An Innovative Pedagogical Tool for Robotics Engineering Studies

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Abstract

At the Engineering School of Barcelona (ETSEIB-UPC) a multimedia pedagogical tool has been developed in order to training concepts and ecojustice, environmentalism and sustainability to the students in Technical degrees, specifically in Robotics Engineering. This didactical tool consists in a serial of multimedia world maps that describes the world situation in a wide range of different trends such as the nuclear energy, the fossil fuels, the electronic components of the machines, the atomic weapons, etc. The developed pedagogical instrument uses a slide presentation format in order to integrate the relevant information of different economical-environmental-social themes related with actual society. In this paper one of the multimedia maps is explained and discussed: the nuclear energy map. This pedagogical resource boosts the reflection in our students about several aspects of social interest in a sustainable overview and students are able to understand the role of Robotics in many and relevant applications.

1. Introduction

Nowadays there are a large number of people worldwide being driven into an economic crisis. The entire world network of governmental and supra-governmental summits are taking good note of it, and have sprung into action with the financial measures we all know about through the media coverage the issue has attracted. However, there are two other critical issues in the world today, namely the social and environmental degradation, which are not receiving the same political and media attention. As a consequence of this, social awareness of their impact on our lives is scarce. It is only in what is known as the alternative summits, such as the 2012 Thematic Social Forum [1][2] in Porto Alegre, removed from decision-making scenarios, which these issues are brought to the fore.

What do we mean by social and environmental degradation? These terms require some clarification. If we try and describe what they mean, [3][4] lists the following phenomena as being a consequence of such social and environmental problems these days: climate change, peak oil, deforestation, the destruction of many ecosystems in the world, poverty, wars, human rights reduction and social inequality. Literature abounds which has identified them as being equally or even more important than the current economic crisis

In relation to social awareness and responsibility, we understand that Higher Education institutions (HE), as the rest of the educational system, have a key role to play in bringing attention to such social and environmental crises/issues and their consequences. We would like to advocate their engagement in trying to bring them to the attention of students and staff; something they can do in their two main functions, namely teaching and research. More specifically, given that HE institutions stand as a bridge between the educational and the professional world, this should stand as one of their main priorities or, in fact, goals: that when students start with their professional careers and need to make decisions concerning social and environmental issues, they adopt the adequate decisions based on well-founded social criteria.

That is, to integrate the "Sustainability and Social Commitment" competence in different subjects in scientific and technological degrees. In fact, the present social, economic and environmental crisis is a good opportunity to renew the didactical models and the pedagogical teams. It is a matter of fact that crisis has a presence in natural sciences, in knowledge building, in the modernity, in the world phenomena. Complexity reveals a trend to the holistic thinking that "the world is complex" and "total is total". This thought makes necessary the tendency to the disciplines dissolution and a solid evolution of knowledge that allows facing new challenges and problems. Applying the above to the didactical models, the complex thinking swaps objectives for competences, knowledge transmission for knowledge socio-building, vertical management for

horizontal management, individual act for cooperative act. Critical thinking is that mode of thinking - about any subject, content, or problem - in which the thinker improves the quality of his or her thinking by skillfully taking charge of the structures inherent in thinking and imposing intellectual standards upon them. Therefore, analyzing economic, social and environmental models is also a growing need nowadays.

In order to achieve the above competence, firstly, those topics should have to be included as an integral part of their curricula and, secondly, to afford themselves of adequate pedagogical tools to develop the topic. It is to this question that this paper seeks to contribute.

Hence, the objective of this paper is to present in detail an innovative didactic tool to bridge the existing gap in the area of curriculum design and pedagogical innovation when dealing with environmental and social issues in technical universities. This tool is conceived to allow the lecturer in the classroom to explain his/her regular subject with new didactical models that incorporate the complexity and the critical thinking. The fundamental challenge is to move towards a new educational model that without being dogmatic it does not fall in the relativism; a model that without resigning to the search of responses it does never resign to the competence to question; a model that enables to think integrating emotion and indeterminism [5].

