4.2 Course curriculum outline

Authors: Stassini Frangou, Kyparisia Papanikolaou, Dimitris Alimisis

In this section, we present a pilot training course for teachers, developed according to the methodology described in section 4.1. Firstly, we present the overall aims and objectives of this course, then we give a brief outline of the course curriculum and, lastly, we give a detailed description of the proposed teaching activities. Worksheets and other training materials can be found in the next section 4.3.

4.2.1 Overall aims and objectives

The overall aim of the course is to provide opportunities for teachers to examine how robotics 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 assume a new role. This means that opportunities, such as exposure to a number of critical examples, experience in designing computer-based robotics activities and integrating same in their classroom practice in constructivist ways, are of great priority. The goal is teachers to be convinced by their own personal experience about the potential of robotics technology as a learning tool.

In this course, we assume that technology alone cannot affect teaching practices. Our curriculum design follows an innovative constructivist perspective with an emphasis on aligning computer and robotics 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.

Specific objectives: More specifically, our objectives are:

- to familiarise trainees with an appropriate robotics-based learning environments (Lego Mindstorms 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 through 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 educators and teachers with a view to making easy and sustaining teachers' professional development in using robotics tools to support their students' learning by active exploration and social construction of new knowledge.

The expected impact is teachers to be trained in a way that robotics technology-enhanced learning will play an important part in their future work as teachers or professional educators. Trainees are expected:

- to develop innovative collaborative strategies in their classes and promote the development of e-learning communities,
- to select exploratory learning activities that can support social constructivist teaching and learning,
- to use the proposed tools in real classroom situations,
- to design, build and program their own robotic models and develop their own projects for their students.

4.2.2 Outline of the training course curriculum

The pilot training course is organized in six modules and its total duration is 36 teaching periods (of 45 minutes). It provides an initial training (a) in constructing and programming a robot and (b) in developing robotics projects for students. In particular, the six modules are:

1. Introduction to the course.

2. Building a **'Didactic contract'** aimed at presenting to trainees the rationale and the means which are going to be used during the course in question.

3. Robotics as learning object aimed at introducing basic constructing and programming features of robotics technology

4. Theoretical framework embracing learning theories and the appropriate background for designing robotics-enhanced projects.

5. Introduction to the **methodology for developing robotics projects** and designing such projects.

6. Evaluation of the course based on semi-structured interviews and questionnaires.

An outline of the course and the estimated duration of each module can be found in table 4.2.1.

Table 4.2.1 *Course outline*

Training Course Curriculum Outline		
module	**title**	**Duration (teaching periods)**
C.1	**Introduction**	1
C.2	**'Didactic contract'**	1
C.3	**Robotics as learning object**	**13**
C.3.1	Introduction to LEGO NXT and sensors	2
C.3.2	A first approach to construction of robots	3
C.3.3	A first approach to programming robots	3
C.3.4	"The cat, the mouse and the master" project	3
C.3.5	The "data logger" project	2
C.4	**Theoretical framework**	**4**
C.4.1	Constructivism and Constructionism	2
C.4.2	Why robotics in education?	1
C.4.3	Project-based learning	1
C.5	**Methodology for developing robotics projects**	**14**
C.5.1	Model for organizing robotics projects	1
C.5.2	An example of a robotics project: "BusRoute"	3
C.5.3	Working on a new robotics-enhanced project	7
C.5.4	Presentation and evaluation of the trainess' projects	3
C.6	**Evaluation of the course**	**3**

The exact timetable of the course can be formed according to the needs of the trainees. It can be taught over a period of 4 weeks (9 teaching periods per week) or

over 3 weekends (12 teaching periods every weekend) - one weekend per month. In order to enhance class communication during and beyond the face-to-face meetings, we suggest maintaining through the course an e-workspace (find a description of the e- space at section 4.1). A useful tool in collecting information about the work done by trainees during the meeting, their thoughts or other issues concerning the implementation of the course is the diary. Each group spends a few minutes at the end of each session to write a few lines on an electronic diary. Suggested questions to be included in their diaries are:

- What did you do during this session?
- What was the best thing that happened to you during this meeting?
- What was the worst thing that happened to you during this meeting?
- What are you thinking to change next time?
- Other Comments

Finally, most of the activities of the course are carried out in small groups. In order to ensure that groups can work independently we provide worksheets and other resources which can be found in section 4.3.

