A Computer Game Designed for Helping Kids to Make Informed Energy Decision

Jeng-Chung Chen[1], Shin-Cheng Yeh[2], Ho-Wen Chen[3], Han Chen[1]

[1]Department of Environmental Engineering and Science, Fooyin University, Kaohsiung, Taiwan, R.O.C.
[2]Graduate Institute of Environmental Education, National Taiwan Normal University, Taipei, Taiwan, R.O.C.
[3]Department of Environmental Science and Engineering, Tunghai University, Taichung, Taiwan, R.O.C.
chukong@ms4.hinet.net

Abstract - Education has very good role to make a good civilian. Current global issues such as climate change, energy crisis, and environmental sustainability highlight the need to energy education. Without a basic understanding of energy, people cannot make informed decisions on topics ranging from energy use at home to national energy policy. People with energy literacy can understand the nature and role of energy in the world and in our lives. They will also know how much energy he or she uses, for what purpose, and where the energy comes from. The task of this study was to draw out the responsibility of kids to energy use and to teach them energy literacy by using the simulation of computer game. This computer game removed the obstacle in front of realizing energy topics and made kids' participating the learning of energy issues active. Through a teaching test at Hualien Zhong Zheng elementary school, kids who ever experienced this computer game were more patient with all points of view. Eventually they will apply this understanding to make informed energy decisions.

Index Terms - Education, Computer Game, Energy Decision

1. Introduction

Education has very good role to make a good civilian. Current global issues such as climate change, energy crisis, and environmental sustainability highlight the need to energy education. What is the optimal strategy of supporting new energy utilization? What is the best allocation of assigning regional energy? What is the easiest way of fulfilling GHGs emission reduction? And what is the most feasible method of persuading sustainable development? Not only the authorities but also civilians have to think about these answers. Without a basic understanding of energy, people cannot make informed decisions on topics ranging from energy use at home to national energy policy. People with energy literacy can understand the nature and role of energy in the world and in our lives. They will also know how much energy he or she uses, for what purpose, and where the energy comes from. So energy education must let people think in terms of energy systems and apply this understanding to make informed energy and energy use decisions.

Energy is an inherently interdisciplinary topic. In view of energy policy invariably involving multiple issues,

multiple criteria and multiple stakeholders, a large amount of social, economic and environmental information needs to be linked to government policies, stakeholder values, public opinions and management goals[1,2,3,4]. The task of this study was to draw out the responsibility of children to energy use and to teach them energy literacy by using the simulation of computer game. This computer game was given a very important play in the energy education we boosted. It removed the obstacle in front of realizing energy topics and made student's participating the learning of energy issues active. Further, it gave fine training in shaping the ability of expressing opinions about energy in science. Students who took part in group discussions will have responsible attitude to energy use. The simulation of computer game also taught students the need of co-operations, team work and respecting different views as pursuing a consensus in decision-making of energy policy.

Whether populism is good or bad depends on the literacy of civilian. If most of civilians have a basic understanding of energy, government will make a sound energy policy that is also popular to the civilian. Civilian with a better understanding of energy can improve the security of a nation and lead to sustainable energy use. For this concern, governments have the duty to promote the energy literacy of civilian. Recently simulation games are increasingly applied to many subject domains as they allow users to engage in discovery processes, and may facilitate a flow learning experience. There is a close association between the users' learning experience states and their problem solving strategies[5]. In realizing how to formulate sound ethical and moral decisions, the e-society cognitive platform can provide a novel learning way of helping people to improve their behavior[6]. More and more researchers found that computer games could become part of the educational activities. An open source software e-learning platform was proposed to classify and improve student's argumentation level[7]. In order to inspire elementary school students' spatial thinking, game was proved as digital education materials indeed had effects on fostering elementary school students' spatial thinking[8]. He developed flash-based puzzle video games of a map of Japan to support classes on social studies. Before and after the support of game, 70 percent of students had better scores at the post experiment test. Overall computer games could be an alternative teaching method in the classroom to engage students by making learning fun. So this study also used a computer game to simulate what results will come along with their decision-making in the choice of energy structure. As a result, students who ever played the decision-maker of energy in the simulation game were more likely to formulate sound reasonable decisions than those educated by traditional

lectures.