The idea of devoting time and effort to this objective has been one of the goals of a larger project entitled "Sustainability, Technology and Excellence Program" (STEP) [6], developed at the Technical University in Catalonia (UPC). The project seeks to cover the compulsory cross-sectional competences in the curriculum in the area of the environmental and social impact of technology. It focuses precisely on most of the issues mentioned above. One of the lines to which this paper makes a contribution is "inequality North-South and dependency between these two worlds".

2. A Novel Pedagogical Tool

The pedagogical tool that we present in this paper consists of a series of interactive world maps. By interactive world maps we mean maps whose content keeps changing while the map remains still. Such moving effect is achieved by superposing several maps one onto the other and allowing them to show the changing image. The technical sophistication needed to achieve such effect is readily available to the public and does not require a high level of computer literacy, as an average office presentation application and an image manipulation program (i.e. GIMP) should allow it.

At this point we may wish to address the question: Why the use of maps? It is easy to see why we felt the need of such a kind of pedagogical tool if we consider the content which they are designed to represent. The maps allow us to analyze and present visually "inequality between North-South", at the same time as the dependency of North countries from the South countries. The following example should serve as an illustration of it: Nigeria possesses uranium mines, France needs uranium but has no mines and it obtains the economic benefits of extracting uranium in Nigeria and shipping it out to France where it is used to produce electricity. It is clear that we are dealing with fluxes and movements of goods across the world. The visual movement that our maps allow is crucial when trying to portray such dealings related to the extraction, consumption and production of goods across countries.

It is true that the available facts related to such topics can be found in books, articles or reports, they are indeed accessible to the general public. However, it must be said that the information found in those sources is scarcely reader-friendly. We believe that our maps are an efficient tool to overcome such a disadvantage. Consequently, these maps constitute an innovative way of acknowledging North-South inequality in a readily straightforward and clear manner, as a complementary didactic material for academic purposes.

Regarding their use, we have identified four main uses that maps may have. In the first place, didactic maps can present students with the background knowledge of topics dealt in the curriculum. Scientific/technical degrees/subjects rarely offer general information when covering specific topics. Consequently, students end up without a global image of what they are studying. For example, when analyzing chemical reactions, the information concerning where minerals come from.is generally missing. In the second place, didactic maps can also be a tool strictly for learning technical/scientific concepts. In scientific/technical degrees/subjects students rarely have many opportunities for developing critical thinking towards environmental and social issues. In our case, we have used them in math subjects. We may create exercises which should model the information contained in the maps mathematically; for example, in the case of differential equations they might be instrumental in calculating life expectancy of petrol resources in a particular country. In the third place, didactic maps can also be a tool for offering additional material to a specific topic to make the lesson/laboratory less dense as far as the mathematical operations and concepts. In fact, they can be used to give students a well-deserved break in abstract thinking!! Finally, maps can also be used at prior educational levels, primary and secondary, to generate

discussion, because it is not complicated to understand and interpret the maps, due to the fact that the information contained in them is visual and graphical.

Nowadays, with the commitment of university community and in a wider sense the scientific and engineering community, education in engineering should have an integrate approach about skills, attitudes, abilities and values; it should embed disciplines in the social sciences and humanities; it should promote the multidisciplinary team working; it should stimulate a systemic thinking and an holistic approach; it should aware about the challenges posed by globalization [7]. In this sense, in this work the presented tool uses a slide presentation format in order to integrate and to treat the existing information on a topic of social interest in a scientific and technical subjects in the university through series of interactive maps which describe the cycle and interactions among this theme and different aspects of the remainder world (such as, economy, society, etc.) in order to train in the complexity and the critical thinking [8]. The idea is that the lecturer will work in the lecture room using a pedagogical 'scientific model'. The Gilbert's definition of 'model' [9] is of interest: "A model is a simplified representation of a phenomenon, focusing attention on specific aspects. The model is used to provide explanations as an answer to a question". In 2000 the OECD has already defined what science learning at school should compromise: "Developing pupils' capacity to use scientific knowledge to identify questions and obtain conclusions based on facts, in order to make decisions about the natural world and the changes in it caused by human activity". In order to achieve this, pupils must be helped to develop their ideas about facts, objects and phenomena in their surroundings, to bring them closer to scientific ideas, or scientific explanatory models [10]. This methodology can be used in the higher education also. The diagram in Figure 1 shows the aspects that we believe are fundamental in the modeling process at University.

