Designing a Clean Energy and Energy Conservation Website for Costa Rican Schoolchildren

An Interactive Qualifying Project
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Abstract

The Instituto Costarricense de Electricidad (ICE), Costa Rica's national electric utility, supports its country's "Peace with Nature" initiative by educating the public about energy conservation. The purpose of this project was to design an educational website for ICE about clean energy and energy conservation, targeted towards Costa Rican schoolchildren of ages seven through twelve. The features of the website make use of Jean Piaget's theory of cognitive development and an analysis of existing educational websites.

Acknowledgments

This project would not have been possible without the help of a number of people. We first thank everyone at the Instituto Costarricense de Electricidad (ICE) for all of their hospitality and kindness. More specifically, we thank Marko Garita Rojas, Ana Lorena Torres, and Angelique Bohórquez for coordinating interviews and site visits and helping us feel at home in a different country, as well as Luis Guillermo Marín Rojas for being an excellent source of information. Without their help, this project would lack valuable information.

We thank the web designers and developers Fabian Rois, José Álvarez, and Karina Vanegas, who took the ideas on our storyboard diagrams and brought them to life with animations and vivid illustrations.

We thank Johnny E. Perez O. and Marlen Arias at Compañía Nacional de Fuerza y Luz for allowing us to visit the Centro de Enseñanza Permanente de Conservacíon de la Energía program and learn about how it works and who it affects.

We also thank our advisors, Profs. Isa Bar-On and Ingrid Shockey, for their feedback on the project. Through the many revisions we were able to turn our proposal draft into a finished project.

Lastly, we thank the Global Perspectives Program at Worcester Polytechnic Institute for giving us the opportunity to immerse ourselves in a different culture and complete a project that we hope will have a positive impact on children in Costa Rica.

Executive Summary

On July 6th, 2007, President Oscar Arias of Costa Rica launched the "Peace with Nature" initiative, which declared the country's dedication to fight environmental degradation and made a commitment for Costa Rica to reach carbon neutrality by the year 2021 (Dobles, 2007). Instituto Costarricense de Electricidad (ICE) is Costa Rica's national electric and telecommunications utility. It is its mission to "improve the quality of life and economic and social development, through an electric service that increases the prospects of well-being, comfort, and progress of all Costa Ricans" (ICE, 2009b). ICE is the only company in Costa Rica in the electrical generation and telecommunications market and has strong ties to the government. Since the "Peace with Nature" initiative was created by President Arias, ICE began to tailor its efforts to help achieve the mission to combat environmental degradation. It is particularly interested in making conservation a part of the national culture by educating Costa Rican schoolchildren. ICE asked us to design a website to educate Costa Rican schoolchildren of ages seven through twelve about clean energy and energy conservation.

ICE produces around 94% of its electricity from renewable resources within Costa Rica (ICE, 2007). However, during hours of peak electrical demand, ICE has to burn imported oil to produce sufficient electricity. Promoting energy conservation throughout the country, especially conservation during these peak hours, could reduce the need to import oil, the burning of which constituted around 6% of ICE's total energy production in 2006 (ICE, 2007). The construction of new power plants, whether clean or dirty, destroys natural habitats and national resources. In the construction of hydroelectric plants, rivers need to be dammed, which affects their flow rate and water temperature (Tahmiscioglu, Anul, Ekmekci, & Durmus, 2007). These factors can severely impact the quality of life of the surrounding communities that depend on the river's plants, animals, and other resources. These problems could be mitigated by energy conservation, which would lessen the need to build more power plants to meet increasing energy demand.

What is the best way to teach a seven- to twelve-year-old child about conservation? Noted developmental psychologist Jean Piaget proposes a model of cognitive development in which children go through several stages as they mature. Educational methods that incorporate this model and are believed to be effective for children of this age group include using concrete

props and visual aids, presenting problems that require logical and analytical thinking, and giving students opportunities to test ideas and to manipulate and classify objects (Huitt, 1997). Additionally, research has found that children who can distinguish between the concepts of "more" and "less" can understand conservation of substances, while those who cannot make the distinction do not have that ability (Boersma, Harasym, & Maguire, 1971). Exercises that teach children to make this distinction using concrete methods can also help children understand conservation.

The multimedia and communication tools afforded by web technologies make websites a promising platform for incorporating these theories into educational practice. ICE already hosts a children's website about energy, entitled *Parque de la Energía*, which is heavily animated with games, background music, and a cast of voiced cartoon characters. Though the site contains a great deal of information, it is structured more for casual exploration than for research – the site is not fully searchable internally, navigation often causes instructional animations to play, and the site does not provide any instructions for hands-on activities or tools directly relevant to the students' schoolwork. The website we designed was intended to be a more interactive and visual experience than *Parque de la Energía* and to provide content directly relevant to the students' schoolwork.

We determined that, in all, the website needed to meet the following requirements:

- The website must somehow provide homework help to students.
- The website must educate students on the topics of energy conservation and clean energy using appropriately formatted content.
- The website must include cost calculators that students can use to calculate the financial cost of their energy consumption.
- The website must include instructions for hands-on experiments and activities.
- The website must include the same cast of characters as ICE's *Parque de la Energía*.

The most significant features of the website help meet the requirement that it educate students about energy conservation and clean energy. The website also includes cost calculators, instructions for hands-on activities, and ICE's usual characters, but these features, though they represent important content elements, were relatively trivial design matters. The requirement that the website be educational posed a particular challenge, because the degree to which

something is educational is difficult to measure and there are no hard and fast rules for creating educational media. Doing so requires answering two questions: what outcomes must this education effect, and what features will make the website educational?

The target outcomes included increasing students' understanding of the subject matter and motivating behavior change, but the question remains, what features will help the website produce these educational outcomes? Research has shown that strong organizational features – that is, interface features that make it easy for users to locate information – are significantly more important than flashy multimedia features in motivating student users of educational websites (Loh and Williams, 2002). With this in mind, we critiqued the designs of nine existing educational websites about clean energy and energy conservation, including ICE's *Parque de la Energía*, and identified common features that we thought made it more difficult to navigate the sites and find information. We also considered Jean Piaget's research, as it pertains to pedagogical principles, to identify what the website could do to bring about the desired learning outcomes. Since Piaget's research shows that children in the target age group may have difficulty thinking abstractly and understanding conservation of substances, educators can work with these children by presenting concrete information and opportunities to manipulate substances (Huitt, 1997). Of course, a website cannot provide students with physical substances to mold with their hands, but interactive, virtual substances might be sufficient.

Having considered Piaget's research, we did not expect that many of our student users would be capable of formal, abstract thinking, so we aimed to present information in a concrete context with plenty of visual aids. We also considered that it might be easier for students of the target age group to understand the effects of energy conservation if they were able to manipulate energy as though it were a substance.

This line of thought led us to design two features: a set of animated cross-section diagrams of power plants and an interactive simulation in which students could change electrical consumption levels in a few houses and see the effects of these changes at the power plants supplying them with electricity. Given Piaget's research on cognitive development, it is reasonable to expect that these features would contribute to the educational quality of the website.

The navigation scheme of the web design was heavily influenced by our evaluations of existing educational websites about energy. We discovered four problems exhibited by many of these websites' navigation schemes. First, several websites had inconsistent layouts that changed dramatically between pages. Second, excessive use of animation made some sites slow to navigate. Third, a few sites identified their links with cryptic labels. Fourth, several sites displayed multiple navigation schemes that overlapped with each other in a way that made it difficult to infer the structures of the sites. With these issues in mind, we designed a navigation system that remains consistent throughout the site, displays no animation, uses clear labels, and does not overlap with any other navigational components.

The web design addressed most of its requirements, but we feel that it can be further improved. Due to time constraints, we were not able to get information from teachers and students to create a “homework help” section for the website. Because of this, we recommend that in the future ICE obtain the necessary information from these sources to create this section. Additional recommendations include gathering feedback from students on the website's usability and appeal and adding additional tools that give children the ability to exchange information between user and server and to interact with other children.