2. Background

According to the forecast conducted by the International Energy Agency (IEA), the global energy demand will grow as 55% from 2005 to 2030[9]. On the contrary, the reserves of fossil fuels which occupy over 80% of the total energy supply are in the trend to depletion. For energy security, people worldwide have to take the principles of green energy and the sustainable living movements. This job is particularly tough in Taiwan due to its high dependency on imported fossil fuel, the total supply of primary energy source had been up to 138.05 million MLOE in 2009 and only 0.63% of them are domestic. In addition the GHGs emission from Taiwan had reached the amount of 276.2 million tons CO_2-eq, i.e., the 22nd place in the world. How to diversify energy supply and cope with GHGs reduction simultaneously is really big challenge to Taiwan.

Since government announced a "no-nuclear community" policy in 2000, Taiwan has been crawling on the one-way destined for a change of energy structure. However debates about energy structure are never vanishing here. A team composed of the members from four Taiwan's universities was born in the duty of finding the best energy structure and they finished the development of Taiwan Energy Policy Educational Model (TEPEM) [10] in 2010. The computer game we designed was based on TEPEM. We considered the concept of "trade-off" is very important to any decision-maker in the process of forming an informed energy decision. Once the kids clearly understand each other's views, a consensus in class will be reached more easily[11,12]. So we had some interactive designs in the computer game to help kids catch up on the concept of "trade-off", and encouraged kids who took part in group discussions to adopt some compromises to deal with a complex issue such as energy policy.

3. The Core of Computer Game

This paper introduces a computer game for guiding kids how to wisely think the issues of energy policy, and in this computer game we chose TEPEM as the core model. TEPEM divided the energy demand into two categories: fuel and electricity. With further consideration in renewability and carbon intensity, the energy supply was categorized into fossil fuel energy (coal, oil and LNG), clean energy (wind power, hydro power, solar power and bio-energy), and nuclear energy. Energy in this model was consumed by seven ways: energy purpose, industrial purpose, transportation purpose, agricultural purpose, residential purpose, commercial purpose, and the other. TEPEM calculated the energy cost by summing up the related costs from fossil fuel, clean energy, and nuclear energy.

LINDO is a software being popular in system analysis, there are several solvers of optimization in this software. The LINDO Application Programming Interface (API) let the software developers easily incorporate optimization into their own application programs. In the LINDO API 6.1, it is available to run optimization via the interface developed by C# and VB.NET. The simplex solver is one of the primary means for solving linear programming problem in LINDO API 6.1. Its flexible design allows the users to fine tune each linear programming model by altering one or several of the algorithmic parameters. Figure 1 shows the process of developing TEPEM. There are four steps: data preparation, modeling, format convert, and c# coding to finish this model.

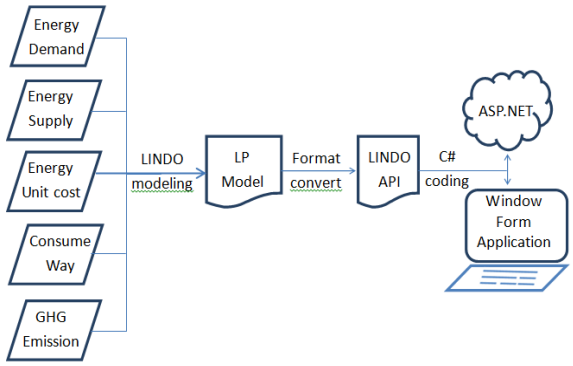


Fig. 1. The flowchart of developing TEPEM.

TEPEM is a linear programming model which has 48 parameters to be the columns and 15 constrains to be the rows. The simplex method will solve this model by moving along the edges of the feasible region defined by the constraint sets. TEPEM had several constraints including energy demands in various sectors, restrictions on GHGs emission, limitations on energy supply, etc. In this model, minimization of the total system cost was considered as the objective function. The cost analysis of different energy structures at varying energy markets will teach kids the concept of "trade-off".

