eCity Pedagogical Guidelines

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Contents

Contents ................................................................................................................................... 2

1. Mobile Connection ................................................................................................................ 4
   1.1. Description .................................................................................................................. 4
   1.2. How to play the scenario (and try to win) ................................................................. 4
   1.3. Activity 1 (Session 1): Presentation of the problem and playing with eCity .......... 11
   1.4. (Session 2) Activity 2: Students become teachers and evaluation ...................... 12

2. Energy Distribution ............................................................................................................... 13
   2.1. Description ................................................................................................................ 13
   2.2. How to play the scenario ......................................................................................... 14
   2.3. Activity 1: Presentation of the problem and playing with eCity ....................... 17
   2.4. Activity 2: Students became teachers & Evaluation ............................................. 18

3. Renewable Energies ............................................................................................................ 20
   3.1. Description ................................................................................................................ 20
   3.2. How to play the scenario ......................................................................................... 21
   3.3. Activity 1: Solving the Problem ........................................................................... 21
   3.4. Activity 2: Comparison with the Real World ....................................................... 22

4. Public Transportation .......................................................................................................... 23
   4.1. Description ................................................................................................................ 23
   4.2. How to play the scenario ......................................................................................... 24
   4.3. Activity 1: Solving the Problem ........................................................................... 27
   4.4. Activity 2: Comparison with the Real World ....................................................... 27
   4.5. Activity 3: Graph Theory ....................................................................................... 28

5. Earthquake Protection ....................................................................................................... 29
   5.1. Description ................................................................................................................ 29
   5.2. How to play the scenario ......................................................................................... 30
   5.3. Activity 1: Presentation of the problem and playing with eCity ....................... 30
   5.4. Activity 2: Students become teachers ................................................................. 36
   5.5. Activity 3: Evaluation ......................................................................................... 36

6. Internet Service Providers (ISP) ....................................................................................... 38
   6.1. Description ................................................................................................................ 38
   6.2. How to play the scenario (and win) ................................................................. 38
   6.3. PBL organization ...................................................................................................... 43

7. Pollution ............................................................................................................................ 45
   7.1. Description ................................................................................................................ 45
7.2. How to play the scenario (and try to win) ................................................................. 45
7.3. PBL organization ........................................................................................................ 50
8. Flood protection ........................................................................................................... 52
  8.1. Description .................................................................................................................. 52
  8.2. How to play the scenario ........................................................................................... 53
  8.3. Activity 1: Presentation of the problem and playing with eCity ............................... 55
  8.4. Activity 2: Students become teachers ........................................................................ 56
  8.5. Activity 3: Evaluation ............................................................................................... 56
1. Mobile Connection

1.1. Description

The main objective of this lesson plan is that students know and understand basics of mobile phone cellular networks. The lesson plan involves several activities. Next sections explain, step by step, what to do in each activity.

This lesson plan is designed especially for secondary schools, to motivate students and to allow them to get an idea of what they can find in technical careers such as Telecommunications Engineering. The lesson plan can also be used in higher education engineering degrees to present the basics of mobile cell networks.

The lesson plan follows a problem-based learning approach. First the students are presented with a problem: to provide a mobile network service in a certain city. The students will be provided with a game scenario in the eCity platform where they can distribute antennas and frequencies in order to solve the problem. Different arrangements are available, but also constraints need to be satisfied. In the first stage students are not provided any information. They can play and explore. Then, in next stages, students share their findings and exchange information. The teacher provides further explanations and introduce the main concepts.

1.1.1. Students age

Over the age of 14

1.1.2. Duration

Approximately 2 sessions, 2 hours per session.

1.1.3. Learning Goals

• To learn basics of mobile telephony.
• To motivate and to favour working in groups.
• To find a solution using a budget.
• To awaken curiosity in the students.
• To show how science is present in the real life.

1.1.4. Topics

Basics in telecommunications and budget management.

Students will use and will work with all these concepts in an entertaining way.

1.1.5. Scenario goals

To keep at least the current population in the city and give it 90% mobile distribution coverage within 1 year time.

1.2. How to play the scenario (and try to win)

The player has to place antennas in different locations in the city in order to achieve the required coverage.
1.2.1. Introduction

This is the initial view of the scenario:

Mobile phone coverage is provided by creating a network of antennas. Antennas are provided in three different frequency ranges (Band A, Band B and Band C). Different overlapping bands will complement each other while overlapping same bands will collapse and block service in the overlapping area.

Although all antennas have the same capacity, there are two models: one with a large radius and other with a smaller radius. The optimal scale choice will thus depend on your city’s population density.

Networking menu:
Small red antenna characteristics:

Large green antenna characteristics:
1.2.2. First general analysis

To start the game the best option is to analyse the city from a general point of view. It is recommended to detect the different areas, with different population density to decide where the small antennas should be located and where the big ones should be placed.

The theory says that urban areas need antennas with a small radius and rural areas need antennas with a big radius. In any case, this selection depends on the population density. If an antenna with a big radius is enough to provide mobile coverage in an urban area, this will be the best option, because it will be cheaper and more efficient.

1.2.3. Situate antennas

With the previously analysis, players will have more or less a general vision of the antennas’ location.

Each antenna will have a price and a maintenance cost. Players will try to spend the minimum of their budget and, at the same time, to earn the maximum with the benefits. That is, each person with mobile coverage has to pay a specific fare and if all people of the area have coverage with a big antenna, players will have more benefits and fewer expenses.

Now, players can start to situate antennas. They need to take into account frequency reuse concepts, trying to avoid overlapped areas. Two views of the scenario with the same example of frequency reuse:
Furthermore, antennas need to be connected to an ISP and to electricity link. Don’t forget antennas should also be accessible by road.

1.2.4. Modify elements

If the player needs to delete something that has been placed in the city or empty some properties in the scenario, he/she can use the bulldozer functionality.
1.2.5. Final results

Players can compare benefits, population and phone coverage to find a winner. Different solutions can be possible. Example of final results:
1.2.6. **Used resources**

- eCity game platform
1.3. Activity 1 (Session 1): Presentation of the problem and playing with eCity

The main objective of this activity is that students achieve some basic concepts of the mobile telephony while they are playing with eCity, without going in depth in any of the concepts and terms.

1.3.1. To be done previously by the teachers

The teacher should organise the students having in mind the available computers in the classroom. If there is a computer per student, they will work individually. If this is not possible, the teacher will have to divide the students in groups, searching for an organization where nobody stands out among the other members of the same group.

