 pupils

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

- the method,
- the application,
- the precise graphs.

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

- no answer,
- everything was OK.

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

- not basic functions,
- the applications,
- logarithms,
- combinatory,
- derivatives.

Details about answers of 25 pupils:

- I enjoyed the lesson: 1.87
- I learnt something new: 2.15
- I did interesting things in the lesson: 1.99
- Most interesting: the method, the precise graphs.
- Least interesting: all was OK.
- Would like to find out more about: dominantly: no answer.

Lesson Plan 19: How is it being a physics teacher? Meteorology

Date:	**Topic**: How is it being a physics teacher? Meteorology.	**Time**: 10 lessons per 45 minutes preparation: 1 month	**Class**: 12 - 13 years old pupils

SEN pupils	**Gifted and Talented**	**Class Room Support**
Need responsible group-peers	Can get special and more demanding tasks	

Equipment needed for this activity

- Computer
- Beamer

Health and Safety

- Activity suitable also for computer laboratory

Learning outcomes for this activity

All

- Practice knowledge of meteorology

Most

- Strengthen knowledge of meteorology

Some

- Understand special characteristics of meteorological elements and events

Starter Activity

Each lesson: 5 minutes warm up activity, short repetition, naming parts of meteorology

Main Activity

Pupils work in pairs. They prepare the particular topic for their schoolmates and present the topic within 20-25 minutes of the main part of the lesson. They play the role of the teacher. Each pair can choose their own, original method as the introduction of the topic as well as any correct source for the presented knowledge is allowed.

Topics presented by pupils:

- Essential concepts of meteorology. Climate and weather.
- Levels of atmosphere.
- Condensation of water steam.
- (Air) Humidity.
- Clouds and downfall.
- Wind and wind directions.
- Meteorological map.
- Meteorological station.
- (Air) pollution.
- Calamities caused by weather.

In the period between distribution and education of particular topic, the teacher should have individual consultations or some another way of cooperation with pupils at preparation of their lessons.
During the lesson pupils can experience and play the role of how it is to be a teacher, how it can be uncomfortable and difficult to teach others.

Plenary Activity

Each lesson is evaluated at the end.

Reflections on the lessons

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.

Lesson Plan 20: Chemical reaction

Date:	**Topic**: Chemical reaction	**Time**: 45 minutes	**Class**: 14 - 16 years old pupils

SEN pupils	**Gifted and Talented**	**Class Room Support**
Need responsible group-peers	Can get special and more demanding tasks in the special worksheet	

Equipment needed for this activity

- Computer
- Beamer
- Laser pointer
- Projection screen

Health and Safety

- Activity suitable also for computer laboratory

Learning outcomes for this activity

All

- Practice knowledge of chemical reactions

Most

- Strengthen knowledge of chemical reactions

Some

- Understand special characteristics of chemical reactions

Starter Activity Short discussion about chemical reactions.
Main Activity Exposition the lesson topic using the MS PowerPoint presentation. During the exposition active methods of teaching are used, such are discussion and demonstration. Worksheets based on the presented topic were used in this part of the lesson. The main aim of using the worksheets is reinforcement and revision of the presented topic. 25% of worksheets were based on on-line or interactive activity, 75% of worksheets were printed. The printed worksheets are used by pupils for additional notes and homework problems respectively.
Plenary Activity Lesson is plenary evaluated by pupils and teachers at the end.

Reflections on the lessons

Reflections on the lesson by 394 pupils

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

- Presentation
- Pictures on presentation
- Interesting facts

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

- Nothing
- Everything was interesting

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

- Experiments,
- Chemistry in real life
- Researchers in chemistry and interesting facts
- History
- Explosives

Details about answers of 25 pupils:

- I enjoyed the lesson: 1.99
- I learnt something new: 2.11
- I did interesting things in the lesson: 1,80
- Most interesting: presentation, worksheets
- Least interesting: real chemical experiments missing, much theory, facts I already have known
- Would like to find out more about: experiments, chemistry in real life, researchers in chemistry and interesting facts, history, explosives

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Lesson Plans

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