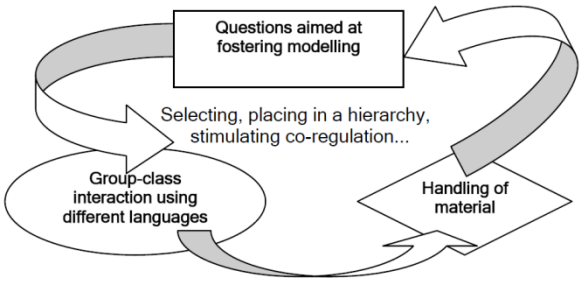

Figure 1. Three fundamental aspects in the process.

To better understand the process, the next illustrative example is taken: the living being model, see Figure 2. What does it mean the living being model? In [11], it is described as "…studying living beings from a systematic perspective that identifies them as open and complex systems They are open in the sense that in order to be, they are continually exchanging material, energy and information with their surrounding environment, and complex because they are made up of many interrelated elements, the whole of which is not the sum of its parts". It is this complexity of views provided by a living being school model such as authors enable ideas to develop throughout schooling.

In this work, authors will focus in the handling material to carry out the modeling process at higher education. The proposed didactical material is the multimedia maps cited previously. The elaborated maps treat about different specific thematic such as: nuclear energy, oil, weapons and their production and trafficking, international conflicts, anti-personnel landmines, aerial traffic, tourism, electronic consumption, health, etc.

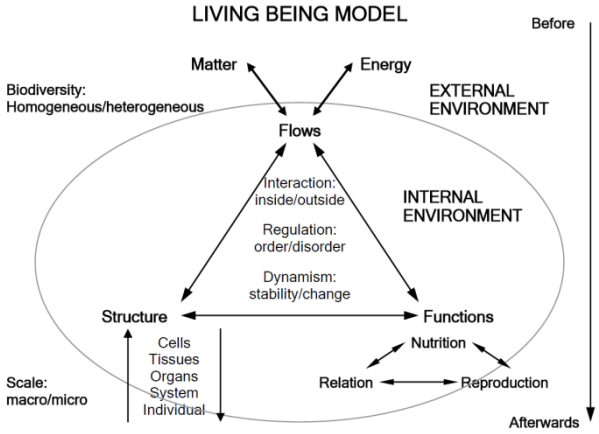

Figure 2. The living being model, [11].

In the particular example of nuclear energy (the example of interest of this paper), these maps make easier for the reader to get an idea of where uranium comes from, where it is mostly used for energy purposes or where it is used for nuclear arms, among other purposes. At the same time, we have tried to make them entertaining to consult by introducing as much visual animation as possible. They also offer the opportunity to analyze the uranium cycle from different knowledge fields: economy, political science and environmental science. Therefore, taking into account the relationships without skipping the entities, every entity is part of a whole. And furthermore, this analysis considers the economic, productive and consumption model as well as the local, regional,

national and worldwide use of natural resources identifying and analyzing the social connections that exist between the North and South countries., the geographical interdependence, the local and global development challenges, the entity and diversity problems in the multicultural contexts.

Those didactic materials will be useful to the lecturer to systemically and critically analyze the worldwide situation.

3. The Nuclear Fuel Cycle Map: A Practical Example

In this section the didactic maps developed at our university are presented in detail. For that purpose we use the nuclear fuel cycle series of maps. This particular map shows the cycle, or stages, of an energy resource strongly linked to nuclear engineering: uranium. Nuclear energy is generally presented to the public as an important power source for the future. However, there are opposing opinions concerning to this idea and to whether we should rely on nuclear energy. Its economic viability and its security are two of the main controversial aspects of nuclear energy [12][13][14]. Indeed, ever since the beginning of the nineteenth century the political debate and social protest around nuclear energy has been recurrent [15][16], having gone further beyond the scientific circles and managed to influence many peoples' position regarding nuclear energy. It has reached the point where in countries such as Germany, social pressure is making politicians change their energy plans and getting rid of nuclear electricity generation plants. The main and most painful, recent evidence of how nuclear energy can affect many peoples' lives is the recent nuclear disaster in Fukushima, which the media has covered quite well. Taking all of this into consideration, an interactive map about the uranium cycle offers a very good opportunity for students to access this controversial of information, and develops their own criteria around this energy source. Ultimately, it will make it possible for them when in their professional careers as part of the general public to better understand the nuclear issue.