4.2.3 Proposed way of course implementation

C.1 Introduction (1 teaching period)

This teaching period aims at 'breaking the ice' between trainees and trainers, at helping trainees relax and get to know each other's names and personal/professional information and at identifying individual learning needs and goals, expectations and possible learning difficulties.

In particular, the trainer(s) introduce(s) himself/themselves. Then, the trainees are asked to form groups of 4-5 people and each one to introduce himself/ herself to the rest of the group in 2-3 minutes. Additionally, trainees are asked to provide personal/professional information, to express individual learning needs and goals, expectations and possible learning difficulties. Lastly, one representative from each group briefly introduces the members of his/her group to the plenary. Also, trainees and trainers are asked to post a message on a relevant topic at the discussion forum of the e-class briefly introducing themselves (forum-topic "Class members")**.**

Alternatively, after this introduction, the trainees in groups of two interview each other for 5 minutes and then introduce themselves in 2 minutes to the whole class.

C.2 Didactic contract (1 teaching period)

The aim of this module is:

- to ensure a consensus between trainer and trainees on the training objectives, content and methods
- to generate interest in the topic of the training

- to make arrangements necessary for the smooth running of the course
- to give a few key ideas on pedagogical issues

The trainer presents the overall aim, the specific objectives of the course, the training methodology and the expected training results. The trainees are asked to express their own expectations, opinions, suggestions and ideas. This module finishes with an agreement between trainer and trainees on the aforementioned issues (and on everything else that may emerge in the training class) leading to the formulation of a "didactic contract". This “didactic contract” is uploaded by the trainer in the Documents area of e-class. Some relevant papers become available for trainees through the e-class and are suggested for reading.

C.3 Robotics as learning object

This module is focused on the introduction of the materials included in the Lego Mindstorms Education NXT kit, and the Lego Mindstrorms Edu NXT software. It is organized in five parts. In the first part, trainees are familiarized with the materials which they are going to use in the construction of their model. In the second part, they get involved in constructing a robot car. The remaining parts of this module are introducing the basic programming feature of the software.

C.3.1 Introduction to Lego Mindstorms NXT brick and sensors (2 teaching periods)

Trainees form small groups of 3 or 4 members and one Lego Mindstorms Education NXT kit is given to each group. They are working in groups and they identify the sensors, the motors and the construction parts, such as blocks, axles etc. of their kit. The trainer makes a brief introduction to NXT brick functions and then the groups are asked to experiment with the touch sensor, light sensor and servomotor in order to become familiarized with them and their parameters by carrying out the activities of the Worksheet C.3.1. At the end of this section, a discussion about the technical characteristics of each sensor takes place in plenary.

C.3.2 A first approach to construction (3 teaching periods)

During the second part, trainees in groups construct a car- robot with two motors. To this end, they use instructions included in the official guide and the Lego Mindstorms Edu NXT software. They are also introduced to the Lego Digital Designer software(http://ldd.lego.com/). At the end of this part, a discussion-evaluation of their experiences through the construction of the robot-car takes place. The trainers and trainees agree on a set of criteria for evaluating robotic constructions.

C.3.3 A first approach to programming: Moving around (3 teaching periods)

The third part is focused on the Lego NXT programming environment and the development of virtual models that guide robots with varying configurations, i.e. motors’ activation using basic programming blocks within the NXT software.

The trainees, working in groups, undertake specific introductory activities to the programming environment of Lego Mindstorms Education NXT. The initial project is to design a program that moves a robot along the sides of a square. To this end, an appropriate worksheet is given with specific instructions (Worksheet C.3.3).

