4.3 Training materials

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Introduction

In this section you can find all the worksheets used during pilot training courses. Each worksheet can be identified by the number of the module that belongs (C.3.1). The way to use each worksheet is described at the corresponding module of section 4.2.

Table 4.3.1. *Course outline*

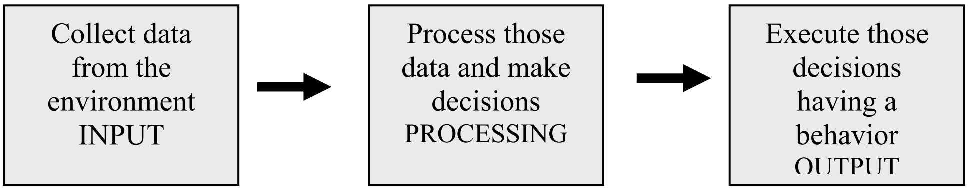
Training Course Curriculum Outline			
Module	**Title**	**Hours**	**Materials**
C.1	**Introduction**	**1**	
C.2	**'Didactic contract'**	**1**	Appendix 1
C.3	**Robotics as learning object**	**13**	
C.3.1	Introduction to LEGO NXT and sensors	2	Worksheet C.3.1
C.3.2	A first approach to construction of robots	3	
C.3.3	A first approach to programming robots	3	Worksheet C.3.3
C.3.4	"The cat, the mouse and the master" project	3	Worksheet C.3.4.1, Worksheet C.3.4.2, Appendix 4,
C.3.5	The 'data logger'	2	Worksheet C.3.5
C.4	**Theoretical framework**	**4**	
C.4.1	Constructivism and Constructionism	2	Worksheet C.4.1
C.4.2	Why robotics in education?	1	Worksheet

			C.4.2
C.4.3	Project-based learning	1	Worksheet C.4.3
C.5	**Methodology for developing robotic projects**	**14**	
C.5.1	Model for organizing robotics projects	1	Worksheet C.5.1, Appendix 2
C.5.2	An example of a robotics project: “BusRoute”	3	Worksheet C.5.2, section 3.2
C.5.3	Working on a new robotics-enhanced project	7	Worksheet C.5.3
C.5.4	Presentation and evaluation of the trainess’ projects	3	Worksheet C.5.4
C.6	**Evaluation of the course**	**2**	Worksheet C.6.1, Worksheet C.6.2

Worksheet C.3.1: Introduction to NXT brick and sensors

NXT brick and sensors-LEGO MINDSTRORMS NXT Edu Software

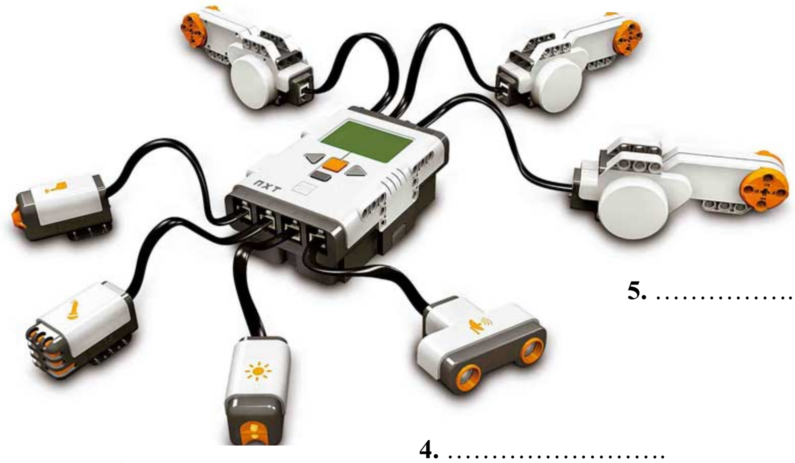
1. A **“robot”** is a structure that can:



According to the above, characterize the following items according to their function.

Item	**Function**
Light sensor	
NXT display	
Play of sound	
NXT brick	
Servomotor	
Touch sensor	

2. The NXT brick can communicate with the computer through a USB cable or a Bluetooth connection. On the NXT brick, sensors, motors, lights are connected with cables. Name the sensors, and motors in the following picture. Please notice to which port each of these objects is connected.



6. …………………….