If it’s the teacher’s first time playing with eCity, they should read the teacher’s guide available in the platform.

1.3.2. Development

The teacher explains to the students that the problem to solve is to provide full cellular network coverage to a certain city. Then, the students, individually if there is available equipment, will start to play with eCity and they will have the first contact with the game. They will be able to test the game and they will be able to do first approximations. In this step they can spend 10 minutes approximately. When this time is over, the teacher will ask them about operating doubts and he/she will solve them.

In the following step, they will play with eCity for 15 minutes and they will have to compete among them trying to solve the problem (full network coverage) while increasing the benefits. The winner will be the student or group with more profits.

1.3.3. Questions for class discussion (before/after the activity)

“How can a person call another using a mobile phone?”

“Why do users sometimes lost coverage?”
1.3.4. Resources

eCity game platform – mobile connection scenario

1.4. Activity 2 (Session 2): Students become teachers and evaluation

In this activity, the student or group that was the winner in the previous step, should explain how to play to the rest of their classmates. This activity also has an evaluation purpose.

1.4.1. Previously

Previously, the teacher will prepare some questionnaires for the students. These questionnaires will be used for the self-evaluation and/or the peer-evaluation.

1.4.2. Development

The main objective is that the winners explain the strategy that they have taken and the decisions that they have made to get to their solution. This statement should cause debates between classmates, exposition of the doubts, defense of the decisions and even it will develop students’ communicative skills. The teacher will guide and help the students, will resolve doubts that will be appearing and will make concepts clear. Key concepts such as the use of different frequencies or the limitations in the number of connections to a certain antenna should be introduced.

10 minutes are needed to complete the questionnaires.

1.4.3. Questions for class discussion (before/after the activity)

Not working situations in the scenario.

In addition, the teacher can introduce concepts or questions to increase the students’ knowledge. Also, the students could have to do some exercises at home to continue with this activity in the following session.
2. Energy Distribution

2.1. Description

The main objective of this lesson plan is that students know and understand basics of energy distribution. The lesson plan involves several activities and the following section explains, step by step, what to do at each activity.

This lesson plan is designed especially for secondary schools, to motivate students and to allow them to get an idea of what they can find in technical careers such as Electrical or Power Distribution Engineering, in this case. The lesson plan can also be used in higher education engineering degrees to present the basics of energy distribution.

The lesson plan follows a problem-based learning approach. In a first time, the students are presented with a certain problem to solve: they need to provide a certain city with a reliable energy distribution system. The students will be provided with a game in the eCity platform where they can install power plants, transformers and power lines in order to achieve the goal. Different arrangements are available, and some constraints need to be satisfied. In this first stage students are not provided any information at all before trying the software. The goal here is that they can play and explore. Then, in the next stage, students share their findings and exchange information among each other. The teacher also provides explanations and introduces main concepts.

2.1.1. Students’ age

Over the age of 14

2.1.2. Duration

Approximately 2 sessions of 2 hours. The lesson can also be segmented differently according to the available schedule, the important aspect being to keep the subdivision introduced with the activity presented below.

2.1.3. Learning Goals

• To learn the basics of energy distribution.
• To motivate and to favor working in groups.
• To find a solution to a certain problem using a budget.
• To awaken curiosity in the students.
• To show how science is present in the real life.

2.1.4. Topics

The main topic here concerns basic knowledge in energy production and distribution, with a hint of budget management.

Students will use and will work with all these concepts in an entertaining way and without realizing they are learning.

2.1.5. Scenario goals

The students need to provide energy to an entire city represented here.
In the beginning of this scenario, the player starts with a whole city already available, complete with a residential area on the right (blue circle), an industrial zone on the left (green circle) and an agricultural part in the middle (purple circle). There is space aplenty to put the necessary power plants, transformers and power lines.

2.2. How to play the scenario

The player has to install near the city some power plants using either renewable energy (windmills, solar panels) or fossil fuel (coal or nuclear).

All the available energy-related elements can be found in the energy panel as presented below.
The city is composed of several types of buildings: housing (requiring low voltage current), commercial centres and farms (requiring medium voltage current).

The power plants using fossil fuel output a high voltage electrical current which is unsuitable for domestic or factory usage. The power plants using renewable energy produce a medium voltage electrical current which is unsuitable for domestic usage.

A high voltage electrical current can be converted to a medium voltage electrical current by a certain transformer, whereas a medium voltage current can be converted to a low voltage current via another type of transformer. A current of a certain voltage has to be transported through a cable adapted to said voltage.

2.2.1. Common mistakes

Very often, players can forget that in order to function most of the buildings will need a road. Without one, nothing at all will happen.

It is imperative that the correct power lines need to be used between buildings.

The transformers only have a limited capacity. Putting only one transformer might not be enough if the target is to power an entire city.

All the buildings can be examined with the magnifying glass, giving a lot of useful information about the way they are currently operating and what they need to function efficiently.

2.2.2. Used resources

- eCity game platform
- A game manual
• Document explaining the theory in which game is based in a simple way
• Additional references:
  - Encyclopedia Britannica for kids: http://kids.britannica.com/comptons/art-53259
  - Energy Efficiency Center: http://www.eec-fncci.org/content-learn-electrical_system
  - Boston University Mechanical Engineering: http://www.bu.edu/me/research/research-areas/green-mfgenergy-and-thermofluid-sciences/sustainable-electric-power-systems/
  - How Stuff Works?: http://science.howstuffworks.com/environmental/energy/power.htm
  - ISET Economist: http://www.iset.ge/blog/?p=655
• Youtube:
  - The Journey of Electrical Energy: https://www.youtube.com/watch?v=-ZBNNcczmDM
  - Anatomy of a Distribution System: https://www.youtube.com/watch?v=fQNKkvGQL0
  - The Electrical Distribution System: https://www.youtube.com/watch?v=Fqk0G1yDjeY
  - Understanding the electrical Grid: https://www.youtube.com/watch?v=IIHp9frZAW0
  - How does a Transformer work?: https://www.youtube.com/watch?v=vh_aCAHThTQ
2.3. Activity 1: Presentation of the problem and playing with eCity

2.3.1. Description
The main objective of this activity is that students can achieve some basic concepts of energy distribution while they are playing with eCity, without going in depth in any of the concepts and terms. They have to understand the differences between the high, medium and low voltage current and where and when those are needed.