Then, the trainees develop their first program and investigate the relation between power of motor and speed of the car robot they have already constructed. The factors which influence the final speed of the car robot is discussed in plenary. Then, they are asked to investigate left and right turns with both, 'move' and 'motor' blocks and, finally, they develop their own blocks for left turn of 90^o and right turn of 90^o. Each group upload the blocks they develop through this activity on the private documents' area of the group in the e-class. Then, the groups are asked to make their robot move on a square path (final programs are also uploaded).

Additional experimentation can be conducted by the trainees in order to make the robot car turn left or right at an angle. During these activities all groups will create programs with blocks such as 'move', 'motor', 'record', 'loop', while they will have also defined their own blocks. Advanced functions like 'record/play' can be also introduced to trainees.

C.3.4 The "cat, the mouse and the master" project (3 teaching periods)

The "cat, the mouse and the master" project is an activity introducing basic programming structures and statements of the Lego Mindstorms Education NXT programming environment. Initially, a mock up with black spots is put on the ground simulating the area where the cat is moving - each black spot corresponds to a mouse!. The groups should adapt their robotic construction in order to make it work on the mock up as a cat running after a mouse. Three activities that gradually introduce trainees to different programming concepts of varying difficulty and complexity are performed. Each activity sets a specific challenge-problem to the trainees:

- At first, they should make the cat run after the mouse and stop when it reaches a black area (the mouse!) using a light sensor, the loop block, and developing their own blocks (Worksheet C.3.4.1),
- Then, the cat's behaviour should be 'extended' to be able to stop for a while and make a sound when the master touches her. To this end, the cat robot should be equipped with a touch sensor. Trainees should also extend the program using condition blocks, and blocks like Display, Sound, Wait For (Worksheet C.3.4.1),
- Lastly, they should use variables in order to make the cat move on a spiral path (Worksheet C.3.4.2, Appendix 4).

At the end of each activity, trainees are invited to present their work and discuss with others their ideas. Different solutions are compared.

C.3.5 The 'data logger' (2 teaching periods)

This part is aimed at enabling trainees to use the data logging functions of the software. These functions are very useful in all science projects. Trainees are asked to study a ready-made program, to collect time and distance data from a moving robot and, finally, to design a graphical representation of the corresponding data that give information about the motion of the robot (Worksheet C.3.5,).

The Lego Mindstorms Education NXT v2.0 has an extra feature for real time and remote data logging.

C.4 Theoretical framework

C.4.1 Constructivism and Constructionism (2 teaching periods)

The first activity of this module is to discuss the question "How the use of: robotics technology in school class could change the traditional teacher-centred teaching model?"

The question can be discussed through a brainstorming activity where the trainer encourage trainees to express freely believes and attitudes on that issue and utilizes the experience and creativity of all participants. The trainer summarizes all the ideas which emerge from the brainstorming.

Then, the trainees are separated in groups of 3-4 people and they are asked to discuss issues concerning constructivism and constructionism through Ackermann's paper "Piaget's constructivism, Papert's constructionism: What's the difference?" Each group presents a part of the paper to the plenary session and the trainer makes a synthesis of trainees' answers and presents his/her own ones (if they are different from those presented by the trainees) focusing on principles such as :

- the knowledge background and culture of the learner plays an important role in learning,
- learners construct their own understanding and do not simply mirror and reflect what they read,
- learning is an active, social process,
- the necessity for collaboration among learners, in direct contradiction to traditional competitive approaches,
- learning is most effective when part of an activity the learner experiences as constructing a meaningful product,
- constructionist learning involves students in drawing their own conclusions through creative experimentation and making social objects,

- teachers have to adapt to the role of facilitators and not transmitters of subject matter. The constructionist teacher takes on a mediational role rather than adopting an instructionist one. Teaching "at" students is replaced by assisting them to understand problems in a hands-on way.