In practical terms, the nuclear fuel cycle series of maps is a slide presentation which has a map for each important stage or process of the cycle of uranium which is within human hands. Information published by the International Atomic Energy Agency (IAEA) and the World Nuclear Association (WNA) has been used to design and construct them. More specifically, we have mainly included the facts available in the database of the World Nuclear Energy's official web site and [17].

More than ever, nuclear energy is at the center of political debate and environmental discussions. These try to address the question of how to provide electricity for the world's needs and how to avoid damaging the planet's climate because of it. Within such circles, there is a growing feeling that contributions are needed from all fields of expertise, in fact, from society at large. The objective of this paper is to present an instrument which we believe can help in this respect, by making the existing information clearer and more attractive. The idea is to show the potential hazard of using nuclear energy with qualitative data and example and to promote the use of renewable energies.

When looking into the existing information related to the political and environmental debate around nuclear energy one finds a considerable number of official reports. They are mostly issued by agencies, such as, the IAEA (International Atomic Energy Agency), the World Nuclear Energy and the organization "WISE" (with wise-uranium as one of its projects), among others. Besides, readers can also find published literature on this matter: books, journals... However, as is obvious when reading the previous list of sources, it is not easy for the general public to access them: the information is not presented in a reader-friendly way, it is not attractive. An additional fact to be taken into account is that it is only within the agencies mentioned that there is a database large enough so that it allows us to obtain the general picture on this issue at once. In sum, although it is not difficult for anyone interested in nuclear energy to access crucial information on the matter, it is however difficult to both gain a general picture of the mechanisms determining the cycle of nuclear energy worldwide, and follow the details of it all.

Such a situation does not help to involve other parts of society in the debate. A solution to it may be to invest time and energy in analyzing the existing information and making it readily available. This is what the authors seek to achieve, in order to fill the gap between very exclusive information and the general public.

Concerning the actual content of the maps, the key points to be represented in the nuclear fuel cycle contained in them include: the uranium reserves around the world, where uranium is extracted, where the economic benefits obtained in this process go to, where nuclear energy is mostly used and, in this particular case where a nuclear weapons are located. Other than this last one, the previous items are the type of information which would similarly appear in maps related to other energy resources. Furthermore, on the basis of the maps and the reliability of the information and figures used, students can come up with their own conclusions on this matter, such as "the degree of exploitation that countries suffer regarding their uranium reserves".

A first visual representation of four maps partly showing this information is presented in Figure 3, as an illustration of the mechanics of this instrument.

Figure 3. Interactive map model.

In Figure 3, authors intend to illustrate how the maps are used when trying to represent a type of flux, in this case the flux of wealth related to the extraction of uranium, in a visual display of information, and the effect they gain by being interactive.

Together with this map, other maps are prepared in order to represent the amount of uranium extracted, where wealth resulting from the extraction of uranium is to be transferred from the country where it was extracted to a receiving country; the direction of the flux, and the actual size of the accumulated wealth. It must be made clear that it is not the uranium itself which travels, but rather the wealth obtained in the operation.

When the maps are shown in a superposed dynamic combination which the PowerPoint allows us to do, it is possible to visualize the movement of the wealth world-wide as a result of the extraction of uranium. By the use of these simple and casual images the students have the opportunity to understand the idea conveyed above in a straightforward manner.

Figure 4. List of countries by exploitation ratio.

On the basis of the mechanics just presented, our project is investing in the use of these maps as teaching material. Our goal is to develop a bank of maps related to different issues and topics. Furthermore we are studying how to incorporate them in subjects that deal with differential equations. For this purpose, we are looking to model a range of mathematical fluxes such as the one presented in Figure 3.

This second stage would represent an important achievement, and the goal of incorporating the tool presented in this paper into technical degrees would begin to take shape.