2.3.2. To be done previously by the teachers
The teacher should organize the students having in mind the available computers in the classroom. In the case of a computer per student, they will work individually. If this is not possible, the teacher will have to divide the students in groups, searching for an organization where nobody stands out among the other members of the same group.

If it’s the teacher’s first time playing with eCity, he/she should read the teacher’s guide available in the platform.

2.3.3. Development
First the teacher will ask a question to the students: “Where does the power necessary to charge your cellphone or to watch TV comes from?” followed by “How does this power come to your house?”.

Students will start thinking about the issue and discuss about it in the classroom, guided by the teacher. The teacher will then present the serious game eCity and explain that the problem to solve is to provide energy coverage to a certain city.

Then, the students, individually if there is available equipment, will start to play with eCity and they will have the first contact with the game. They will be able to test the game and they will be able to do first approximations. In this step they can spend 10 minutes approximately. When this time is over, the teacher will ask them about operating doubts and he/she will solve them.

In the following step, they will play with eCity for 15 minutes and they will have to compete among them trying to solve the problem (full network coverage) while increasing the benefits. The winner will be the student or group with more profits.

2.3.4. Questions for class discussion (before the activity)
“Where does the power necessary to charge your cellphone or to watch TV comes from?” followed by “How does this power come to your house?”.

2.3.5. Questions for class discussion (in the middle of the activity)
Asking the same question and talk about the evolution of the answers. Also ask the question “Who did solve the problem proposed in the scenario?”.

2.3.6. Questions for class discussion (after the activity)
Discuss about the solution used by the students.
2.3.7. **Resources**
eCity game platform

2.4. **Activity 2: Students became teachers & Evaluation**

2.4.1. **Description of part 1**

In this activity, the student or group that was the winner in the previous step, should explain how to play to the rest of their classmates.

The main objective is that the winners explain the strategy that they have taken and the decisions that they have made to get to their solution. This statement should provoke some debates between classmates, where some expose their doubts; others defend their decisions which will develop students’ communicative skills. The teacher will guide and help the students, will help dissipate unclear points that might be appearing and will make the basic concepts of energy distribution clear for all. Key concepts such as the use of different type of currents for different applications should be introduced.

In addition, the teacher can introduce concepts or questions to increase the students’ knowledge. Also, the students could have to do some exercises at home to continue with this activity in the following session.

2.4.2. **Questions for class discussion (after the activity)**

The teacher presents a case of a non-working situation and asks the students why it doesn’t work, like in the example below:

Here is a small list of suggested issues to be detected by the students:

- There is a mismatch in the type of electric cable used
- There is no high->medium or medium->low transformer present
All the different building are powered with the same type of current
- Electric cable are not installed in all the part of the city
- The available transformers are already working at full capacity and new ones need to be installed

2.4.3. Description of part 2
In this activity, the main objective is the evaluation.

2.4.4. Previously
Previously, the teacher will prepare some questionnaires for the students. In addition, the teacher will have another kind of questionnaire ready to evaluate more specific skills and will do interviews in group to detect any weaknesses, needing to be corrected.

2.4.5. Development
During the class session, the teacher will distribute the questionnaires for the students to complete them. In these questionnaires there will also be questions about the teacher, who will be evaluated too.

At the end of the individual evaluation, students can start with the peer-evaluation and, at the same time, the teacher takes this opportunity to do the interviews in group.

Finally, the teacher will finish the evaluation at home doing his/her evaluation of the students and combining all achieved results.

2.4.6. Resources
The questionnaires will be available on paper or through Google Docs

2.4.7. Moments and tools to evaluate
The evaluation can be done at the end of each activity or directly at the end of the lesson plan. It may also be done by the teacher or the students, or by a combination of both.
3. Renewable Energies

3.1. Description

The main objective of this lesson plan is to make students design an energy supply for the city mainly based on renewable energies.

This lesson is planned for secondary schools. They will learn about the advantages and limitations of renewable energies in particular wind and solar energies. The lesson aims to motivate the students in the problem of energy supply in general and to familiarize them with the renewable energies as alternative methods to produce energy.

The lesson plan follows a problem-based learning approach. First the students are presented with a scenario-problem and they are asked to provide energy to a city with 4000 inhabitants using wind and solar energies.

The basic interaction to solve this problem is placing energy plants in the best locations to produce energy. The platform can give information about the areas of stronger wind that generally correspond with the higher altitude locations. However there is a limitation as not all the high altitudes with strong wind have access for the required cables and roads. The solar farms will be located in areas of reduced wind and will get automatically oriented to the sun.

Students are free to explore different locations for placing solar and wind plants. But it will be convenient to place the wind plants near a road and also to explore the orography in order to allow the connection between the plant and the city. That requires a certain configuration of the terrain that the player will be familiar with, after a short use of the platform.

3.1.1. Students age

Over the age of 14

3.1.2. Duration

Approximately 2 sessions.

3.1.3. Learning goals

- Show the importance of the energy supply in real life.
- Show the importance of the renewable energies,
- Learn the basics of renewable energies, their positive and negative aspects.
- Motivate and favor working in groups.
- Combine available budget and problem solution.

3.1.4. Topics

Basic budget management for renewable energy solution.

3.1.5. Scenario goals

Provide 100% renewable energy for a city of 4000 inhabitants.
3.2. **How to play the scenario**

The player can select the level of difficulty and as the first action has to select the best locations for the energy plants. Wind farms are more efficient at higher locations.

Secondly, considering the available budget, optimize the number of plants of each type to be installed. Thirdly, start the installation and build new road around plants.

Keep in mind that every plant, transformer, houses etc, have to be surrounded by a road in order to operate. However it is not required to build a full traffic network connecting all the city locations.

Only the lower level has unlimited time for the player to get the goal.

3.3. **Activity 1: Solving the Problem**

The objective of this activity is to explore the scenario and solve the problem.

3.3.1. **Previously (to be done by the teachers or by students)**

The students will be organized by the teacher in groups 2-3 students, taking into account the available computers in the classroom.

3.3.2. **Development**

The teacher should do an introduction to the scenario problem and to the working strategy (5 minutes).

Once the work is started the teacher will supervise solving possible difficulties that any of the group might experience. The working time will be up to 40 minutes. At the end, the different groups will present their results, to how many inhabitants were able to supply energy. The group with better performance will explain the strategy used (10 minutes).