1. ………

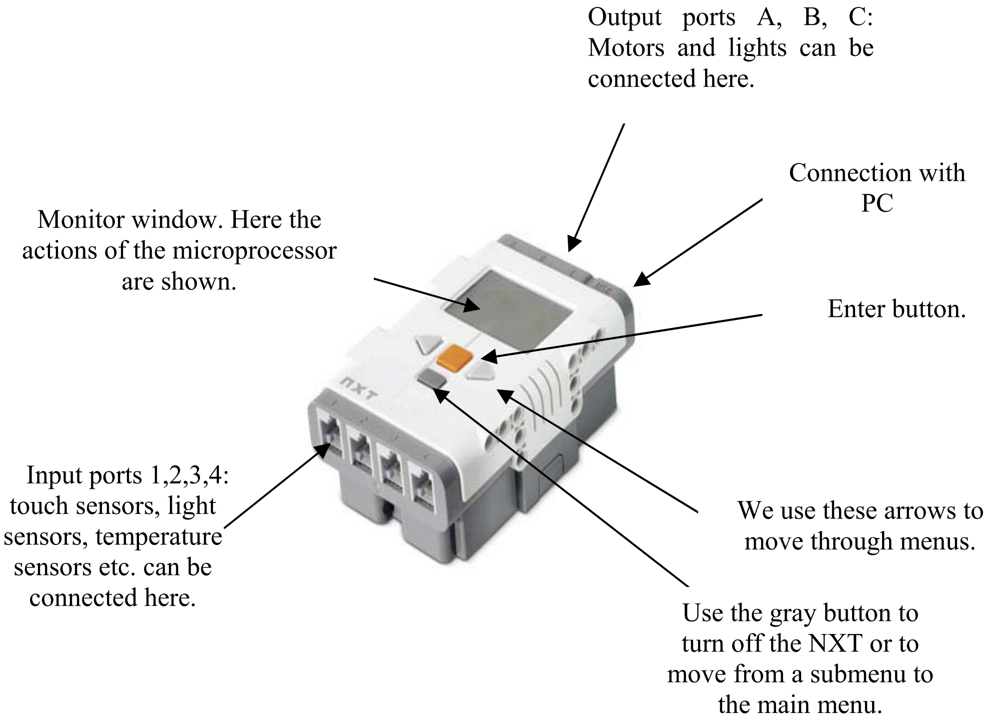
5. …………….

2. …………

4. …………………….

3. ……………

3. Parts of the NXT: On the NXT brick, sensors, motors, lights are connected with cables. Study the following picture.



4. Menu *My Files*: Open the NXT brick and explore the NXT menu. Remember:

Orange button: On/Off, Enter

Light Grey arrows: navigation left and right

Bark grey: Clear, go back

Select *My Files* folder. Which subfolders can you find?

1………………..……… 2………………..…..…….. 3….…………….……….

4. ………………………………

Open subfolder *Sound Files* and run the file *Startup*.

5. Menu View: The behaviour of a robot is usually based on the values of its sensors (e.g. light sensor). We can see the values of each sensor connected to our NXT by the View menu.

5.α Measurement of Reflected Light: The Light Sensor enables the robot to read the light intensity in a room, and to measure the light intensity on colored surfaces. You can test the Light Sensor in different ways using *View*.

Step 1: Connect the Light Sensor to the NXT (port 3). Select View in the NXT display.

Step 2: Select Reflected light

Step 3: Select the right port (port 3) and see the value of the light sensor on your NXT display.

Hold the Light Sensor close to the different colours in your surrounding and see the different readings. Write your observation in the following table.

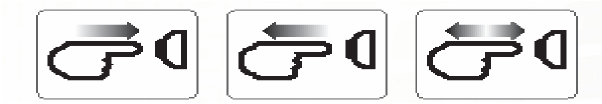
Colour	Value
White	
Green	
Blue	
Light grey	
Black	
In front of the window	
………………………	

Can the robot distinguish the color of a surface?

………………………………………………………………………………………

5.b Touch sensor: The Touch Sensor is a switch: it can be pressed or released.

pressed released bumped



See the current Touch Sensor value on the display using View menu.

Step 1: Connect the Touch Sensor to NXT (port 1). Select View in the NXT display.

Step 2: Select the Touch icon.

Step 3: Select the right port (port 1) and see the value on your NXT display. Press and release the button of the sensor.

Condition	Value
Button Pressed	
Button released	

5.c Interactive Servo Motor: The Interactive Servo Motors have a built-in Rotation Sensor. The rotational feedback allows the NXT to control movements very precisely. The built-in Rotation Sensor measures the Motor rotations in degrees or full rotations. To test the rotation sensor connect the servomotor to NXT

Step 1: Select View in the NXT display.

Step 2: Select Motor degrees.

Step 3: Select the right port (port A or B or C). Now try to attach a wheel to the Motor and measure the degrees by pushing the wheel over the floor.

Can the robot distinguish the direction of rotation?