We created a website design that we believe educates Costa Rican schoolchildren on the subjects of clean energy and energy conservation in a manner appropriate for the target age group. The ultimate goal of this project is to encourage Costa Rican children to develop long-term habits of efficient energy use that will persist through generations. This design represents a strong start for the website, but it can be extended to increase its effectiveness.

Authorship

The authors David Becroft, Emanuel Jimenez, and Quontay Turner have each contributed equally throughout the development of this report. All members have expended equivalent efforts researching, writing, and revising each chapter of this report.

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Introduction

On July 6th, 2007, President Oscar Arias of Costa Rica launched the "Peace with Nature" initiative, which declared the country's dedication to fight environmental degradation and made a commitment for Costa Rica to reach carbon neutrality by the year 2021 (Dobles, 2007). Costa Rica already generates 93% of its electricity sustainably, using natural resources such as geothermal vents and some of the country's 300 rivers (ICE, 2009a). However, the remainder is generated by burning imported oil, a nonrenewable resource that releases carbon dioxide into the atmosphere (ICE, 2009a). Energy conservation on a national scale would ease the electrical system's dependence on nonrenewable resources. Promoting energy conservation in Costa Rica is therefore an important step towards realizing the country's goal of carbon neutrality and an overall healthier environment.

Instituto Costarricense de Electricidad (ICE) is Costa Rica's national electric and telecommunications utility. It is its mission to "improve the quality of life and economic and social development, through an electric service that increases the prospects of well-being, comfort, and progress of all Costa Ricans" (ICE, 2009b). ICE and its subsidiary company, Compañía Nacional de Fuerza y Luz (CNFL), are major contributors to help achieve the goal of the "Peace with Nature" initiative. Both companies run outreach programs to increase public awareness of how and why people should conserve energy. They are particularly interested in making conservation a part of the national culture by educating Costa Rican schoolchildren.

At the time of this writing, ICE hosts two educational children's websites, one of which, entitled *Parque de la Energía*, deals specifically with energy-related topics. ICE asked us to design a third website to educate Costa Rican schoolchildren between the ages of seven and twelve about clean energy and energy conservation. This website was intended to be a more interactive and visual experience than *Parque de la Energía* and to provide homework help directly relevant to the students' schoolwork. Simulations, hands-on activities, and experiments were also part of the design proposal to help children learn about how their everyday actions can affect the environment.

Background

Clean Energy and Conservation

ICE wants to promote energy conservation for many reasons, one of them being that its sources of energy can be unreliable. In the Cariblanco crisis of 2007, the generators in ICE's Cariblanco hydroelectric plant failed due to an earthquake. The flood that resulted from the damage to the dam caused the plant not to be fully functional until 2009, a year after the generators had been fixed (Cantero, 2009). The closing of this plant during this time caused major power outages around the country. To try to alleviate the power shortages, ICE increased the cost of electricity to encourage people to conserve (L. G. Marín Rojas, personal communication, October 28, 2009). This was a temporary fix, but it did not change people's belief that if they have the money to pay for electricity then there will always be electricity to buy. As of 2006, about 77% of ICE's electrical generation came from hydroelectric plants, and that number is steadily increasing with the demand for more energy (ICE, 2007). Even though hydroelectric power is a clean source of energy, it can be vulnerable to natural events such as earthquakes and droughts.

ICE also wishes to promote energy conservation so that Costa Rica can become more self-sufficient in energy production. ICE produces around 94% of its electricity from renewable resources within Costa Rica (ICE, 2007). However, during hours of peak electrical demand, ICE has to burn imported oil to produce sufficient electricity. Promoting energy conservation throughout the country, especially conservation during these peak hours, could reduce the need to import oil, the burning of which constituted around 6% of ICE's total energy production in 2006 (ICE, 2007). Energy self-sufficiency promotes national economic stability and helps support the goal to become carbon neutral by decreasing Costa Rica's dependence on burning imported oil, a process that releases carbon dioxide and is vulnerable to price fluctuations.

The construction of new power plants, whether clean or dirty, destroys natural habitats and national resources. In the construction of hydroelectric plants, for example, rivers need to be dammed, which affects their flow rate and water temperature (Tahmiscioglu, Anul, Ekmekci, & Durmus, 2007). The reservoirs created by the dams can potentially displace whole riverside communities. The construction of any type of power plant also contributes to noise and light pollution and requires trees to be cleared to make space for the facility. These factors can

severely impact the sense of identity and quality of life of the surrounding communities. These problems could be mitigated by energy conservation, which would lessen the need to build new power plants to meet increasing energy demand.

ICE is targeting seven- to twelve-year-old schoolchildren for this particular education effort. Teaching a child a new habit – turning off the lights when leaving a room, for example – is easier than changing an adult's lifelong habits. If children learn about energy conservation at these critical ages, they are more likely to develop lifelong habits of efficient energy use. The hope is that they pass these habits along to future generations.

Education

What is the best way to teach a seven- to twelve-year-old child about conservation? There is no definite answer to this question, but there are theories. Noted developmental psychologist Jean Piaget proposes a model of cognitive development in which children go through several stages as they mature, including the preoperational, concrete operational, and formal operational stages. When children are preoperational, they are not yet able to distinguish their thoughts from their surroundings. In the concrete operational stage, they are able to distinguish their thoughts from the concrete things around them. In the formal operational stage, they are able to formulate thoughts about abstract concepts. Children of ages seven to twelve are mostly concrete operational thinkers, with the transition to this stage being roughly at age seven and the transition to formal operations being at age eleven or twelve (Piaget, 1975).

Teaching a child who has not yet developed formal operational thinking to conserve energy might be difficult because the long-term environmental and economic effects of conservation do not manifest themselves in our everyday experiences. Educational techniques believed to be effective with concrete operational children include using concrete props and visual aids, presenting problems that require logical and analytical thinking, and giving students opportunities to test ideas and to manipulate and classify objects (Huitt, 1997). Research has found that children who can distinguish between the concepts of “more” and “less” can understand conservation of substances while those who cannot make the distinction do not have that ability (Boersma, Harasym, & Maguire, 1971). A proposed explanation for this is that when children are asked to conserve they are usually asked to distinguish which of two things is less or more (Boersma et al., 1971). Exercises that teach children to make this distinction using concrete methods can also help children understand conservation.

The multimedia and communication tools afforded by web technologies make websites a promising platform for incorporating these theories into educational practice. Students in active e-learning environments are busy, engaged, confident, ready to learn, self-managed and self-motivated (Carlson and Repman, 2002). An important feature of websites is that they allow students to receive material in more than one presentation mode; they can employ combinations of images, text, sounds, and/or animations and support higher levels of learning interactivity by exchanging information between user and server (Vugt, Kumrow, and Kazlauskas, 2001). Websites can leverage these features to provide effective educational experiences.

Websites

A number of organizations have made their own educational websites for children on the subjects of clean energy and conservation (Alliance to Save Energy, n.d.; Alliant Energy, n.d.; California Energy Commission, n.d.; Energy Information Administration, 1998; ENERGY STAR, n.d.; Tennessee Valley Authority, n.d.; U.S. Department of Energy, 2008). Most of these websites consist primarily of textual information, in the form of lengthy articles or short blurbs. To varying degrees, they also include simple energy-themed games, instructions for hands-on activities, and teacher resources such as lesson plans. Some of the websites, particularly those of The Alliance to Save Energy and ENERGY STAR, use heavily animated navigation systems and more interactive games. These characteristics suggest that they are intended for use by children both in and out of school. At home, a child might decide to browse the games and activities for entertainment and perhaps pick up some information along the way. In school, a teacher might conduct one of the activities in class or direct students to a website to find information for an assignment. Presumably, the organizations which have invested in significant interactivity hope that it will foster students' interest in the subject matter and motivate them to continue exploring the sites outside of school. However, the designs of these websites do not suggest that they are meant to be any more educational than any other information repository. Although many of the websites include instructions for hands-on activities and often use visual aids alongside their text passages, none of them display design features that let children manipulate or classify objects, distinguish between “more” and “less”, test ideas, or think logically and analytically to solve problems.