A 10 days period will be established to present as a home-work the best strategy to get the target problem,

The student will be asked to work during a 10 days period in this activity, and present different strategies looking for the most efficient way to give energy for a city only using renewable energies

3.3.3. **Questions for class discussion (before/after the activity)**

- How did you start solving the problem? Why? What seemed like most important?
- What happens if you place more or less energy plants?
- How did you decide the number of solar and wind devises?
- What would you make differently if you were to start solving the problem again?

3.3.4. **Resources**

eCity game platform – renewable energies scenario
3.4. Activity 2: Comparison with the Real World

3.4.1. Description

This activity should be presented after the students have reported their home-work. The idea is to ask the students to think about how the found solution in the previous activity relates to the real world. The activity does not require using the game.

The teacher should start by dividing the class in groups of three or four students and assign some directions about their work.

To introduce the discussion the teacher will present the following scenario: The city is exposed to one week of covered skies and reduced wind.

The students will have to consider this particular real situation and find in which extend this factor will forced to adapt the previously suggested solution to this real situation.

Students should be given around 15-30 minutes to prepare a short presentation. Once done, they should take turns presenting their findings in rounds of about five minutes.

3.4.2. Resources

Guides, articles, documents, etc.

Wikipedia

Youtube
4. Public Transportation

4.1. Description

The main objective of this lesson plan is to make students analyze and design an optimal graph structure, represented by the implementation of a public transportation network. The lesson plan involves several activities. Next sections explain, step by step, what to do at each activity.

This lesson plan is designed especially for secondary schools, to motivate students and to allow them to get an idea of the kind of optimization challenges faced in engineering careers. The lesson plan can also be used in higher education engineering degrees as support to illustrate some topics on graphs theory.

The lesson plan follows a problem-based learning approach. First the students are presented with a scenario-problem: to provide a public transportation to a city scattered in smaller provinces. The basic interaction to solve this problem is placing bus stops along the roads. Although there is not one single correct solution, a compromise must be achieved between placement and maintenance costs and transportation network quality.

As in all scenarios, students are free to explore different configurations and all the information needed to solve the scenario is provided in-game. Teachers can use this scenario to introduce some topics on graphs theory (such as the “travelling salesman” issue) and students can share and compare their approaches with the classroom.

4.1.1. Students age

Over the age of 14

4.1.2. Duration

Approximately 2 sessions.

4.1.3. Learning Goals

• To think of the basics of a public transportation network.
• To show how graphs theory is present in the real life.
• To learn the basics of graphs theory.
• To motivate and to favour working in groups.
• To find a solution using a budget.
• To awaken curiosity in the students.

4.1.4. Topics

Basics in graphs and budget management.

4.1.5. Scenario goals

To provide 95% public transportation coverage to a city.
To provide at least 80% median public transportation network quality.
4.2. How to play the scenario

The player has to place bus stops at different locations in the territory in order to achieve the required coverage and transportation network quality. Part of this process might require him to build new roads.

If two or more bus stops are reachable by road they will create a functioning transportation network. In other words, an isolated bus stop, not connected to others by road will be inactive and will not provide transportation network coverage.

Public transportation network quality for each bus station is based on the number of hops required to reach any other bus station in the network. The smallest number of stops between every other bus stop the better the network quality.

This is the initial view of the scenario:

![Initial View of the Scenario]

4.2.1. Build Roads

The first logical step to solve the scenario is to create the roads required to connect all provinces. Roads have a placement cost as well as a periodic maintenance costs so one should look to optimize the layout.
4.2.2. Place Bus Stops

Bus stop units are to be placed over roads. One should look for a balanced pattern when placing stops as to have an optimal service covering area.

Since bus stops also have placement and maintenance costs, one should look to place the minimum number of bus stops. While placing too few bus stops might reduce the transportation network coverage, placing too many will cause the service to be slower and thus reduce the network quality.
4.2.3. Analyze and Iterate

After having achieved a satisfactory transportation network coverage, the player should analyze the current network quality by assessing the transportation network layer.

At this point the player should look to optimize its solution by adding and/or removing bus stops and roads.
4.2.4. Used resources

- eCity game
- Game manual
- Additional references:
  - Wikipedia web page about graphs theory
    http://en.wikipedia.org/wiki/Graph_theory

4.3. Activity 1: Solving the Problem

The main objective of this activity is to let students explore the scenario and freely look to solve in the best possible way, without any previous theoretical contextualisation.

4.3.1. To be done previously by the teachers

The teacher should organise the students having in mind the available computers in the classroom. In the case of a computer per student, they will work individually. If this is not possible, the teacher will have to divide the students in groups, searching for an organization where nobody stands out among the other members of the same group.

4.3.2. Development

The teacher should do a very concise introduction to the scenario problem, leaving out any theoretical introduction.

The students should then start to play and solve the scenario. During the activity the teacher should make sure no one is having interaction difficulties. More importantly, he should wander the classroom and take notes of any interesting remarks students should make (between peers) as these may be starting points for discussion later on.

Solving the scenario should take from 20 to 30 minutes. After that time the teacher should ask students to save their progress, leave the game for a moment and discuss their findings and proposed solutions. Discussion could take another 20-30 minutes.

4.3.3. Questions for class discussion (before/after the activity)

- How did you start solving the problem? Why? What seemed like most important?
- What happens if you place more or less bus stops?
- Is it better to have more roads all around?
- What would you make differently if you were to start solving the problem again?

4.3.4. Resources

eCity game platform – Transportation scenario

4.4. Activity 2: Comparison with the Real World

4.4.1. Description

In this activity, the idea is for students to think about other network examples from the real world and present them to the class. The activity does not require using the game.
The teacher should start by dividing the class in groups of three or four students and assign them to think of other real world systems that work as a network. Students should then think/imagine how these examples could work and propose an optimal setup. They should also be encouraged to draw schemas.

Students should be given around 15 minutes to prepare this short presentation. Once done, they should take turns presenting their findings in rounds of around five minutes.

At the beginning of the activity the teacher should make sure to have some examples ready for students having difficulties starting up. The teacher should also make sure students are focusing in schematizing and using diagrams to express their ideas for this systems. It is not a problem if multiple groups pick the same example as long as they work on an unique presentation.

Some examples:
- Trains
- Metro
- Mail distribution
- Waste disposal
- Supermarket supplying

4.5. **Activity 3: Graph Theory**

4.5.1. **Description**

In this activity the teacher will start by presenting two different (simple) problems in graph theory. Students will then be asked to try and demonstrate them using the Sandbox Mode.