C# is often used in development of Windows Live games, and it is usually combined with the .NET Framework to provide the application on ASP.NET web sites. At the step of C# coding, an interactive interface constructed by C# is embedded with TEPEM and has several scroll bars to adjust the prices of oil, the target of carbon reduction, and the uses of different energy sources. This computer game had two interfaces named as EDGame1 and EDGame2 respectively. EDGame2 can invoke optimization when all the inputs defined by users are passed to LINDO API. The other interface, EDGame1, was designed for impressing on kids the concept of "trade-off". EDGame1 offers an interface to let user make a trial of energy structure. The users have two options in EDGame1: one for single objective and the other for multiple objectives. There are three different types of voters: business man, housewife and driver, and are designated with different favors on energy policy. The kids will play the decision maker to solve the debates among them. This computer game was examined at the low-carbon festival holding in Taipei on March 13, 2011[13].

We designed three characters which consist of boss (character I), mother (character II), and driver (character III).

The character's emotion in this game would be judged by a rule-base system consisting of a set of if-then statements. Each character's favors on the decision-making of energy policy were encoded into the rule set. We imaged that character I only care his expense for using energy, character III also hates to increase the economic burden, but character II is willing to pay any cost for saving the Earth. In addition to the values for money, each character was assigned to different attitudes with respect to environmental protection. We imaged that character I doesn't care this issue, character II dedicates herself to push the policy of GHGs reduction, and character III only opposes the utilization of nuclear power. So we generated Rule 1 to Rule 5 as following:

Rule 1: if increase the economic burden=true then character I would be angry=true and character III would be angry=true.

Rule 2: if reduce the economic burden=true then character I would be happy=true and character III would be happy=true.

Rule 3: if increase the GHGs emission=true then character II would be angry=true.

Rule 4: if reduce the GHGs emission=true then character II would be happy=true.

Rule 5: if increase the nuclear power =true then character III would be angry=true.

In order to simplify the scenario of computer game, the characters would keep their emotion as usual except the above situations, i.e. Rule1 ~ Rule5.

Every user was assigned to the job of being a decision maker to decide energy structure. This game let kids experience the role of law maker, and then give them the duty to propose an energy policy as best as he (or she) can do. In order to form a responsible and rational decision, the kids have to apply the concept of "trade-off" to the interaction with voters; that is, to maximize the supports form voters and to minimize the disappointment to his (or her) proposal. These interactions will help the kids to know what an informed energy decision should be.

4. Experimental Results

In order to evaluate how students valued class with the support of computer game, the team member applied this game to facilitate students exploring the issues that include the energy risk in Taiwan, the debate of nuclear or no-nuclear, and the new lifestyle of energy saving and carbon reduction. This teaching experiment was carried out for months in Hualien Zhong Zheng elementary school. Most of the students in class give positive response to this program. Table 1 describes the student's responses to this class. There are some positive responses including this program make the class more funny, it can stimulate my interest to the energy issues, it help me to realize how energy was used in Taiwan, it let me know how many carbon emission in Taiwan, and I will consider the changing cost while chose energy policy. In contrast, they pointed out some faults in this tool. They suggested the designers to add more alternatives of energy strategies in this tool, to make a simple and clear introduction of tool's function, to make the steps easier, to add an animation role to be on-line teacher, and to design this tool as on-line game.

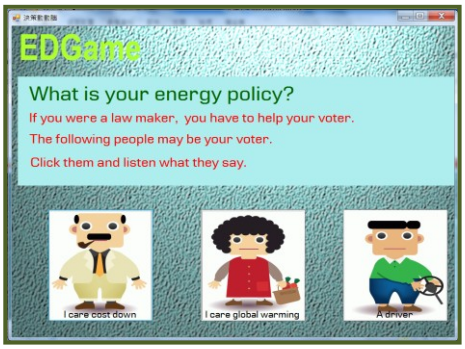
Table. 1. The Student's Responses to Computer Game

COMMENTS
1. I feel funny in this class
2. I have more interest about the energy issues
3. I have realized how the energies come from in Taiwan
4. I know the carbon emission from different types of energy
5. I will consider the changing cost when I chose energy policy
SUGGESTIONS
1. Much more alternatives of energy strategies is necessary in this tool
2. It need a simple and clear text for introduction of tool's functions
3. The process is easily confused because of complicated operating steps
4. To add an animation role to be the on-line teacher
5. To design this tool like on-line game