ICE's own children's website about energy, *Parque de la Energía*, is similar in content and purpose to those described above. It is heavily animated, with games, background music,

and a cast of voiced cartoon characters. Information is provided in the form of text blurbs, longer articles, and monologues given by the characters. Though the site contains a great deal of information, it is structured more for casual exploration than for research – the site is not fully searchable internally, navigation often causes instructional animations to play, and there are many pictorial links that do not make themselves known until the user mouses over them. The site also does not include any lesson plans for teachers, homework help for students, or instructions for hands-on activities. Although the site contains enough information that it could potentially be used as a resource in school, it seems better designed for casual use outside of school.

The website that we designed for this project was intended to be a more academic counterpart to ICE's existing site, for use primarily by students and directly relevant to their assignments, and to explain concretely how and why to conserve energy. We specifically intended to teach conservation principles by letting children manipulate objects, distinguish between “more” and “less”, and test ideas through features of the website.

Methodology

The web design provides space for information on clean energy, power plants, and conservation in Costa Rica, as well as instructions for hands-on experiments and activities that pertain to this information. It is targeted towards Costa Rican schoolchildren of ages seven through twelve. The details of the strategies we used to form this website design are outlined below.

Gathering Requirements

We gathered requirements for the website through meetings with members of ICE and with two directors of CNFL's Centro de Enseñanza Permanente de Conservación de la Energía (CEPCE), an energy education program for schoolchildren. ICE communicated that, above all, the website had to be educational and academic. It was to achieve this by providing students with homework help resources that directly integrated with their school assignments. ICE also felt that students were likely to find *Parque de la Energía*'s many lengthy, text-only articles uninteresting and difficult to understand, and therefore required that the website present some of the same content in a format that might be easier for students to process. The two directors of CNFL's CEPCE program with whom we met suggested that the website use visual aids and interactive features as an alternative to text passages. They noted that the website could supplement its information with instructions for hands-on activities. CNFL also stressed the importance of including cost calculators, tools that students could use to determine the cost of using a particular device for some amount of time, as a means of indicating the financial motivations for conserving energy. Finally, ICE required that the website include the same cast of characters as their other two children's websites, since some students are likely to be familiar with these characters already.

In all, the website needed to meet the following requirements:

- The website must somehow provide homework help to students.
- The website must educate students on the topics of energy conservation and clean energy using appropriately formatted content.
- The website must include cost calculators that students can use to calculate the financial cost of their energy consumption.
- The website must include instructions for hands-on experiments and activities.

- The website must include the same cast of characters as ICE's *Parque de la Energía*.

Requirements Analysis

Upon completion of the requirements list, we determined how to meet the requirements with features of the website. One of the most important requirements was to provide homework help to students. Designing a website that provides homework help requires close collaboration with the schoolteachers who assign the homework. Unfortunately, we were not able to arrange any interviews with these teachers for logistical reasons, so we recommend that future developers of the website undertake this investigation in earnest.

The other critical requirement was that the website educate students about energy conservation and clean energy. Doing so requires answering two questions: what outcomes must this education effect, and what features will make the website educational? The target outcomes included increasing students' understanding of the subject matter and motivating behavior change. In particular, our goal was to help students understand how to conserve energy at home, why energy conservation is beneficial, and how clean energy is produced, and to motivate them to practice conservative energy use behaviors in their daily lives.

The question remains, what features will help the website produce these educational outcomes? We answered this question by examining web design principles and pedagogical principles. As far as web design, research has shown that strong organizational features – that is, interface features that make it easy for users to locate information – are significantly more important than flashy multimedia features in motivating student users of educational websites (Loh and Williams, 2002). With this in mind, we critiqued the designs of nine existing educational websites about clean energy and energy conservation, including ICE's *Parque de la Energía*, and identified common features that we thought made it more difficult to navigate the sites and find information.

We also considered Jean Piaget's research, as it pertains to pedagogical principles, to identify what the website could do to bring about the desired learning outcomes. Since Piaget's research shows that children in the target age group may have difficulty thinking abstractly and understanding conservation of substances, educators can work with these children by presenting concrete information and opportunities to manipulate substances (Huitt, 1997). Of course, a website cannot provide students with physical substances to mold with their hands, but interactive, virtual substances might be a valid substitute. In summary, making the website

educational meant increasing student understanding of the subject matter and encouraging conservative energy use behaviors by designing a usable navigation system, presenting information concretely, and emulating physical substances with virtual, interactive substances.

Results and Recommendations

Results

Once again, the features of the website needed to meet the following requirements:

- The website must somehow provide homework help to students.
- The website must educate students on the topics of energy conservation and clean energy.
- The website must include "cost calculators" that students can use to calculate the financial cost of their energy consumption.
- The website must include instructions for hands-on experiments and activities.
- The website must include the same cast of characters as ICE's *Parque de la Energía*.

The most significant features of the website help meet the requirement that the website educate students about energy conservation and clean energy. The website also includes cost calculators, instructions for hands-on activities, and ICE's usual characters, but these features, though they represent important content elements, were relatively trivial design matters. The website does not include homework help, since without the help of the teachers we were not able to satisfactorily define what homework help would entail. Since providing homework help remains an important objective of this website, we recommend that the feature be developed in a future project.

The requirement that the website be educational posed a particular challenge, because the degree to which something is educational is difficult to measure and there are no hard and fast rules for creating educational media. Considering Piaget's research, we did not expect that many of our student users would be capable of formal, abstract thinking, so we aimed to present information in a concrete context with plenty of visual aids. We also considered that it might be easier for students at the preoperational or operational stages of cognitive development to understand the effects of energy conservation if they were able to manipulate energy as though it were a substance. This line of thought led us to design two features: a set of animated cross-section diagrams of power plants and an interactive simulation in which students could change electrical consumption levels in a few houses and see the effects of these changes at the power plants supplying the electricity. Given Piaget's research on cognitive development, it is

reasonable to expect that these features would contribute to the educational quality of the website.

A mockup of one of the animated cross-section diagrams can be seen in Figure 1. In one corner, a general description of how the power plant produces energy appears in concise bullet points. The cross-section view makes visible the inner workings of the plant, and the user can click on the important structures to view brief text blurbs about their respective roles in the system. The animation, which the user can pause if he or she chooses, illustrates the plant's moving parts. The diagram is intended to convey as much information as possible visually, but also contains textual explanations for clarification. On each page there is a gallery of photos of actual power plants of the type diagrammed, to further ground the information in the physical world.