4.5.2. **Development**

Before the class the teacher will pick two common graph theory problems, simplify and prepare them to be presented to students. After the presentation students will be given 20 minutes to try and illustrate the problems using the eCity Sandbox Mode. Once ready, some of the results should be presented and discussed with the classroom.
5. Earthquake Protection

5.1. Description

The main objective of this lesson plan is that students know and understand basics of earthquake protection for a city. The lesson plan involves several activities. Next sections explain, step by step, what to do at each activity.

This lesson plan is designed especially for secondary schools, to motivate students and to allow them to get an idea of what they can find in technical careers such as Geographical Engineering, Civil Engineering and City Planning areas, in this case. The lesson plan can also be used in higher education engineering degrees to present the basics of city planning on earthquake areas.

The lesson plan follows a problem-based learning approach. First the students are presented with a problem: there is a city just after an earthquake with demolished buildings, energy system and roads. The students will be provided with a game in the eCity platform where they can rebuild the city considering fault lines under the city and building types in order to achieve the goal of accommodating certain number of people and surviving other earthquakes through the game. Different arrangements are available, but also constraints need to be satisfied. In this first stage students are not provided any information. They can play and explore. Then, in next stages, students share their findings and exchange information. The teacher also provides explanations and introduce main concepts like fault lines, building structures, how to get the minimal damage in a possible earthquake.

5.1.1. Students age
Over the age of 14

5.1.2. Duration
Approximately 2 sessions.

5.1.3. Scenario Goals

5.1.4. Learning Goals

- To learn basics of city planning from earthquake point of view.
- To raise awareness for earthquakes.
- To motivate and to favour working in groups.
- To find a solution using a budget.
- To awaken curiosity in the students.
- To show how science is present in the real life.

5.1.5. Topics
Basics in geology, civil engineering, city planning and budget management.

Students will use and will work with all these concepts in an entertaining way and without realizing.
5.1.6. Questions for class discussion

“What is last earthquake you remember?”

“Is our city on a fault line?”

“Are you protected from earthquakes?”

“Is your city is protected from earthquakes?”

“Is your house strong enough to survive an earthquake?”

“What can be done to protect against earthquakes?”

5.2. How to play the scenario

Explain how to play and solve the scenario. Explain that the player has to find the rules and apply them to be successful in the game. For example, examining fault lines before starting to build the city is very important. Fault lines are found in the layers menu. Also explain that each structure needs some factors to work. For instance, a building needs road and energy to accommodate people or a reactor needs two transformers to transform high voltage to medium voltage and medium voltage to low voltage. Buildings can only use low voltage. These few clues can be enough according to the level of students. They will try to find out other rules of the game.

5.2.1. Used resources

- eCity game platform
- A game manual
- Document explaining the theory in which game is based in a simple way
- Additional references
- Wikipedia
- Slide show presentation program
- Youtube
- Google Docs

5.3. Activity 1: Presentation of the problem and playing with eCity

5.3.1. Description

The main objective of this activity is that students can achieve some basic concepts of the earthquake protection, fault lines and building type while they are playing with eCity, without going in depth in any of the concepts and terms. The scenario starts with a city which has just been hit by an earthquake. Most of the buildings and roads have been demolished and the player has to create a city with a given budget and give housing to a certain number of people in a limited time to complete the game. In addition to general working principles of the game like the budget, engineering rules, population rising activities etc., the player has to investigate the fault zones in the ground and the building types. These factors affect the survival of buildings and the number of dead and injured people in the earthquakes which continue happening in some intervals during the game.
5.3.2. To be done previously by the teachers

The teacher should organise the students having in mind the available computers in the classroom. In the case of a computer per student, they will work individually. If this is not possible, the teacher will have to divide the students in groups, searching for an organization where nobody stands out among the other members of the same group.

On the other hand, if it’s the teacher’s first time playing with eCity, they should read the teacher’s guide available in the platform.

5.3.3. Development

First the teacher will ask a question to his/her students: “What is last earthquake you remember?”. Then the teacher and students talk about the earthquakes they know. Then the discussion can be enlarged with questions like “Is our city on a fault line?”, “Are you protected from earthquakes?”, “Is your house strong enough to survive an earthquake?” etc. Students will start thinking about it and then the teacher will present eCity. He/She explains to them that there is a city which has just suffered a major earthquake and students are in charge of rethinking the city’s layout. The destroyed buildings’ construction was not very good and the problem to solve is that students will use their engineering background to analyse the geography and relocate the inhabitants by considering fault lines, building types and budget. Their goal is to safely relocate XXXX people and survive other possible earthquakes.

Then, the students, individually if there is available equipment, will start to play with eCity and they will have the first contact with the game. They will be able to test the game and they will be able to do first approximations. In this step they can spend 10 minutes approximately. They will learn the controls and tools. When this time is over, the teacher will ask them about operating doubts and he/she will solve them.

The teacher shows some controls and values of the game. Here the date, budget and population are seen on the left top corner.

On the right top corner there are zooming, rotation and similar options.

On the right bottom corner there are objectives, underground, overlays and menu options.

Teacher show students layers menu as an example and explain briefly that colours represent dangerous zones and fault lines as it is also indicated at the right bottom corner.
Then show the students left menu bar where there are main game options.
In the following step, students play eCity for one session (aprox. 30 minutes) and they will have to compete among them trying to reach the given population. The winner will be the student or group who finishes the game first by reaching target population or in case no-one finishes the game, the one populates the city more than others.

The game starts with a city just after an earthquake as in the following picture. Most of the city is demolished, but there are some remaining structures needing road, energy etc.
The player should investigate all factors and build the city according to the rules.

When necessities of a building are being provided the buildings become illuminated and they start to accommodate people. This is also true for factories and other plants. Each element has an engineering factor to work.

As well as energy and roads, education, health, safety and fire departments are important and the game directs the player to provide them.
In the picture below hospital demand of the city is covered by blue circles. Health, fire department, education demands are also provided with the same method.

Earthquakes continue during the game. If the player gives incorrect decisions, he/she can lose everything he/she has built.

After giving enough clues according to the level of students, the teacher let them play the game for one session (approx. 30 minutes) and gives limited help to those who cannot get on some steps.
5.3.4. The game Resources

eCity game platform – earthquake scenario

5.4. Activity 2: Students become teachers

5.4.1. Description

In this activity, the student or group that was the winner in the previous step, should explain how to play to the rest of their classmates.