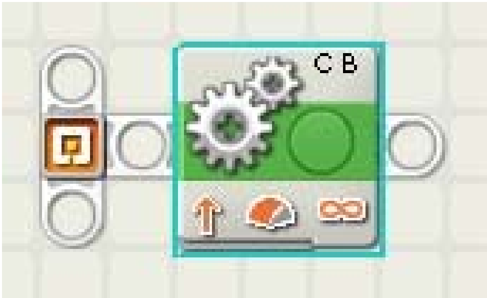
………………………………………………………………………………………

Test the option *Motor rotation*…

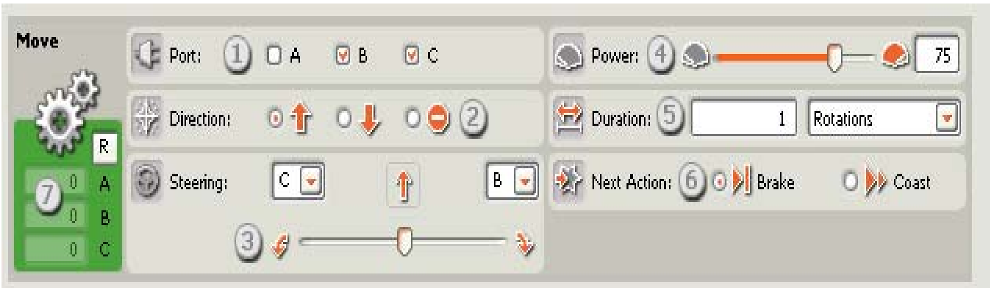
Worksheet C.3.3 A first approach to programming

Moving Around

1. Moving forward: For programming the behavior of a robot we may use the Lego Mindstorms Edu NXT software. This is a graphical programming environment. All available blocks (commands) can be found on the left hand side of the screen.



1.a. Open the Lego Mindstorms Edu NXT software and drag a Move block from the Common Palette on the workspace. Move Block can set our robot to go forwards in a straight line, backwards or to turn by following a curve. *Duration* (5), *power* (4), *direction* (2) of the motion can be defined by the properties of the block (configuration panel, lower part of the screen). Set the parameters of the configuration panel as below. (For more information on the properties of any block you can use the Help menu of the software).

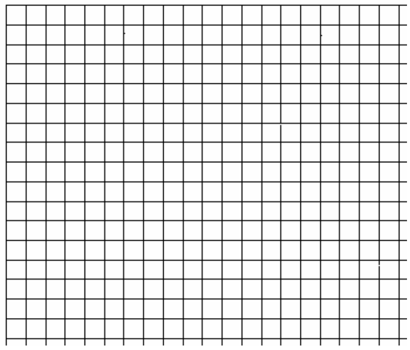


1.b. You have already made your first program. You can save it as *move_fd.rbt*. Can you guess what is going to happen if you run this program?

1.c In order to test this program connect your NXT to you computer and open it. Press the Download button of the *Controller* (on the right side of your screen). You can run the program from the software (press the *Rum button*) or from the *NXT* buttons (*Files/Software files /move_fd/run*). (Make sure that the motors are connected to the right ports)

2. Speed and Power: The power of motors defines the speed of your robot. Make measurements of the distance traveled by your robot in a specific time interval for different values of motor's power. Fill the following table with your measurments.

POWER	Time (sec)	Distance (cm)	Speed (cm/sec)



Use the grid to construct a power-speed graph. Can you figure out the exact formula for speed?

3. Turn Left: The Motor block allows for precise control of one motor's speed. You can find it at the *Complete Palette/Action/Motor*. (For more information on the properties of any block you can use the Help menu of the software).

3.a Write a program which changes the direction of your robot by 90 degrees to the right. Test your program. Save it as *right_turn.rbt*.

3.b. Sketch your program below making some notes on the appropriate properties of each block (duration, power etc.)

3.c. You can make a new command block which turns your robot to the right and save it for later use.

Step 1: Select the blocks of your *right_turn* program by your mouse.

Step 2: With the blocks selected, choose the *Make a New My Block* command from the *Edit* menu at the top of the NXT software interface. This will open the first screen of the *My Block Builder* wizard.

Step 3: Give the name *Right_turn* to your new *My Block*. Then clik *Next*.

Step 4: Use your mouse to drag an icon representing turn into the editing box. Click *Finish* when you are done. Your new *Right_turn* block will appear in your current program and in the *Custom* palette, which is accessible by clicking the right-most tab at the bottom of the programming palette.

Now if you need to make your robot to turn right you can use this block.

3.d Use the *Move* or *Motor* blocks, the *Right_turn* block and a *Loop* block to program your robot to move on a square path. Save your program as *square.rbt*. Upload your file to eclass at the area of your group.

4. Make an investigation and propose a program that changes the direction of your robot by any angle. Upload your work at your group area of e-workspace.

5. Use a few minutes to complete your diary. Write your ideas, thoughts or comments and upload it at your group area.

Worksheet C.3.4.1: The Cat, the Mouse and the Master (I)

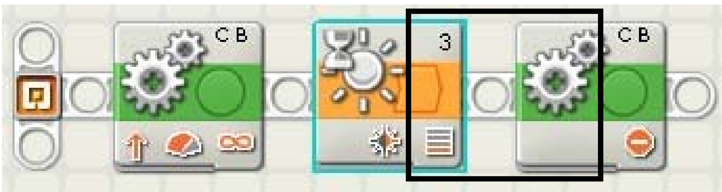
When a robot acquires senses and control…

In this activity, you will progressively construct a 'cat-robot' simulating the movement of a cat chasing mice. You will also need a mock up with small black areas around to put the robot move.