4. Discussion and Assessment

Having presented how The Nuclear Fuel Cycle Didactic Map works, and the mechanics of using it, this section includes an interpretation of the information that the didactic maps offer. It should be noted that the interpretation given here focuses on those aspects related to environmental and social issues.

In the first place, there are relevant facts to be noted when analyzing to what extent countries are exploited in relation to their uranium reserves. The perception is that those countries that are most exploited are not industrialized countries (or countries from the North).

Effectively, when doing the division of (tons of uranium produced)/(known recoverable resources), the countries which have the highest ratio are Southern countries (see Figure 4.)

Figure 5. World Nuclear Power Reactors & Uranium Requirements (2013).

In the second place, when comparing the figures related to mining and those related to the benefits from mining, it is noticeable that there are countries that do not obtain the benefit they should, when compared to what is extracted in them (see Figure 3). This is particularly so in the cases of the African countries. On the other hand, some countries benefit from uranium mining without having mines in their countries. France and England are cases in point. It is important to mention though, that this is not the general rule. As can

be also in Figure 3, Kazakhstan and Uzbekistan, which are considered Southern countries, keep the wealth they produce. However, it has to be said that the wealth accumulated in a country is not necessarily the same as the benefits accumulated by that country. Indeed, there may be foreign investors who benefit from the wealth obtained through the company shares.

A third interesting observation which can make when studying the uranium map relates to the amount of uranium the countries need and use of uranium to generate electric power.

In this respect, none of the Southern countries produce electricity from nuclear energy, whereas all the countries that need uranium are Northern countries. One can conclude that there is a large dependency of this mineral on the Southern countries, on the part of both the Northern countries on the one hand, and the so-called emerging economies on the other hand. In Figure 5 the numbers indicate the tons of uranium needed by different countries.

The students in Robotics Engineering, after the reflection in front of this study, realize about the worldwide energetic reality and the need to tackle this reality through the Robotics field.

For most industries in which robots have been or are expected to be applied in significant numbers, such as auto- mobile production, metalworking, and machinery manufacture, the incentives to robotize relate directly to preserving or recapturing competitive advantage through lowered unit costs of production and improved product quality. But for some industries, the attraction of robots is their potential to work in hazardous environments, thereby reducing the human risks associated with the work. The electric utility industry is one such industry. Although utilities are not viewed by most industrial robot manufacturers as a significant potential market, special-application robots are under development for performing inspection and maintenance tasks inside nuclear power plants, where radiation levels, heat, and humidity either rule out the presence of human workers or severely limit their ability to work. For many of these tasks in a nuclear plant, robots would be a welcome addition to the workforce, freeing humans from some of the more onerous and discomforting jobs and, possibly, permitting certain tasks to be performed while a plant remains on-line, thus avoiding costly plant downtime for inspection or maintenance. The use of remotely operated and robot-like equipment to protect nuclear workers in high-radiation areas is not new. In many industrial applications of robots, the objective is to replace human workers with machines that are more productive, efficient, and accurate. But for nuclear applications, the objective is not so much to replace workers as it is to extend their presence—for example, to project their reach into areas of a nuclear plant where the thermal or radiation environment prohibits or limits a human presence [18].

There are no explicit questions about Sustainability in the robotics subject exam because the real objective is to integrate it within the theoretical topics of each subject. Therefore, the Sustainability and Social Commitment competence is implicitly assessed with the regular exams. Anyway, a questionnaire is given to each student to know his/her opinion about the integration of this competence in the regular subject and the answers are very positive which encourages lecturers to keep on the competence and improving the contents.

5. Conclusion

In this paper authors presented an innovative pedagogical tool which offers new integrative materials to classrooms in technical/scientific degrees, such as Robotics Engineering. Why are they integrative? The maps allow us to focus on a topic and cover it comprehensively with the consequence that the information gathered in such a manner becomes revealing. One manages to capture at a glance the different angles and sides of the same topic and this is a key element to understand social and environmental issues as a part of many things that are involved in the technical/scientific field. But above all, the advantage of using an interactive map is that whatever one wants to represent is made clear to whoever uses them. In fact, the elaborated pedagogical material has been developed in order that lecturer have such a material to cover the compulsory transversal competence of "Sustainability and Social Commitment" in different technological and scientific degrees, from the complexity and critical thinking.

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