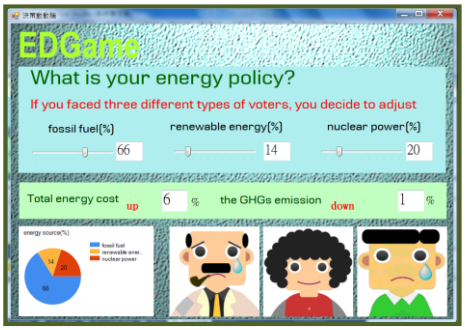
Trade-off analysis is the basic process to form a responsible and rational decision, that is, a good decision is done with full comprehension of all the sides with respect to a particular choice. In EDGame1, three types of voters: business man, housewife and driver represent different favors on energy policy respectively. The user will play the role of law maker to propose an ideal energy policy. The scenarios we set are one for single objective and the other for multiple objectives. The way for single objective means that decision maker only have to care the favor of one particular voter. This study assumes that business man may put cost as his first priority, housewife may especially care environmental risk, and driver may notice both cost and health. The user can see the effect of decreasing one or more key factors and simultaneously increasing one or more other key factors in a decision. For example, an energy policy of reducing cost will please both the business man and the driver, and they will show his smile face in EDGame1. On the contrary, you can see their sorrow by rising up energy cost. Such an energy policy that can reduce greenhouse gases emission or mitigate environmental pollution will make the character of housewife happy. Although the driver cares the rising cost, he also hates the nuclear power because of worrying about the health risk due to nuclear accidence.

In this version of EDGame1, we have nine scenarios with respect to the concerns about cost, environment, and risk. A law maker has a duty to help his (or her) voter to get ideal energy policy. So listen what your voter claims is very important before making decision. This game reminds the user that many different voices are around us. All we have to do are to respect different voice and to negotiate each other. Through the responses with EDGame1, the user will be impressive to the importance of "trade-off". Figure 2 (a) is the initial form of EDGame1. Three carton images are displayed on this form. These images are also the "on-click" buttons. Once the button being pressed, it will carry out a series of introduction about the specific character. Figure 2 (b) (c) (d) display the outcomes via different scenarios on energy policy. Scenario I rises up the ratio of energy power and induces the cost up and the GHGs

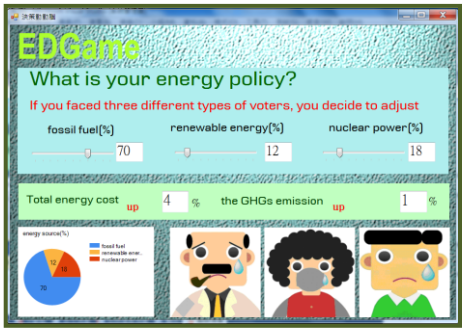
emission down. Thus the housewife shows her smile to support your efforts on mitigating GHGs emission. At the same time, the other characters are unhappy for the rising cost. The increasing ratio of nuclear power also scares the driver. Scenario II will make all your voters disappoint you. That result pushes the user to make more trials on adjusting energy structure. Why we spend more money but emit more GHGs in this scenario is an interesting topic for discussing in the class. Scenario III increases the ratio of fossil fuel. The cost down will please the smoking man and the driver. But it let the housewife mask her face and display her disappoint in silence. Now question comes to the user. Which scenario is your best choice? The user might feel that to please all people is hard, so negotiation is necessary to reaching a consensus decision-making from divergent favors. The users have to work out a wise solution through compromise with each other.