1.A Cat chasing a Mouse: *block, loop structure, light sensor*

1.a The **cat-robot** should make use of the C, B motors and should, also, include a light sensor, which provides input to port 3. Note that in order to connect the light sensor, follow the building instructions provided in the Lego Mindstorms Edu NXT software, area of the Robot Educator/Common palette/16.Detect Dark Line /Building Instructions / Light Module Down).

Open the Lego Mindstorms Edu NXT software. Develop the following program that simulates the movement of a 'cat-robot' that chases mice and name it as "cat-robot.rbt"! The program may have the following form and is based on the 'Wait Light' block.



1.b Make the cat-robot move: Let us suppose that your robot is a cat chasing a mouse (black spot on the floor)! Which are the individual steps that make up the cat's behavior? **State them** one after the other:

1. ……………………………………………………………………………………

2. ……………………………………………………………………………………

3. …..…………………………………………………………………………………

4. ……………………………………………………………………………………..

5. ……………………………………………………………………………………..

State the cat's behaviours, as recorded during the preceding step, in correspondence with the commands included in the program and the necessary settings for each command.

Behaviour	Commands	Conditions / Settings

Run the program. In order to achieve the desired behavior, most probably you will need to make some changes to the control condition of the Wait Light block.

1.c Develop your first procedure or block **(My Block)**. Store the above program in a block (My Block) and name it 'mouse-stop'. By creating a 'MyBlock' command in your program, you may re-use the particular series of commands whenever you wish, provided that each time you call the block with that name!

Tip: Use the following commands: Menu selection: *Edit - Make A New My Block.*

1.d Use the block 'mouse-stop' and develop a program that makes the cat stop for a while, when encountering a dark area, and then, change direction and continue to chase mice, i.e. looking for black areas on the white mock-up. **Put** below a screenshot of your program (use Alt - PrintScreen to save the current screenshot)

1.e Loop construct: Modify the above program so that the cat should look for mice for 30 seconds!

Tip: In order to form the loop structure, select from the left hand side menu the Common palette, the Loop block (attention with the control condition that terminates the Loop Block!).

Put below the screenshot of your program (use Alt – PrintScreen to save the current screenshot)

Save the final version of the program as cat_mouse_groupxxx.rbt (where xxx represents the number of your team) at your group area of e-workspace.

1.f State in which ways you can terminate the loop structure:

2. The Cat encounters its Master: *Selection structure, Touch sensor, Display, Sound, Wait For*

What is going to happen if the cat's Master appears? At his/her touch, it will, probably, miaow, smile, stop for 3 sec and, then, will continue undeterred ☺ its chasing effort. In that case, the cat's behavior changes depending on the context. This behavior can be programmed using the *Switch* Block.

2.a You need a Touch Sensor in your robot (port 1).

In order to connect the sensor follow the building instructions provided in the Lego Mindstrorms Edu NXT software, area of the Robot Educator/Common palette/ 18.Detect Touch /Building Instructions / Touch Module Front.

2.b Develop and test a program that simulates the cat's behavior when chasing mice and it suddenly meets its master.

State the behavior that you want the cat-robot to have when its master touches it.

If [the cat gets a touch] ***then***

………………………………………………………………………………..

Enter the above functions in your program "cat_mouse_groupxxx.rbt". Make use of the blocks *Switch, Display, Sound*.

Tip: The *Switch* block is located at the left hand side menu *Common palette* (attention to the condition that controls the touch sensor!). Find there, also, the block *Display* (appearance of icon, text, or sensor values on the NXT display), *Sound* (sound production) and *Wait For* (stops the motion). Consult, also, the Brief Guide at the end of this worksheet.

Save the program as 'cat-mouse-man_groupxxx.rbt'.

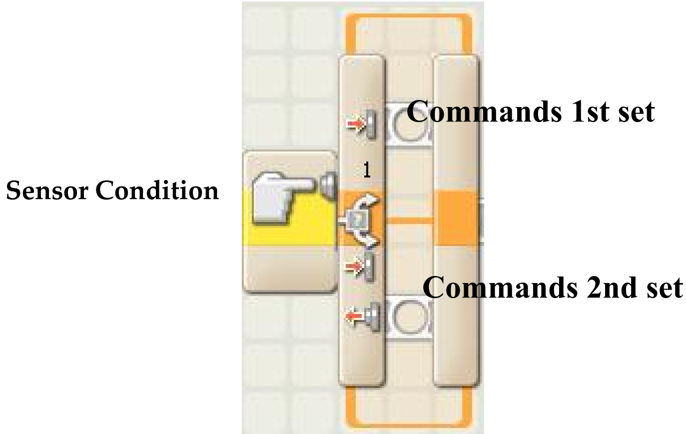
Save the worksheet as 'Worksheet 3.4.1 _groupxxx.rbt'

<u>**Brief Guide**</u>

'Display' Block: This block is used in order to display an icon, a text or to draft something on the NXT brick monitor.
'Sound' Block: This block is used in order to produce a sound. The sound files are saved separately in the NXT in a special folder.