The main objective is that the winners explain the strategy that they have taken and the decisions that they have made to get to their solution. This statement should cause debates between classmates, exposition of the doubts, defense of the decisions and even it will develop students’ communicative skills. The teacher will guide and help the students, will resolve doubts that will be appearing and will make concepts clear. Key concepts such as fault lines, construction types, soil layers should be introduced.

In addition, the teacher can introduce concepts or questions to increase the students’ knowledge. Also, the students could have to do some exercises at home to continue with this activity in the following session.

5.5. Activity 3: Evaluation

5.5.1. Description

In this case the evaluation will be a multiple evaluation: self-evaluation, peer-evaluation and teacher evaluation.

5.5.2. Previously

Previously, the teacher will prepare some questionnaires for the students. These questionnaires will be used for the self-evaluation and the peer-evaluation. In addition, the teacher will have another kind of questionnaire to evaluate more specific skills and will do interviews in group to detect any weaknesses that allow to improve in next lesson plans.

If there is available equipment in the classroom, questionnaires can be done using Google Docs, for example. In the case of there not being enough and/or available equipment, questionnaires will be done using traditional techniques, in paper, although the following analysis will be more tedious.

5.5.3. Development

During the class session, the teacher will distribute the questionnaires for the students to complete them. In these questionnaires there will also be questions about the teacher, who will be evaluated too.

At the end of the individual evaluation, students can start with the peer-evaluation and, at the same time, the teacher takes this opportunity to do the interviews in group.

Finally, the teacher will finish the evaluation at home doing his/her evaluation of the students and combining all achieved results.

5.5.4. Resources

Google Docs
5.5.5. Moments and tools to evaluate

The evaluation can be done at the end of each activity or directly at the end of the lesson plan. It may also be done by the teacher or the students, or by a combination of both.

The teachers can make an overall evaluation taking into account the outcomes of the game, how good they are, how long the students needed to reach the solution, etc. They can also consider the working with other colleagues, collaboration, support, the existence of leadership attitudes, or even how many times they have had to intervene. Furthermore the teachers can also make a written, oral or test directly with eCity, to evaluate knowledge acquired by the student.

If the student takes the evaluation it can be a self-evaluation, a comprehensive evaluation of the system or even he/she evaluates their peers. With the self-evaluation the objective is to get the students to be self-critical and to think about what they did well and what they have done wrong. In the case of the overall evaluation of the system a general student perception of eCity is searched. The peer evaluation is a subjective assessment where often the competition is more important than acting fairly.

To do the evaluation, of whatever kind, different techniques can be used: questionnaires, interviews, exercises, presentations, test, etc.
6. Internet Service Providers (ISP)

6.1. Description

The main objective of this lesson plan is that students know and understand basics of data distribution networks. The lesson plan involves several activities. The next sections explain, step by step, what to do at each activity.

This lesson plan is designed especially for secondary schools, to motivate students and to allow them to get an idea of what they can find in technical careers such as Telecommunications and Data Communication Engineering. The lesson plan can also be used in higher education engineering degrees to present the basics of data distribution networks.

The lesson plan follows a problem-based learning approach. First the students are presented with a problem: to provide a city wide internet distribution that covers at least 90% of the city. The students then will be provided with a game in the eCity platform where they can explore in order to achieve the goal. Different arrangements are available, but also constraints need to be satisfied. In this first stage students are not provided any information. They can play and explore. Then, in next stages, students share their findings and exchange information. The teacher can use this moment to provide some explanations and introduce the main concepts.

6.1.1. Students age

Over the age of 14

6.1.2. Duration

Approximately 2 sessions, 2 hours per session.

6.1.3. Learning Goals

- To learn basics of data distribution (mainly through fiber and DSL cables).
- To motivate and to favour working in groups.
- To find a solution using a budget.
- To raise curiosity in the students about Engineering.
- To show how science is present in the real life.

6.1.4. Topics

Basics in telecommunications and budget management.

Students will use and will work with all these concepts in an entertaining way.

6.1.5. Scenario goals

To keep at least the current population in the city and give it 90% internet coverage in two years.

6.2. How to play the scenario (and win)

The player has to distribute the different pieces of equipment, respecting the rules.
6.2.1. Introduction

This is the initial view of the scenario:

Your goal is then to create and place adequately the right data distribution objects in the city. These are the objects you can place:
You have the following objects:

- **ISP Core building**: the main focus of data distribution. You can attach fibre optics cables to it
- **ISP Street substation**: cheaper distribution station allows to attach DSL cables to it. Must be connected to an ISP core building.
- **Fibre cable**: more expensive but higher capacity cable
- **DSL cable**: less expensive but lower capacity cable

### 6.2.2. First general analysis

To start the game the best option is to analyse the city from a general point of view. It is recommended to detect the different areas, with different population density to decide where the ISP building should be located.

The scenario is basically played by setting distribution points (either the ISP Core building or the ISP Street substation) and connecting them to the houses with either fibre cable (more expensive but allowing more houses to be connected) or DSL cable (cheaper but with less capacity).

We have to do this quickly in view of the time frame and carefully considering the cost of each piece of equipment. Each object **will have a price and a maintenance cost**. Players should try to spend the minimum of their budget and, at the same time, **to earn the maximum with the benefits**.

### 6.2.3. Locate an place the ISP Core building

We should place this building in a dense area so that we can reach a lot of people with either fibre or DSL cables. Remember to place a road on the side and connect the building with low tension energy (yellow).

The ISP building with roads and energy.
We now connect the ISP building to the surrounding houses using cables. Houses can be connected between themselves through cables. The light blue indicates connected houses and the dark blue houses without internet.

If you need to change/delete something in the scenario, you can use the bulldozer functionality.

To feed the other part of the city we have to check if it is more economic to extend the cable until there or build a new ISP building. In this case the second option is better (if you have enough money) because cables cannot cross water.

And the final result is…
Then you have the option to continue playing or to go back to the menu.

6.2.4. Used resources

- eCity game platform
- A game manual
- Document explaining some basics of internet distribution and cables
6.3. **PBL organization**

6.3.1. **Previously (to be done by the teachers)**

Play the game and the scenario. Follow the instructions and achieve success. Then try different ways of winning. Become comfortable with the scenario.

In the class organize the students in groups of two having in mind the available computers in the classroom. If this is not possible, divide the students in larger groups but never more than three per computer.

6.3.2. **Questions for class discussion (before/after the activity)**

“How does internet reach your house?”

“How is your computer connected to computers all over the world?”

“Why the internet speed is different?”

“What are cables made of?”

“What is fiber optics?”