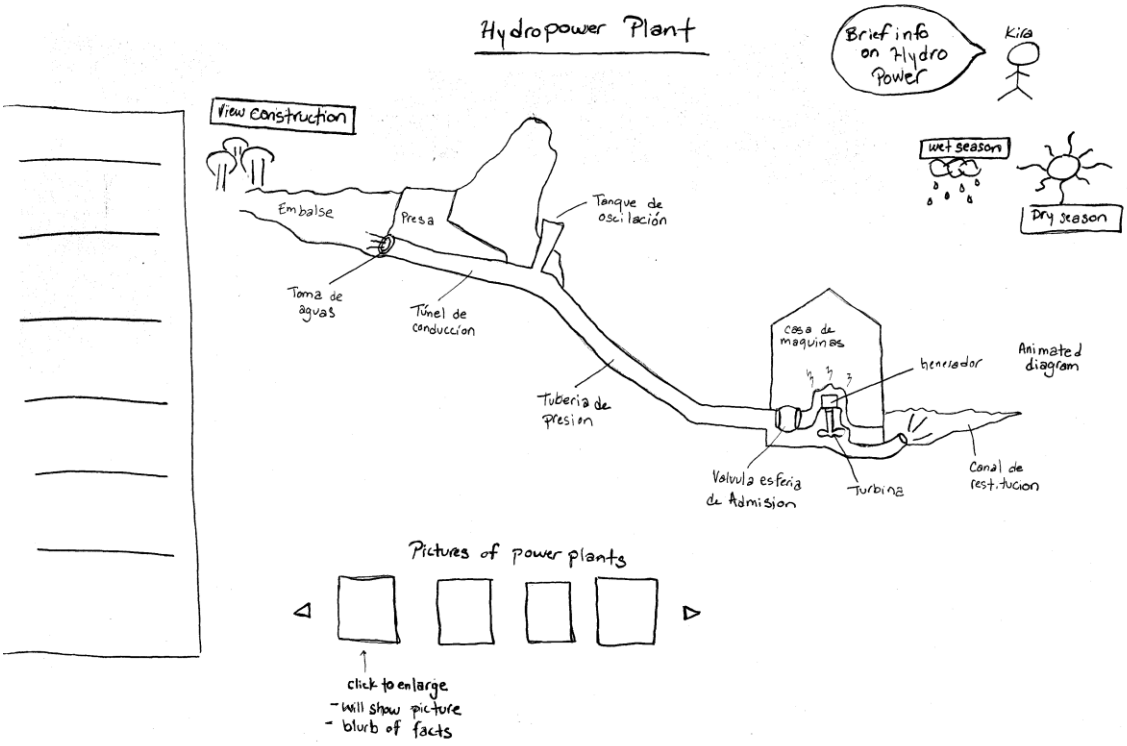

Figure 1: Cross-section diagram of Power Plant

The interactive energy conservation simulation consists of two screens. The first screen that the user sees upon starting the simulation allows him or her to view any of three houses, one at a time, and adjust the energy use habits of the characters inside. A mockup of this screen is shown in Figure 2. The simulation displays the house's rate of electrical consumption and which devices are consuming the electricity. This information is represented visually as a flow of

sparks, moving into the house from a power line and out through the devices. We hoped that giving the user three houses to play with, each with a different set of characters and devices, would give a sense that communities must cooperate to bring about large changes in energy demand.

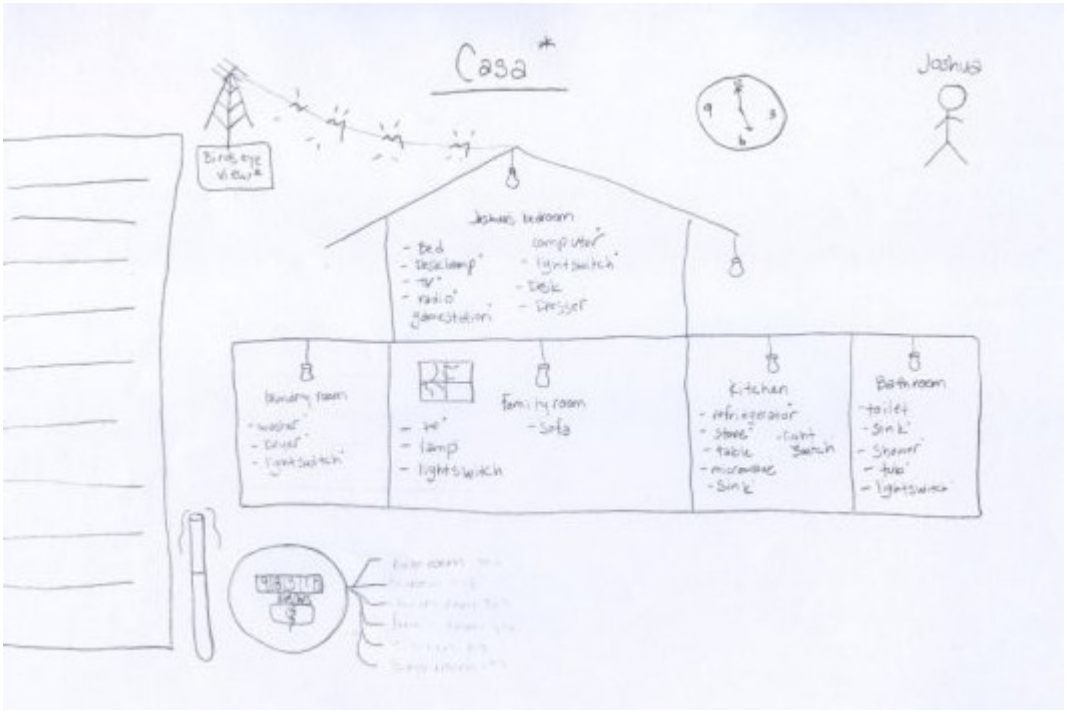

Figure 2:"Casa" Screen of the Simulation

The user can click a link to move from the house view to a "bird's eye view", shown in Figure 3, which displays a landscape dotted by the three houses and one of each of Costa Rica's most common types of power plant: hydroelectric, geothermal, and thermal. The combined demand level for the three houses is displayed. The user can also see sparks flowing from the power plants to the houses and meters showing how much energy each plant is contributing to meet the demand. Each plant might be on or off, depending on the demand, and the thermal plant can be seen to consume oil and eject carbon dioxide as it runs. Thus, the simulation displays energy flowing from power plants into houses and out through devices, and the user can see how specific changes in energy use at home can affect the operation of power plants.

Figure 3: "Bird's Eye View" Screen of the Simulation

The navigation scheme of the web design was heavily influenced by our evaluations of existing educational websites about energy. We discovered four problems exhibited by many of these websites' navigation schemes. First, several websites had inconsistent layouts that changed dramatically between pages. The internal pages of *Energy Quest* (California Energy Commission, n.d.), for example, bear almost no resemblance to the home page: the background color, navigation schemes, and alignment all change. Second, excessive use of animation made some sites slow to navigate. *ENERGY STAR KIDS* (ENERGY STAR, n.d.) and *Parque de la Energía* (Grupo ICE, n.d.) displayed animations at the click of every internal link, making it difficult to browse the sites quickly, while the icons in *Energy Quest* required the user to mouse over them to see where they led. Third, a few sites identified their links with cryptic labels. *ENERGY STAR KIDS*, for example, prominently displayed a link labeled "Join the Lorax", while *Energy Quest* displayed such links as "Devoured by the Dark" and "Oops" on its home page, which tell the user little about what he or she is likely to find on the other side. Fourth, several sites displayed multiple navigation schemes that overlapped with each other in a way that made it difficult to infer the structures of the sites. The home page of *Energy Quest*, for example, displays three sets of links: a navigation bar along the top of the page, an animated image of a

room in which many of the objects are links, and three rows of links in a small font along the bottom of the page. Each set contains some of the same links, but there are also differences – for example, the "Search" link in the navigation bar appears as "Find it Fast" in the room, while both "Search" and "Find it Fast" appear in the links at the bottom of the page, leading to the same place. With these issues in mind, we designed a navigation system that remains consistent throughout the site, displays no animation, uses clear labels, and does not overlap with any other navigational components.

A mockup of a typical page on the website can be seen in Figure 4. A title appears at the top of the page, the navigation bar occupies the left margin, and the rest of the screen displays an image containing objects that can be clicked on. These objects are labeled if they are links, and these links can also be seen in the navigation bar. The navigation bar uses indentation to display the tree structure of the website – links to the main sections of the website are always displayed, while links to subsections appear indented underneath their parent section as the user "drills down".