'Loop' block: All of the blocks that are placed within a Loop are repeated for a specific number of times (count), for a specific time period (time), or until a certain condition is met (sensor) / forever (unlimited) according to the control condition which is selected.

'Switch' block: When the sensor condition is set 'true', the program performs the command set No. 1; otherwise, it performs the command set No. 2. This command may take more than one conditions.



'Wait for' block: delays the performance of the next block for the time defined in the appropriate parameter. In this case: wait for 1 second.

Worksheet C.3.4.2 The Cat, the Mouse and the Master (II)

Selection construct, Variables and Data Input

In this activity, you will progressively make the 'cat-robot' move in a spiral route.

1. Open the Lego Mindstorms Edu NXT software. Search for the file spiral_display.rbt. You may ask your trainer for help. Study this program and try to describe the kind of behavior that you expect your robot to execute once it has run that program.

Comment on the actions performed by each of the blocks of the program "spiral_display.rbt". You can add comments above each block by using the tool *Comment tool* of the tool bar.

2. Run the program: What kind of actions does your robot perform?

……………………..…………………………………………………………………

After the observation of the cat's behavior add or modify the comments on the actions performed by each block of the program "spiral_display.rbt". This time use CAPITAL (upper case) letters.

……………………..…………………………………………………………………

Save your program as "cat_spiral_move_groupxxx.rbt" at your group area of e-workspace.

3. What is the name of the variable that controls the distance run by your robot before turning?

……………………..…………………………………………………………………

Which is its initial value?

……………………………………………………………………………

Which is its final value, as quoted in the NXT screen?

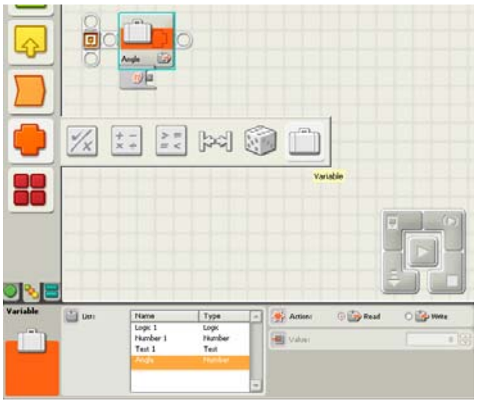
……….……………………………..

Save your worksheet as "Worksheet4-3-2-groupxxx.rbt" at your group area of e-workspace .

Brief Guide

Variable: The definition and use of variables in the Lego Mindstroms Edu NXT environment is carried out in 3 steps.

Step 1: Variable definition: Select from the *Edit* menu / the *Define variables* option. Define the name and the type of the variable (numeral, logic, text).



Step 2: Variable initialisation: Select from the Complete palette the command “Variable”. You can see the settings of this block at the following picture:

Parameters of the variable block

1. Select from the list the name of the variable you want to use in your program (variable definition is described in Step 1).

2. Select the action that the Variable block will perform. By selecting the *Write* command, the variable acquires a value. With the *Read* option, the value of the variable becomes available in the program.

3. Area wherein the value of the variable is defined.

Step 3. We recall the value of the command and we can use it as input in other commands (option *Read*).

Math Command: It allows the execution of arithmetic operations. It can take input values from other variables.

Number to Text Command: It accepts as input a numerical value which it converts into a text and can display it, on the NXT display.

Worksheet C.3.5 The "data logger"

Linear motion

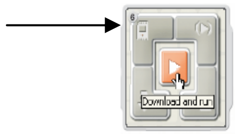
1. The NXT through the *File Access* Blocks can collect, save and retrieve data from timers or sensors.

To collect and save the data you need three *Access blocks*. These three blocks could be positioned right next to each other or could be spaced throughout your program.

The first *File Access* block (with "*Delete*" selected in its configuration panel) would clear content of the file.

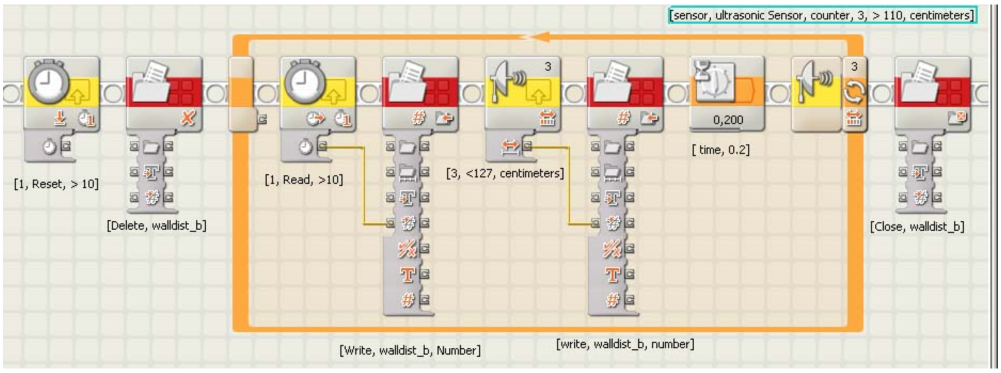
The second (with "*Write*" selected in its configuration panel) would write data to a file.