6.3.3. **Activity 1: Presentation of the problem and playing with eCity**

The main objective of this activity is that students can achieve some basic concepts of the ISPs and data distribution while they are playing with eCity, without going in depth in any of the concepts and terms.

Explains to students what the problem is. Tell them to start the game, load the easy mode scenario and test it. They will be able to test the game and they will be able to do first approximations. In this step they can spend 15 minutes approximately. When this time is over, ask them about operating doubts and solve them.

In the following step, they will play with eCity for 15 minutes and they will have to compete among them trying to solve the difficult level problem while increasing the benefits. The winner will be the student or group with more profits in the time allotted by the teacher.

6.3.4. **Activity 2: Students become teachers and evaluation**

In this activity, the student or group that was the winner in the previous step, explains how to play to the rest of their classmates. This activity also has as a goal evaluation.

The main objective is that the winners explain the strategy that they have taken and the decisions that they have made to get to their solution. This statement should cause debates between classmates, exposition of the doubts, defense of the decisions and even it will develop students’ communicative skills. The teacher will guide and help the students, will resolve doubts that will be appearing and will make concepts clear. Key concepts should be introduced.

Explain how this scenario relates to engineering.
6.3.5. **Activity 3 (optional): Students evaluation**

Distribute the evaluation questionnaire to students so that can report their perception on the game. Give them 10 minutes to complete it.
7. **Pollution**

7.1. **Description**

The main objective of this lesson plan is that students know and understand basics of pollution and pollution prevention/remediation. The lesson plan involves several activities. Next sections explain, step by step, what to do at each activity.

This lesson plan is designed especially for secondary schools, to motivate students and to allow them to get an idea of what they can find in technical careers such as Environment and Chemical Engineering. The lesson plan can also be used in higher education engineering degrees to reinforce some knowledge in this domain.

The lesson plan follows a problem-based learning approach. First the students are presented with a problem: to solve the pollution problems of a city that grew around a set of industrial plants.

The students will be provided with a game in the eCity platform which they can explore in order to achieve the goal. Different arrangements are available, but also constraints need to be satisfied. In this first stage students are not provided any information. They can play and explore. Then, in next stages, students share their findings and exchange information. The teacher can use this moment to provide some explanations and introduce the main concepts.

7.1.1. **Students age**

Over the age of 14

7.1.2. **Duration**

Approximately 2 sessions, 2 hours per session.

7.1.3. **Learning Goals**

- To learn basics of pollution control and prevention.
- To motivate and to favour working in groups.
- To find a solution using a budget.
- To raise curiosity in the students about Engineering.
- To show how science is present in the real life.

7.1.4. **Topics**

Basics in environment and pollution.

Students will use and will work with all these concepts in an entertaining way.

7.1.5. **Scenario goals**

To maintain 20000 inhabitants in the city, 340 workers and to have no house with pollution.

7.2. **How to play the scenario (and try to win)**

The player has to distribute the different pieces of equipment, respecting the rules.
7.2.1. Introduction

This is the initial view of the scenario:

Your goal is then to create and place adequately the right objects in the city so that pollution is controlled. This is the industrial menu:
You have 8 different types of industries and each produces different types of pollution (air, ground, water). In the bottom row you have three different treatment plants for each of these pollution issues.

**7.2.2. First general analysis**

To start the game the best option is to analyse the city from a general point of view. It is recommended to detect the different problematic areas and the different types of pollution. The scenario is basically played by setting correctly the treatment plants. You can also place parks to get a pollution reduction.

You have to do this quickly in view of the time frame and carefully considering the cost of each piece of equipment. Each object will have a price and a maintenance cost. Players will try to spend the minimum of their budget and, at the same time, to earn the maximum with the benefits.

Pollution layer indicating the main problematic areas.

**7.2.3. Placing a treatment plant**

A treatment plant must be in accordance with the type of pollution and should be placed near the pollution source. Furthermore the treatment plants must be supplyed with the right energy (middle tension – brown) and near roads.

The solution to this scenario is basically a mix of three actions:

- Place treatment plants near the main industrial focus
- Relocate some industries to the outer skirts of the map
- Bulldoze buildings near the main pollution sources and relocate inhabitants to other places without pollution
- Build parks
If you need to change/delete something in the scenario, you can use the bulldozer functionality.

To feed the other part of the city we have to check if it is more economic to extend the cable until there or build a new ISP building. In this case the second option is better (if you have enough money) because cables cannot cross water.

And the final result is…
Then you have the option to continue playing or to go back to the menu.

7.2.4. **Used resources**

- eCity game platform
- A game manual
7.3. PBL organization

7.3.1. Previously (to be done by the teachers)
Play the game and the scenario. Follow the instructions and achieve success. Then try different ways of winning. Become comfortable with the scenario.

In the class organize the students in groups of two having in mind the available computers in the classroom. If this is not possible, divide the students in larger groups but never more than three per computer.

7.3.2. Questions for class discussion (before/after the activity)
“How is pollution?”
“Why types of pollution are there?”
“What actions can we take to prevent and/or control pollution?”

7.3.3. Activity 1: Presentation of the problem and playing with eCity
The main objective of this activity is that students can achieve some basic concepts of pollution while they are playing with eCity, without going in depth in any of the concepts and terms.

Explains to students what the problem is. Tell them to start the game, load the easy mode scenario and test it. They will be able to test the game and they will be able to do first approximations. In this step they can spend 15 minutes approximately. When this time is over, ask them about operating doubts and solve them.

In the following step, they will play with eCity for 15 minutes and they will have to compete among them trying to solve the difficult level problem while increasing the benefits. The winner will be the student or group reaching the goal quicker.

7.3.4. Activity 2: Students become teachers and evaluation
In this activity, the student or group that was the winner in the previous step, explains how to play to the rest of their classmates. This activity also has as a goal evaluation.

The main objective is that the winners explain the strategy that they have taken and the decisions that they have made to get to their solution. This statement should cause debates between classmates, exposition of the doubts, defense of the decisions and even it will develop students’ communicative skills. The teacher will guide and help the students, will resolve doubts that will be appearing and will make concepts clear. Key concepts should be introduced.

Explain how this scenario relates to chemical and environment engineering.
7.3.5. Activity 3 (optional): Students evaluation

Distribute the evaluation questionnaire to students so that can report their perception on the game. Give them 10 minutes to complete it.
8. Flood protection

8.1. Description

The main objective of this lesson plan is that students know and understand the basic actions to be put in practice in order to prevent and control a flood. The lesson plan involves several activities. The following sections explain, step by step, what is to be done in each of the activities.