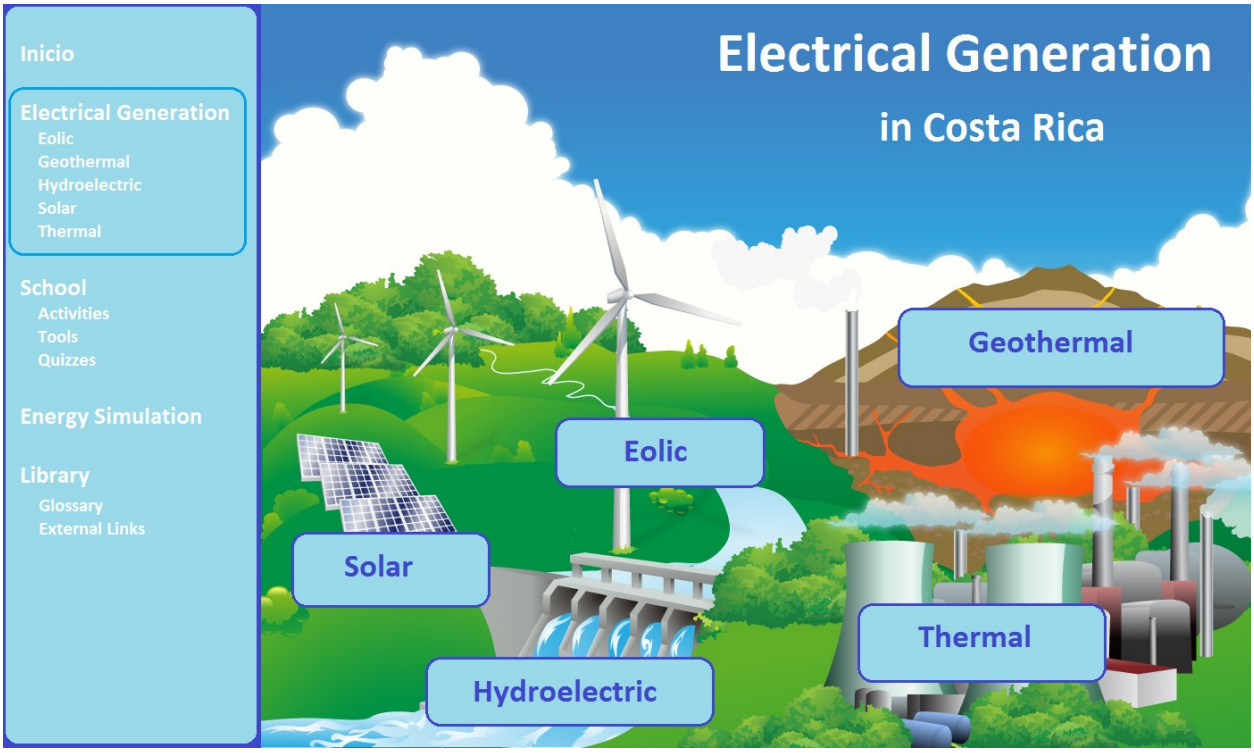

Figure 4: Typical Page

Validity

ICE is the only company in Costa Rica in the electrical generation and telecommunications market and has strong ties to the government. Since President Arias created the "Peace with Nature" initiative, ICE has tailored its efforts to help achieve the mission to combat environmental degradation. It was because of this that ICE became one of our primary sources of information about clean energy and energy conservation educational outreach efforts in Costa Rica.

The website's design was based on Jean Piaget's theory of cognitive development in childhood, as well as our critiques of existing educational websites from various energy companies. Most of these websites' designs had aspects that we thought worked well and others that we thought we could improve upon. By applying these lessons to the design and combining the result with a visual and interactive explanation of the notion of conservation, we created a web design tailored to the cognitive development of seven- to twelve-year-old children.

Recommendations

The web design addressed most of its requirements, but we feel that it can be further improved. We provide the following recommendations for the future.

One important requirement that this design did not meet was to provide homework help. Information from teachers and students from several schools is necessary to create this. Students at different schools are likely to have different needs for their homework, and it is important to meet the needs of as many students as possible. Due to time constraints, we were not able to get the necessary information from teachers and students, and the website can be greatly improved if this information is gathered and the design revised accordingly.

We also recommend that ICE pursue feedback from students on the usability, appeal, and content of the website. ICE could also conduct a study to determine whether the website's educational features are truly effective in bringing about the target learning outcomes. The design and content could then be revised accordingly.

Research shows that the exchange of information between user and server through a website can be an effective educational tool (Vugt, Kumrow, and Kazlauskas, 2001). Possible methods for creating this exchange of information include allowing children to publish their work on the website for other children to see and tracking high scores for online activities on a

public scoreboard. Web technology can also enable children to interact directly with one another. The website could have a forum for communication or an on-line activity in which multiple children could participate from the same computer or from different places around the world.

Conclusion

We created a website design that we believe will help educate Costa Rican schoolchildren on the subjects of clean energy and energy conservation. The ultimate goal of this project is to encourage Costa Rican children to develop long-term habits of efficient energy use that will persist through generations.

We have met most of the requirements we gathered through meetings with employees from ICE and CNFL. We believe the website educates students on the topics of energy conservation and clean energy in a manner appropriate for the target age group. The website includes cost calculators that students can use to calculate the financial cost of their energy consumption and instructions for hands-on experiments and activities. It also incorporates the same cast of characters as ICE's *Parque de la Energía*. We analyzed the requirements through critiques of existing educational websites and research of academic journals and the work of Jean Piaget.

This website design presents information in an engaging manner, using concrete visual aids, an interactive simulation, and hands-on activities to teach children about clean energy and energy conservation. This design represents a strong start for this website, but it can be extended to increase its effectiveness.

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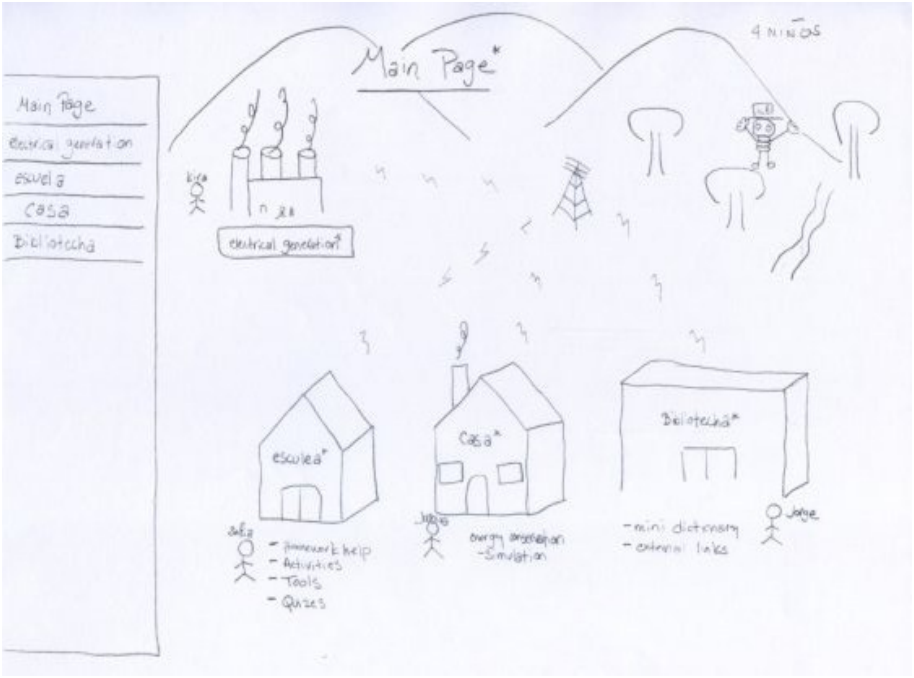
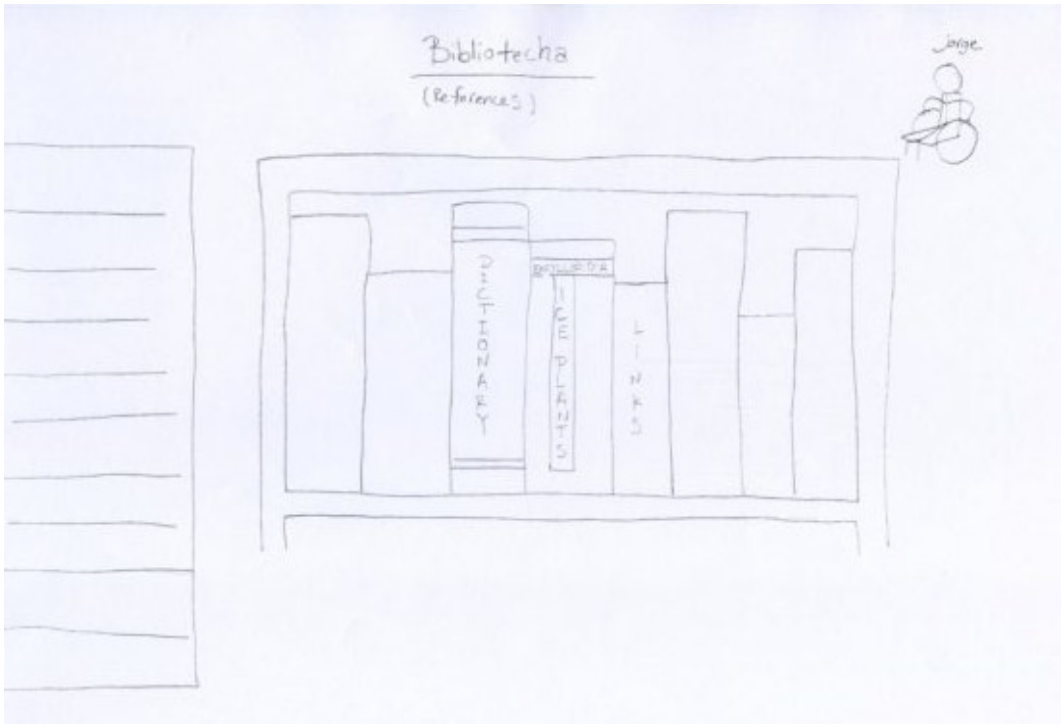
Appendix A: Concept Drawings