The third *File Access* block (with "*Close*" selected in its configuration panel) positioned somewhere later in the program would close the file.



To retrieve the data you should access NXT memory through NXT Window button (on the Controller: NXT window/Memory/Others) and Upload the *.txt file to your computer).

2. A simple data logging program that collects data from a timer and the ultrasonic sensor is shown at the following picture (comments in brackets [ ] are the parameters of each block). Try to make this program on your computer.



2.a Please identify: The timer block, the ultrasonic block, the three File Access block and their functions.

2.b. What is the name of the data file created by this program?

2.c Which is the condition that terminates the loop?

2.d What kind of data is going to be collected if you run this program?

3.a Create a parallel sequence beam by moving the mouse pointer over the starting point and pressing and holding your mouse button while you move it. Double click to finch this action. And blocks in order to make your robot moving forward with steady speed. Save your program as walldistance.rbt at your group area.

3.b Add an ultrasonic sensor (find instructions in Lego Mindstrorms Edu NXT Robot Educator/Common palette/ 14.Detect distance/Building Instructions / Ultrasonic Module). You are ready to test your program. Make all necessary arraignments in your workspace and test it.

3.c Download and run it. Retrieve the data file.

4. Propose at least two activities, suitable for students who have already been introduced to linear motion with constant velocity, which will make use of this set of data.

1st activity …………………………………………………………………………….

……………………………………………………………………………………..

……………………………………………………………………………………..

2nd activity ……………………………………………………………………………..

……………………………………………………………………………………….

………………………………………………………………………………………

5. Suggest a program which can collect data for uniform accelerated motion. Upload your program.

6. Find more information about the functions of *timer*, *ultrasonic*, *file access b*lock at the *Help* menu of the software.

7. Take a few minutes to complete your diary. Write your ideas, thoughts or comments and upload it at your group area.

Worksheet C.4.1 Constructivism and Constructionism

1. Read the main points of the following paper with the members of your group (20 min).

Ackermann E., (2001) Piaget's constructivism, Papert's constructionism: What's the difference? Future of Learning Group Publication

2. Discuss and write down the main similarities and differences between constructivism and constructionism (20 min).

3. Choose one representative from your group to present to the whole class your work (5 min)

Worksheet C.4.2 Why robotics in education?

1. Read a part from the article (20 min):

Resnick M (2002). Rethinking Learning in the Digital Age. In The Global Information Technology Report: Readiness for the Networked World, edited by G. Kirkman. Oxford University Press.

2. Discuss in your group the ideas presented by the author. Point out three reasons you consider as important for the introduction of robotics in school education. (20 min)

3. Upload in the forum area of the e-workspace a summary of what you have discussed (5 min).

4. Choose one representative from your group to present to the whole class your work (5 min).

Worksheet C.4.3 Project based learning

1. Read the main points of the article (20 min):

Mike Carbonaro, Marion Rex, Joan Chambers (2004) Using LEGO Robotics in a Project-Based Learning Environment, *The Interactive Multimedia Electronic Journal of Computer-Enhanced Learning* 6 (1) 2004

2. Discuss in your group and point out three main advantages of the project-based learning against the traditional teacher-centered teaching model. (20 min)

3. Upload in the forum area of the e-workspace a summary of what you have discussed (5 min).

4. Choose one representative from your group to present to the whole class your work (5 min).

Worksheet C.5.1 Model for organizing a robotic project

Activity 1 (20 minutes, work in groups of 4 trainees)

In previous sessions of this course we have discussed thoroughly constructivism learning approach and its implications in teaching. Concerning *Robotics in Education* we have illustrated interesting features of learning by constructing artifacts and we have discussed the constructionist approach in teaching and learning.

1. Make a list of seven features that a robotic project should have in order to serve constructivist and constructionism perspectives of teaching and learning.

……………………………………………………………………………………….
……………………………………………………………………………………….

2. Be prepared to present your list to the whole class.

Worksheet C.5.2 An example of a project: "The BusRoute"

Activity 1 (35 minutes)

"The BusRoute" is a robotic project designed for students of secondary education. Its duration is 12-14 teaching periods (45 minutes). The project follows the project model presented in previous sessions and it is developed in five stages: Engagement stage, Exploration stage, Investigation stage, Creation stage, Evaluation stage.