After that discussion, the trainees are encouraged to write their opinion on the same topic in the forum of their e-class.

C.4.2 Why robotics in education? (1 teaching period)

The trainees are separated in groups of 4-5 persons (the synthesis of the groups might be different from the previous one). Each group is asked to read a part of the article: 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, which bas been available to the trainees through the e-class. Then, they are asked to upload a summary of this paper and their comments in the forum of e-class. A presentation of their opinions is also made to the plenary session. The trainer synthesizes and summarizes all relevant ideas and adds his own comments on the educational value of robotics.

C.4.3 Project-based learning (1 teaching period)

The trainees are separated in groups of 4-5 people (the synthesis of the groups might be different from the previous ones). They are invited to study the paper Carbonaro M., Rex, M. & Chambers, J. (2004). Using LEGO Robotics in a Project-Based Learning Environment. *The Interactive Multimedia Electronic Journal of Computer-Enhanced Learning*, 6(1). Retrieved 22/9/2008, from http://imej.wfu.edu/articles/index.asp and then to write down and present three main advantages of the project-based learning against the traditional teacher-centered teaching model.

The trainer makes a synthesis of trainees' answers and presents his/her own ones (if they are different from those presented by the trainees) focusing on helping trainees to recognise the educational advantages of project-based learning as a model for classroom activities that shifts away from the classroom practices of short, isolated, teacher-centered lessons and, instead, emphasizes learning activities that are long-term, interdisciplinary, student-centered, and integrated with real world issues and practices.

C.5 Methodology for developing robotics projects

Projects are long term activities that bring together ideas and principles from different subject areas. Teaching and learning through projects seems to be a complex and demanding activity for teachers and students. As a part of this training course this module aims to provide the trainees with "a hands on" experience in designing robotics projects. In particular, during this module the trainees will:

- Reflect upon basic features of a robotics project which is developed according to constructivist and constructionist principles,
- Study an example of a project developed according to the theoretical framework proposed in previous lessons (five stages),
- Analyze each stage of the project according to the type of activities performed by teacher and student,
- Apply the same model to a subject of their interest and develop their own project.

The module 'Methodology for developing robotics projects' may cover 14 teaching periods.

C.5.1 Model for organizing a robotics project (1 teaching period)

During this teaching period trainees are working in small groups (4-5 people) on Activity 1 of the worksheet C.5.1 for 20 minutes.

Activity 1 **20 minutes**

(Working in groups of 4)

In previous sessions of this course, we have discussed thoroughly the constructivist learning approach and its implications in teaching. Concerning Robotics in Education, we have illustrated 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 robotics project should have in order to serve constructivism and constructionism perspectives of teaching and learning.

2. Be prepared to present your list to the rest of the class.

After the end of this activity, trainees present their list to the rest of the class and the trainer summarizes their answers (20 minutes). If necessary, the trainer can add more features in the list. (Additional information can be found in Appendix 2 Project –Based learning: Important features, section 4.3).

Then, the trainer presents, with a slide show, the five stages of a project. This presentation can be enriched with a short description of each stage. Trainees can also be asked to combine the list of features they created during Activity 1 with the five

stages mentioned above. Stages and their description can be found in Chapter 3.1 and in Appendix 3 of section 4.3.

C.5.2 An example of a robotics project: "The BusRoute" (3 teaching periods)

At this stage, trainees are going to work on a project example in order to explore and elaborate on its main stages through an authentic experience. As a project example, we use here the project "The BusRoute" that we present in section 3.2. A brief outline of "The BusRoute" project can be seen in table 4.2.2

Table 4.2.2*. Outline of "The BusRoute" project*

Stage	**Duration (teaching periods)**	**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	

Trainees, in small groups, may go through the "The BusRoute" project stage by stage (or alternatively, each group undertakes one stage). They study the description of each stage and they carry out the activities of the relevant worksheets (relevant materials can be found at section 3.2). Then they complete the activity 2 of the worksheet C.5.2. In particular they complete the following table with ideas, interesting elements they found in the project and new ideas that they think as important.