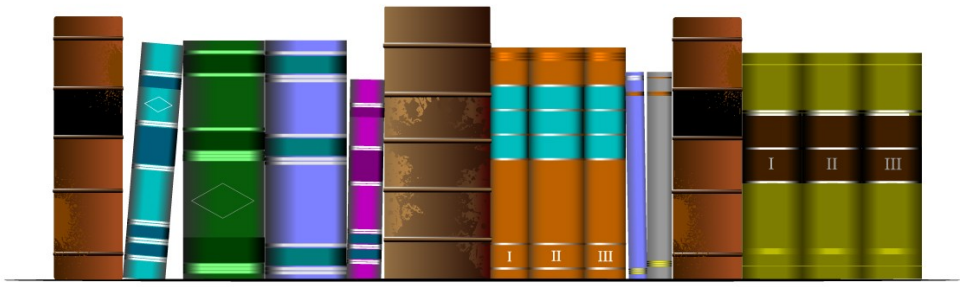


Concept drawing of the home page

Web developer's drawing of home page

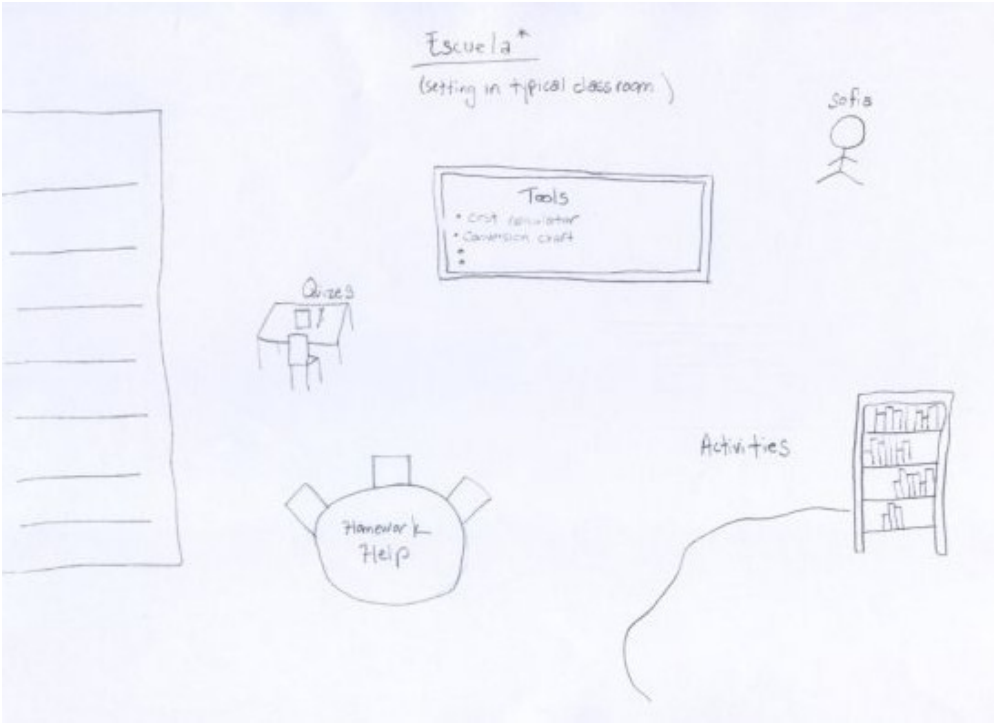


Concept drawing of the library page



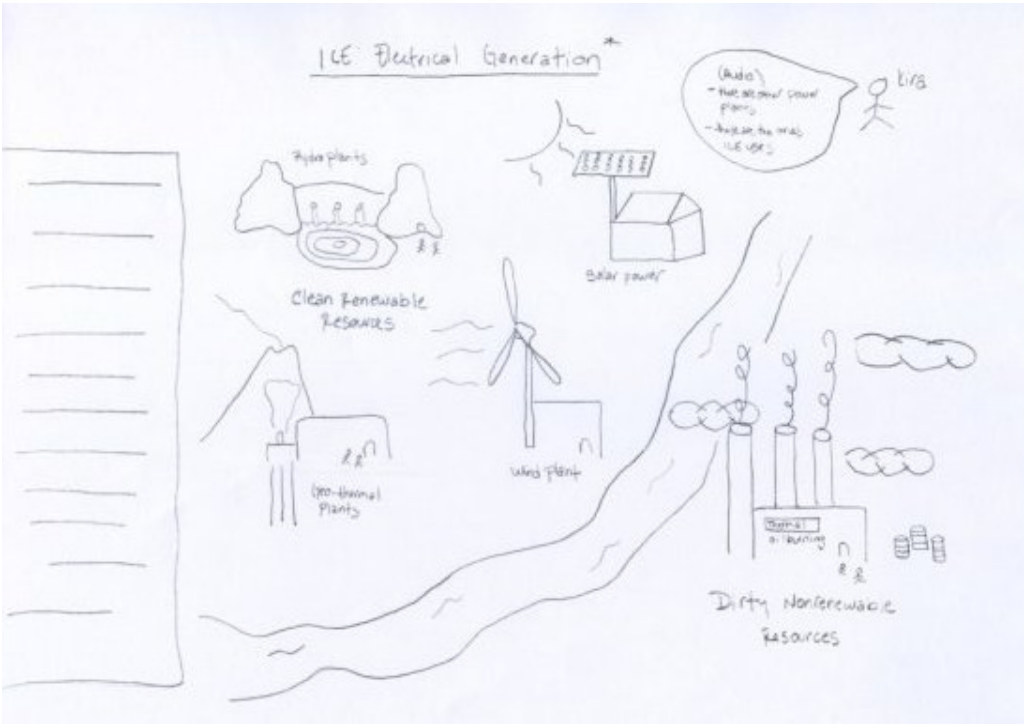
Web developer's drawing of the library page