Stage	hours	Teaching Theme	Worksheets
Engagement stage	2	Public Transport A robot bus	Worksheet 1 Worksheet 2
Exploration stage	4-5	Getting to know the structural materials Construction of a robot car Programming a robot Use of light sensor	Worksheet 3, Worksheet 4, Worksheet 5, Worksheet 6
Investigation stage	2-3	Construction of the bus Suggest a solution	Worksheet 7 Worksheet 8
Creation stage	1-2	Synthesize and Create	Worksheet 9
Evaluation stage	1-2	Presentations & Discussion	

We suggest you to select one of the above stages and study with your colleagues the description of this stage and the relevant worksheets. The materials are available through e-workspace (each group must select a different stage to study)

Activity 2 (10 minutes)

After the end of the Activity 1 discuss in your group the following issues:

1. What kind of difficulties may a teacher face during the implementation of this stage?

2. What kind of difficulties may the students face during the implementation of this stage?

3. Complete the following table with activities that may be included in the stage you have studied.

Stage	**Teaching Strategies-Tools**	**Student activities**	**Teacher activities**

4. Be prepared to share your thoughts with the rest of your class.

Worksheet C.5.3 Working on a new robotics-enhanced project

Developing a robotics-enhanced project: specifications

We propose that your work includes either an activity or a project. Both cases should include actions involving students, promoting experimentation, exploration, open problems and self-evaluation.

Follow the following pattern for the description of your work by answering each question included in each stage.

Expected Results: What learning outcomes are expected (outcomes may be classified in knowledge, skills, attitudes and values)?

Describe the stages of the project and develop the appropriate materials by answering the questions of each stage.

Engagement Stage: What is the real problem set by this project? How are you going to involve your pupils in its formation?

Exploration Stage: Which are the materials that students will use in their work? Which of the basic software functions will they utilize? How are the pupils going to be organized?

Investigation Stage: Which of the open problems you would like your pupils to investigate? How are the pupils going to be organized in relation to the open questions that they will investigate?

Creation Stage: How should the diary of the pupils be structured in order to reflect their actions and thoughts?

Evaluation Stage: What kind of evaluation are you going to use: self evaluation, peer evaluation teacher evaluation? Select criteria and formulate rubrics.

Stage	Description Objectives	Resources	Expected Products	Actions of students
Engagement				
Exploration				
Investigation				
Creation				
Evaluation				

Brief Description of the project: Upload in the e-workspace a brief description of your project and other materials that may support your proposal.

Worksheet C.5.4 Presentation and evaluation of the projects

Rubrics for assessing a robotics project

	Novice	Apprentice	Practitioner	Expert
Authenticity	Content and skills are connected to later use in school only.	Content or skills are somewhat connected to life outside of school.	Content and skills are clearly connected to life outside of school, such as the work world.	Content and skills are highly relevant by connecting to students' lives right now.
Open-Ended	Task has only one correct response.	Task allows limited room for different approaches.	Task allows for different approaches based on the same content/skills base.	Task allows students to choose different assessment measures for the task
Complexity	Task contains different skills, most lower order.	Task contains many different skills and content.	Task contains many different skills and content, including higher level thinking.	Task contains many different skills and content, including higher-level thinking. Task contains opportunities for students to choose some of the skills and content.
Curricular Connection	Task is loosely connected to key skills and content in curriculum.	Task is clearly connected to key skills and content in curriculum.	Task is connected to key skills and content in curriculum. time frame and scope of task match time frame and scope in the curriculum.	All tasks are clearly connected to national curricular standards.

Appendix 1 . "Didactic Contract"

During the module 2 (Agreeing on a "didactic contract") trainers and trainees discuss the overall aim, the specific objectives of the course, the training methodology and the expected training results. This discussion is expected to result in a "didactic contract" that will offer a better adjustment of the course to the trainees' needs and interests. What follows is the "didactic contract" agreed with the trainees in the pilot TERECoP training course held in ASPETE, Athens (April-May 2008).

The overall aim of the course is to provide opportunities for teachers to examine how robotic technologies can be used to promote a constructivist-constructionist approach to learning under a co-operative and collaborative frame of work. The implementation of robotics-enhanced constructivist teaching and learning practices demands that teachers play a new role. This means that opportunities, like exposure to a number of critical examples and experience in designing computer-based robotic activities and integrating them in their classroom practice in constructivist ways, are of great priority. The goal is teachers to be convinced by their own personal experience for the potentiality of robotic technology as learning tool.

In this course we regard that technology alone cannot affect minds. The curriculum design will follow an innovative constructivist perspective with emphasis on aligning computer and robotic technology with subject matter and learners' needs for the purpose of constructing meaning in social learning environments. In such learning environments the focus is not on the individual but on interactive systems that include individuals interacting with each other, instructional materials, subject matter, and tools. Computer-based robotics is an innovative technology that can create a rich interactive environment encouraging constructivist learning.