Stage	**Teaching Strategies-tools**	**Students activities**	**Teacher activities**

Table 4.2.3 *Strategies, tools and activities in each stage of the project.*

Stage	**Teaching Strategies - tools**	**Students' activities**	**Teacher activities**
Engagement stage	Stimulate interest with pictures, videos or newspaper articles. Make real world connections. Discussions in plenary session. Discussions in small groups. Handouts.	Share experiences with peers and teacher. Provide ideas for creation of questions and artifacts. Define the project. Determine collaboratively evaluation criteria.	Provide open ended activities. Facilitate discussions. Summarize.
Exploration stage	Guided explorations. Introduction of new tools, skills and materials. Handouts.	Follow instructions. Experimenting. Observe. Gather information. Conclude. Compare.	Create a learning environment. Give assignments. Provide structured set of inquiry steps for learner to follow. Reinforce learning.
Investigation stage	Formulate the problem and analyze it. Choose one problem to investigate (one for each group). Diary.	Ask and refine questions. Refine evaluation criteria. Select appropriate tools. Planning. Experimenting. Apply knowledge in new situation. Evaluate. Communicate ideas and findings to others.	Challenge students by asking questions. Mediate group work.
Creation stage	Select resources. Create final artifacts. Diary.	Synthesize. Collaborate and negotiate. Evaluate. Draw conclusions.	Ensure individual and group learning.
Evaluation stage	Presentation. Peer evaluation. Evaluation Rubrics.	Present final product. Evaluate. Compare. Give and take feedback.	Facilitate group evaluation and self- evaluation.

Finally, they share their thoughts in a plenary session. The trainer synthesizes all ideas in a common table and uploads this file to the documents area of the e-class. This table may look like Table 4.2.3.

C.5.3 Working on a new robotics-enhanced project (7 teaching periods)

During this session, trainees are expected to use the methodology for designing robotics-enhanced projects in order to develop a new project**.** Trainees, working in groups, are encouraged to use materials created and experiences gained during the previous sessions of the course in order to develop a new project.

This session is the "creation stage" of the pilot course, so trainees should be gradually become capable, through the course, of contributing to the work at this stage. To that direction, a very helpful activity that can be carried out at any session of this course is to ask trainees to search the web for interesting robotic constructions and share their findings with other members of the class through the e-class space.

As an introduction to the work of this section, trainees in groups are asked to write and upload an idea (or ideas) of a project they would like to develop further. The ideas of each group are presented to plenary sessions and all participants can contribute with useful comments.

The trainer keeps giving the trainees some general guidelines helping them to describe the work expected from them (worksheet C.5.3). Then, the trainees are asked to agree on a set of criteria/rubrics according to which their projects are going to be evaluated. An example of rubrics can be found in worksheet C.5.4.

Finally, each group takes the responsibility to organize its work in the laboratory or at home and submit their projects on time.

C.5.4 Presentation and evaluation of the projects (3 teaching periods)

During this session, trainees present their work to the rest of the classroom. Presentations consist of: (a) demonstration of the function of the robot involved, (b) description of the project with emphases on the exploration and investigation activities expected to be preformed by students.

The work of each group is commented and evaluated by (a) the group (self evaluation),(b) any other group of trainees (peer evaluation), (c) the trainer (or trainers). The evaluation can be done by the rubrics agreed on at previous stages or in any other way.

C.6 Evaluation of the course (3 teaching periods)

The evaluation of the course can be based on:

- **Group diaries:** After the end of each session, each group keeps notes in a text file. In this diary, we expect to find information about: activities carried out during the session, time taken for each activity, the results of each activity, the collaboration among trainees, the robots they created and the proposed programming features.
- **Electronic portfolios** of the works produced by each group through the pilot course.
- **Structured interviews** conducted in groups at the last meeting of the course (Worksheet C.6.2),
- Individual **questionnaires** (Worksheet C.6.1)