Web developer's drawing of the library page

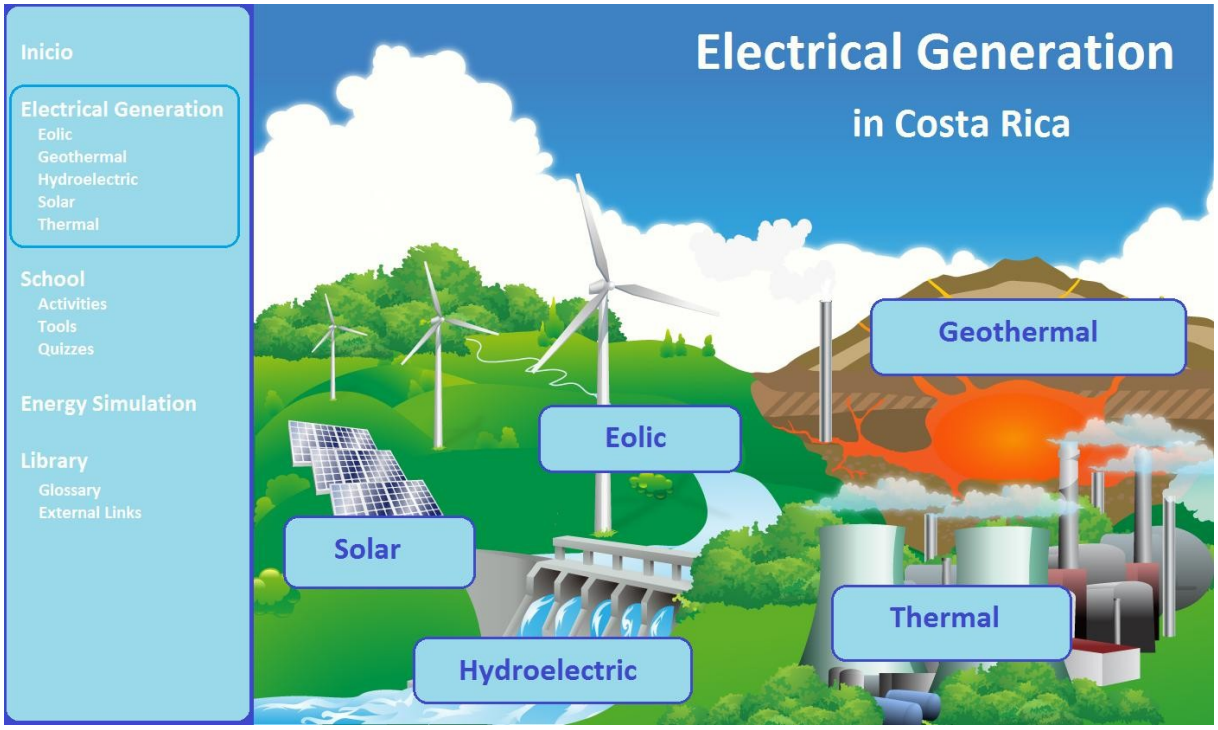


Concept drawing of the school page

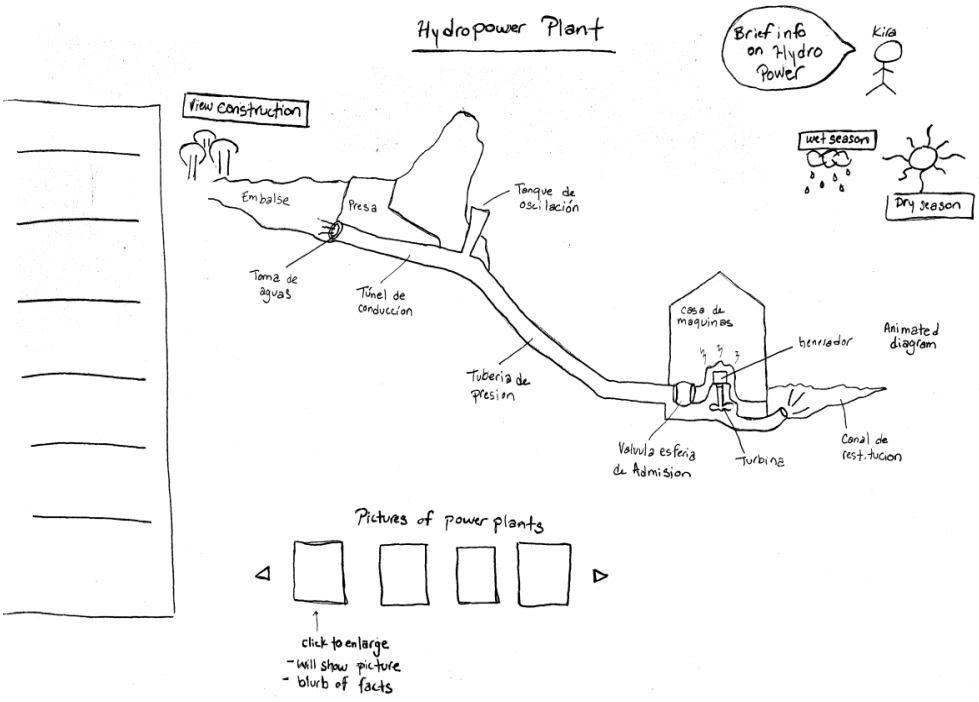
Web developer's drawing of the school page



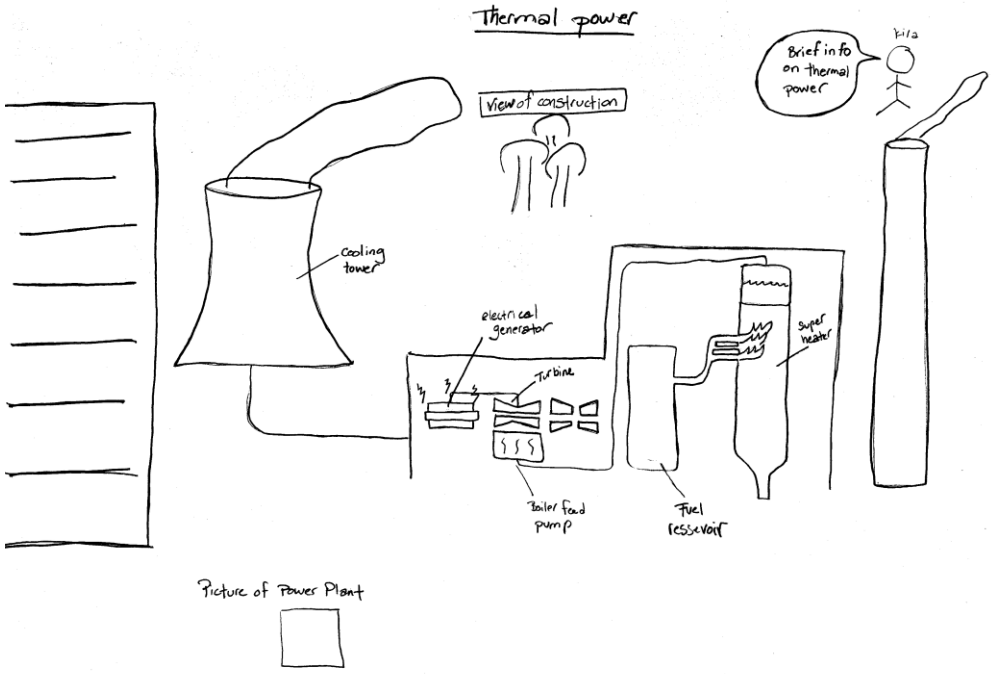
Concept drawing of the electrical generation page



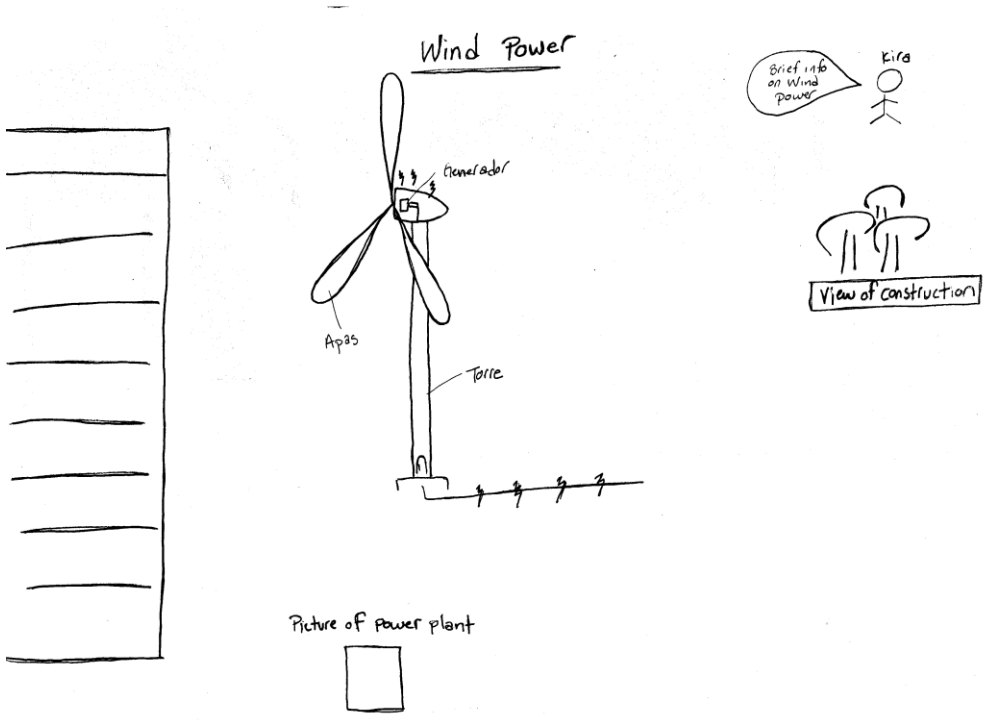
Web developer's drawing of the electrical generation page