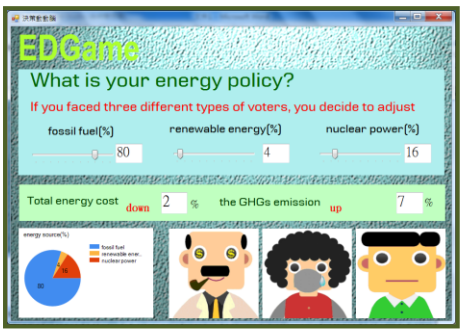
(a) The initial form of EDGame1



(b) Scenario I of EDGame1



(c) Scenario II of EDGame1

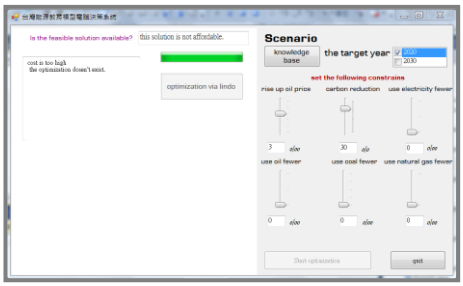


(d) Scenario III of EDGame1

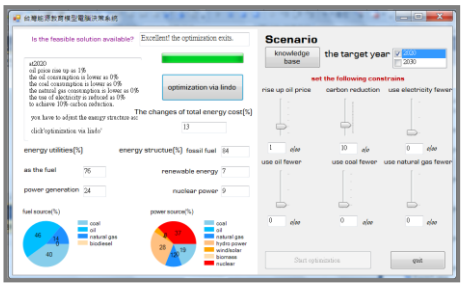
Fig. 2. The scenarios of EDGame1.

Although decision maker can work out a wise solution via try-and-error, using computer supporting analysis to get an optimal solution is the trend to solve the complex problem. EDGame2 is embedded with an optimization function of TEPEM. There are six scroll bars to set up the changing rates of oil price, the target of carbon reduction, annual consumptions of electricity, oil, coal, and natural gas. In addition, the user can pick up different target year and easily adjusts the levels of constraints, then checks whether the solution exists. The analysis via LINDO API can produce an optimal energy structure which complies with all constrains we set.

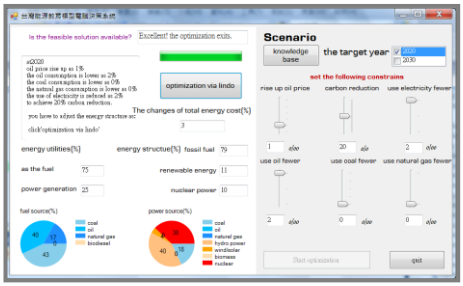
Figure 3 (a) (b) (c) display the optimization analysis with three different scenarios. In scenario IV, the optimization is failed because the cost is too high. When the oil price annually increase by 3%o, to cut off 30% of GHGs emission at the target year of 2020 will induce an unaffordable cost. Next scenario V gets an optimization solution through computer analysis. The oil price is set as annually risen up by 1%o and the target of carbon reduction (i.e. GHG emission reduction) is to reach 10% off at the target year of 2020. As a result, the optimization suggests that the ratio of oil is higher than coal in the fuel sources, the nuclear power is the major power source to generate electricity, but the total energy cost is risen up by 13%. Then we rise up the level of carbon reduction to 20% off at scenario VI. We also reduce the use of electricity by 2%o and reduce the use of oil by 2%o simultaneously. The total energy cost through optimization analysis is only risen up as 3%. Saving energy (i.e. reducing the use of energy) is confirmed as necessary to reduction of GHGs emission. Although we set a higher target of carbon reduction, we still can get the optimization solution by using fewer electricity and oil. According to optimization analysis the ratio of biomass to be power source is up to 40%, both renewable energy and nuclear power occupy higher ratio in energy structure. The result of scenario VI implies that we should save energy, increase renewable energy, and keep the use of nuclear power to afford the higher target of carbon reduction.



(a)scenario IV



(b)scenario V



(c) scenario VI

Fig.3 The optimization analysis of energy structure

5. Conclusions

While facing a complex problem like energy policy, people had better take a responsible and rational attitude. This paper designs a computer game to help kids to make informed energy decision. Through a funny interaction with computer game, the user easily to catch up on the concept of trade-offs. It is useful to mitigate the controversy over energy policy. Kids who ever played the role of law maker in the simulation of computer game will be easier to discover different of view. On the other hand, the optimization analysis via LINDO API gives the user an optimal energy structure which easily complies with all constrains he (or she) set. It highlights to use a good tool to solve problem is better than working via try-and-error.

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