The specific objectives are

- to familiarise trainees with appropriate robotics-based learning environments including Lego Mindstorms NXT system and a set of critical examples and activities that can support constructivist teaching and learning in science and technology subjects
- to enable trainees to use robotics technology in a way that can contribute to the realisation of
  - meaningful learning based on students' own team work with teaching materials
  - authentic learning using learning resources of real-life, occupational situations, or simulations of the every day phenomena,
  - social learning though the use of e-learning classes
  - active-reflective learning working on experiments or problem-solving and using available resources selectively according to their own interests,

search and learning strategies
  - project-based learning seeking solutions to real world problems, which are based on a technology-based framework
- to create a community of practice between trainers and teachers for facilitating and sustaining teachers' professional development in using robotic tools to support their students' learning by active exploration and social construction of new knowledge.

Pedagogical and didactical approach: Constructivist-constructionist pedagogy and a learner-centered didactical approach will be applied taking into consideration learner's characteristics for an effective technology-enhanced learning design. A collaborative e-learning environment will support the course based on the belief that the inherent dynamics of a necessary mutual process are likely to be more conducive to meaningful transformation, carrying so a sense of greater potential for development.

The expected impact on trainees is to be trained in a way that robotic technology-based learning will play an important aspect of their future work as teachers or professional educators. Trainees are expected to be able to

- develop innovative collaborative strategies in their classes supported by the development of e-learning communities
- select exploratory learning activities that can support social constructivist teaching and learning.
- use the proposed tools in real classrooms situation.
- design, build and program their own robotic models.

Appendix 2. Project –Based learning: Important features

In previous sessions of this course the constructivism approach and its implications in teaching has been thoroughly presented. Concerning Robotics in Education interesting features of learning by constructing artefacts have been illustrated. Finally constructionist approach in teaching and learning has been discussed. At that point we suggested that the appropriate way to implementing robotics in a learning process is through projects. A robotic project with the following features may serve constructivism and constuctionism approach to teaching and learning.

A robotics-enhanced project may focuses on creation of a product (artifact) that reflects learners' abilities and learners' understanding. Therefore project activities should be organized around a question (driven question) or a theme which can guide learners progressively through the learning process. The driven question or theme of the project should be open ended in order to serve different learning goals and different learning styles. It is also very important for a successful project, that the theme of the project is significant and meaningful for the learners. For example, projects which deal with real life problems provoke students' interest and motivation.

In a project learners are actively involved in the formation of the driven question and in the description of the final product. Clarification of the goals of the project and the criteria for assessment of the final product (rubrics) are collaboratively agreed by student and teachers in the beginning of the project. Learners organize their work by themselves and they work autonomously over extended periods of time.

Teacher is a facilitator /mediator of the learning process. S/he creates a learning environment and provides support for the learners. S/he allows them to take as much responsibility for their own learning as they can. Teacher keeps the balance between guiding his/hers students through learning activities and challenging them with interesting questions for further investigation.

Communication in group level and in the classroom is an important element of a project. Learners express their ideas and test their understanding through their collaboration in small group or in the classroom. Feedback from each other and the teacher give learners the opportunity to improve their work and meet the learning goals of the project.

Appendix 3. Methodology for organizing robotics-enhanced projects

Engagement stage:	Students are provided with an open-ended problem and get involved in defining the project. This stage requires the identification and representation of a scientific problem. Students work as a class putting their ideas into a question format. As they are doing so, they are identifying and representing a problem and different issues involved (e.g. brainstorming at class level).
Exploration stage:	Students get familiar with LegoLogo, controlling devices and software, make hypothesis and test their validity in real conditions, provide initial ideas. Students are divided in groups in order to answer to simple questions and study specific cases in order to get familiar with the controlling devices and software (e.g. work in groups with worksheets – structured activity).
Investigation stage:	Students search for resources and investigate alternative solutions. Students reconsider the problem and the different issues rose during the engagement stage based on their experience gained through the exploration stage. At this stage students in collaboration with the teacher formulate the driving questions/problems which link with the learning goals of the project. The student groups undertake to solve the particular problems, investigate alternative solutions and argument on their final proposals concerning the artifact and the software the developed (e.g. work in groups with worksheets, keep diary – open activity).
Creation stage:	Students share and combine their artefacts, synthesize 'solutions' to the project reflect on their initial ideas. Students present their work in class and then each group work on the synthesis of a final 'product' including the artifact and the software (e.g. work in groups with worksheets, keep diary – result in a product). This work may lead to similar solutions but also to innovative proposals.
Evaluation stage:	Students share their ideas, products at class level, argument on their final proposals and evaluate them. Alternative solutions are presented at class level and evaluated based on the driving questions/criteria posed in previous stages of the project (stages of engagement, investigation). At this stage students should critically judge their work, express their opinions, compare their works, and reach a common proposal to the project (e.g. make presentations, discuss, peer evaluation). Students should also reflect on and evaluate their collaboration.

Appendix 4

Description of the spiral_display.rbt (to be used with worksheet 3.4.2)