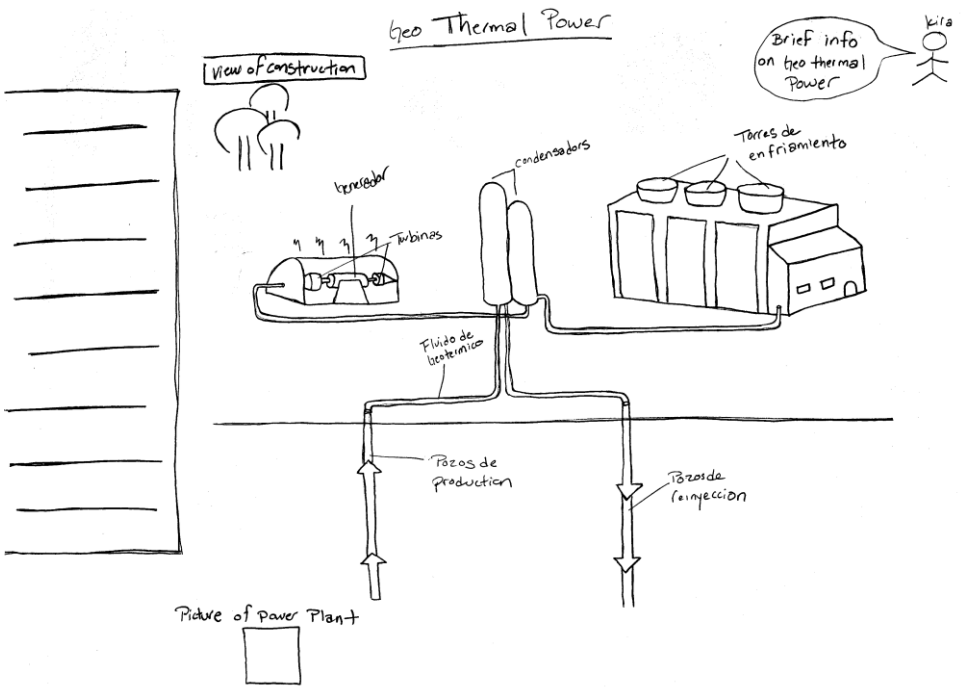
Concept drawing of the hydroelectric generation page



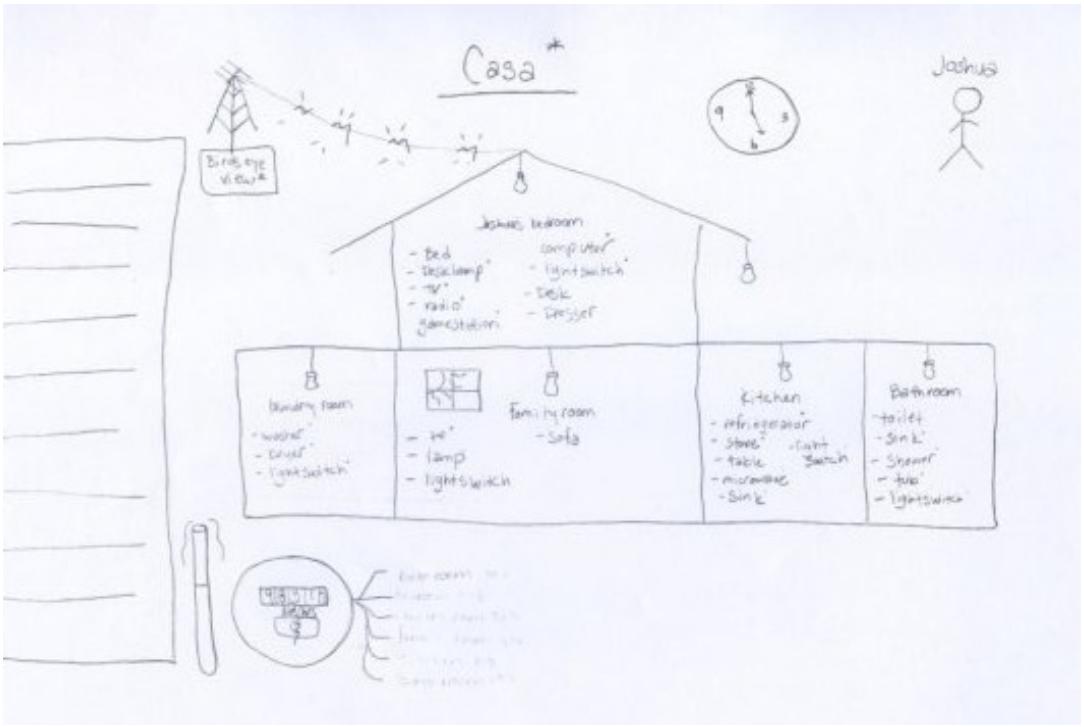
Concept drawing of the thermal generation page



Concept drawing of the wind generation page

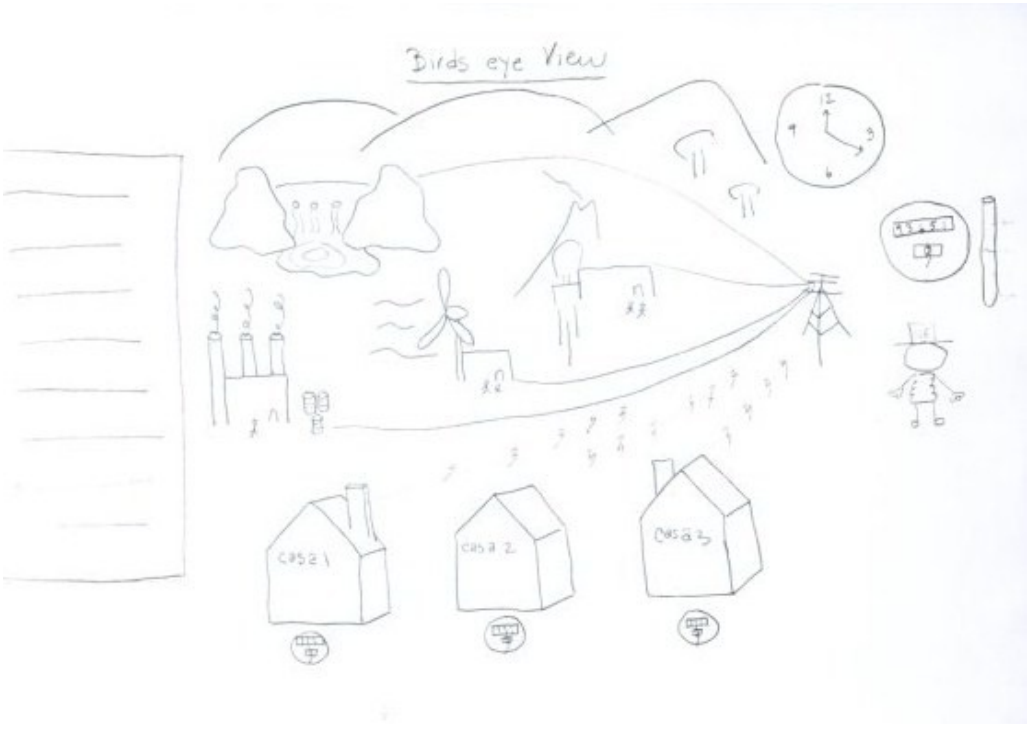


Concept drawing of the geothermal generation page



Concept drawing of the house section of the simulation page

Web developer's drawing of the house section of the simulation page



Concept drawing of the bird's eye view section of the simulation page

Web developer's drawing of the bird's eye view section of the simulation page