This lesson plan is designed specifically for secondary schools, to motivate students and to allow them to get an idea of what they can find in technical careers such as the career of Environment Engineer, in this case. The lesson plan can also be used in higher education engineering courses to present the basics of environment protection processes.

The lesson plan follows a problem-based learning approach. First the students are presented with a problem: they need to do something with the city layout in order to prevent new floods from destroying citizens’ houses. In this first stage students are not provided with any information. They can play and explore. Then, in next stages, students share their findings and exchange information. The teacher also provides explanations and introduces main concepts.

8.1.1. Students age

Over the age of 14

8.1.2. Duration

Approximately 2 sessions, 2 hours per session.

8.1.3. Learning Goals

- To learn basics of environment engineering in the field of flood protection.
- To find a solution using a budget.
- To awaken student curiosity.
- To show how science is present in the real life.
- To motivate and to favour working in groups.

8.1.4. Topics

Basics in environment engineering and budget management.

Students will use and will work with all these concepts in an entertaining way, learning by solving problems.
8.1.5. Scenario goals
To redesign a city layout to prevent new floods, safely relocate people after a flood, provide them with health and safety services, and keep good town finances.

8.2. How to play the scenario
The player has to redesign the city layout to safely relocate people after the city was flooded more than once.

The player has to correctly relocate houses and buildings, and arrange the layout in order to make the city safer to live.

8.2.1. Introduction
This is the initial view of the scenario:
The objectives are given clicking on the first icon to the left in the bottom right hand corner.

8.2.2. First general analysis

In the first place it is necessary to examine the existing layout, the flood location, the ruined houses and dwellings, and to find the new location for relocating the inhabitants and providing them with health and safety services.

After the initial analysis, when the player has already an idea on where to relocate the inhabitants and establish new public services, players start to redistributing the layout. Each house, police station, fire station etc., will have a price and a maintenance cost.

Players will try to spend the minimum of their budget and, at the same time, earn the maximum with the benefits.

8.2.3. Used resources

- eCity game platform
- The game manual
- Additional references:
- Slide show presentation on flood control methods ([http://www.slideshare.net/HNurton/methods-of-flood-control](http://www.slideshare.net/HNurton/methods-of-flood-control))
8.3. Activity 1: Presentation of the problem and playing with eCity

8.3.1. Description
The main objective of this activity is that students achieve the understanding of some basic concepts of flood control while they are playing with eCity, without going in depth in any of the concepts and terms.

8.3.2. Preparation (to be done by the teachers)
The teacher should organise the students having in mind the available computers in the classroom. In case of a computer per student available, they will work individually. If this is not possible, the teacher will have to divide the students in groups, searching for an organization where nobody stands out among the other members of the same group.

On the other hand, if it’s the teacher’s first time playing with eCity, the teacher should read the teacher’s guide available in the platform.

8.3.3. Development
First the teacher asks a question to his/her students: “How can we control floods?”. Students will start thinking about it and then the teacher will present eCity. He/She explains to them that the problem to solve is to provide a new safe layout for the city.

Then, the students, individually if there is available equipment, will start to play with eCity and they will have their first contact with the game. They will be able to test the game and they will be able to do first approximations. In this step they can spend approximately 10 minutes. When this time is over, the teacher will ask them about any arising doubts and he/she will solve them.

In the following step, they will play with eCity for 20 minutes and they will have to compete with each other trying to solve the problem while increasing the benefits. The winner will be the student or group with more profits.

8.3.4. Questions for class discussion (before/after the activity)
Why floods happen?
What do you think, is it possible to prevent floods? Do you think we can control floods and how?
What are the most important aspects to keep in mind?

8.3.5. Resources
eCity game platform – flood prevention scenario
8.4. Activity 2: Students become teachers

8.4.1. Description

In this activity, the student or group that was the winner in the previous step should explain how to play to the rest of their classmates.

The main objective is that the winners explain the strategy that they have taken and the decisions that they have made to reach the solution. This statement should cause debates between classmates, exposition of the doubts, defense of the decisions and it will even develop students’ communicative skills. The teacher will guide and help the students, will resolve doubts that will be appearing and will make concepts clear. Key concepts should be introduced.

In addition, the teacher can introduce concepts or questions to increase the students’ knowledge. Also, the students could have to do some exercises at home to continue with this activity in the following session.

8.5. Activity 3: Evaluation

8.5.1. Description

In this case the evaluation will be a multiple evaluation: self-evaluation, peer-evaluation and teacher evaluation.

8.5.2. Previously

Previously, the teacher will prepare some questionnaires for the students. These questionnaires will be used for self-evaluation and peer-evaluation. In addition, the teacher will have another kind of questionnaire to evaluate more specific skills and will do interviews in groups to detect any weaknesses that allow for improvement in the following lesson plans.

If there is available equipment in the classroom, questionnaires can be done using Google Docs, for example. In the case of there not being enough and/or available equipment, questionnaires will be done using traditional techniques, in paper, although the following analysis will be more tedious.

8.5.3. Development

During the class session, the teacher will distribute the questionnaires for the students to complete them. In these questionnaires there will also be questions about the teacher, who will be also evaluated.

At the end of the individual evaluation, students can start with the peer-evaluation and, at the same time, the teacher takes this opportunity to do the interviews in group.

Finally, the teacher will finish the evaluation at home doing his/her evaluation of the students and combining all achieved results.

8.5.4. Resources

Google Docs
8.5.5. Moments and tools for evaluation

The evaluation can be done at the end of each activity or directly at the end of the lesson plan. It may also be done by the teacher or the students, or by a combination of both.

The teachers can make an overall evaluation taking into account the outcomes of the game, how good they are, how long the students needed to reach the solution, etc. They can also consider working with other colleagues, collaboration, support, the existence of leadership attitudes, or even how many times they have had to intervene. Furthermore the teachers can also make a written or oral or test directly with eCity, to evaluate knowledge acquired by the student.

If the student takes part in the evaluation it can be a self-evaluation, a comprehensive evaluation of the system or even he/she can evaluate the peers. With the self-evaluation the objective is to get the students to be self-critical and to think about what they did well and what they did wrong. In the case of the overall evaluation of the system a general student perception of eCity will be looked at. The peer evaluation is a subjective assessment where competition is often more important than acting fairly.

To do the evaluation, of any of these kinds, different techniques can be used: questionnaires, interviews, exercises, presentations, tests, etc.