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## **A Virtual World as an Introduction to Green IT Awareness**

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### **ABSTRACT**

*This paper describes a project to explore the possibilities of virtual worlds in educating Green IT. In the project, a virtual world has been created with various assignments to create awareness on sustainability aspects of IT. The world (and the assignments) will be incorporated in a course for first-year IT students. In order to measure the effects of the course, a questionnaire has been developed which can be used before and after the course to measure the change in attitude towards green IT.*

**Keywords:** Sustainability, awareness, education, virtual world

### **INTRODUCTION**

From the growing capabilities of technology and the Internet the question arises whether (and if so, how) education can benefit from these possibilities. In this paper, we describe a project in which the possibilities of a virtual world as a platform for educating Green IT awareness are assessed. The aim of the project was to create an environment where students can experience the effects on sustainability resulting from their behaviour.

In the context of educating Green IT, awareness there is certainly room for improvements. Currently most students attend lectures, and travelling to and from these lectures takes up a lot of time, which has a negative impact on the environment. What's more, a lecture may not be enough to inspire students on Green IT awareness. To attain this awareness, IT itself may be used as a platform to educate and inspire students. Simulation games for example are suitable for this goal as simulation games are "experimental, rule-based, interactive environments where players learn by taking actions and by experiencing their effects through feedback mechanisms that are deliberately built into and around the game" (Mayer, 2009). The following five goals can be distinguished in relation to the use of simulation games (Faria, Hutchinson, Wellington & Gold, 2009; Stoppelenburg, de Caluwé, & Geurts, 2012):

1. Achieving a learning objective.
2. Improving decision-making skills.
3. Improving communication and teamwork.
4. Strategy formulation and policymaking.
5. Gaining experience and insight about a future situation.

In our project, we want students to gain experience on the topic of sustainability and IT in order to improve their decision-making skills. We expect that by immersing students in a simulation game on Green IT, they will be better equipped to formulate a strategy and/or policies for Green IT. Therefore, we focus on the goals 1, 2, 4 and 5 as stated above.

Simulation games have been used before to practise complicated and demanding strategies (Bignell, 2011; van Bree, 2013). Moscato and Boekman (2010) used a virtual world in Second Life as a platform to simulate security issues in a server centre. This inspired the construction of a similar simulation. Apart from the possibility to experience, a simulated environment has the benefit that students can access it from their home anytime they want. Students may work on tasks alone or, by using the communication tools in virtual world environments, together.

This paper describes the pilot project of building a virtual world and the competencies that are intended to be attained in following the assignments in this world. The research question for the project was, "How can virtual educational environments contribute to sustainable and high-level quality teaching and learning processes about sustainability in higher education in the Netherlands."

The project consisted of three phases (see Table 1). In the first phase, we have conducted a literature study to determine which competencies are relevant to students in relation to Green IT and on what proficiency level. In this phase, we explored how virtual worlds can be used in education as well. In the second phase, a first concept for a course on Green IT has been developed and consequently the course in the virtual world itself has been developed in several iterations. As environment for the virtual world, we decided to use OpenSim, as there is quite a lot expertise with this environment in the Netherlands. The third phase of the project consisted of developing an instrument to determine the effects of the course on Green IT awareness by students. Hereto a questionnaire has been constructed that students fill in before they take the course and again after they have finished the course. The actual building of the virtual world (which has been named GreenIT) was done by students who took a minor program called "Virtual and Social Networks" as part of their bachelor training. In this program students learn about the possibilities of social media in organisations as a platform for communication, marketing, sharing information and education. Students are lectured on various Social Media subjects, they work on a project to practise the lessons taught and they contribute to a real problem posed by an organization. One of these projects was to build a virtual world that can be used to teach first year IT students Green IT awareness.

Phase	Project/Research Activities
1) Determine Green IT competencies and how virtual worlds are used in education.	<ul style="list-style-type: none"> <li>• Desk research</li> <li>• Interviews with specialists on virtual worlds in the Netherlands</li> </ul>
2) Develop Green IT course for IT bachelor students in the OpenSim virtual world environment	<ul style="list-style-type: none"> <li>• Determine final set of competences</li> <li>• Develop assignments and assessment</li> <li>• Realization of the Green IT virtual world</li> </ul>
3) Measure the effect of the Green IT course	<ul style="list-style-type: none"> <li>• Desk research on existing methods</li> <li>• Develop an instrument for measuring results</li> <li>• Determine the effects of the course</li> </ul>

**Table 1: Overview of Project Phases and Activities.**

In the following sections, the competences related to sustainability and, more specifically, Green IT will be presented. Subsequently, virtual world environments and their use in education will be introduced. A description of the virtual world—Green IT—that has been developed as part of this project, will follow. The effects the education module has on students in relation to their awareness on sustainability and how such is measured finishes the discussion of the program. Conclusions and recommendation for further research conclude the paper.

### LEARNING OUTCOMES: COMPETENCIES FOR GREEN IT

When developing a course, it is—independent of content and form—good practice to start with the intended learning outcomes: what students should have mastered after finishing the course. Nowadays, the learning outcomes of a curriculum are commonly described in competencies to be acquired. A competency is normally associated with a combination of knowledge, skills and attitudes appropriate in a given context. Dochy and Nickmans (2005) define a competency, as “a competency is a personal capability that becomes visible by showing successful behavior in a specific context.” A competency may combine technical knowledge with general problem solving skills and social-communicative behavior. Competencies are usually derived by analyzing the typical products delivered by professionals in the line of their work that are in accordance with professional standards as well. When a competency is applicable in a broader domain (e.g., uses a problem-oriented approach), we will call it a *domain-general* competency. If on the other hand, a competency is specific for a certain profession (e.g., able to program in C++) we will call it a *profession-specific* competency.

A good example of a set of competencies for the IT sector provided by Comité Européen de Normalisation (CEN) in the European e-Competence Framework (EeCF), version 2.0 (2010) that discerns 36 profession-specific competencies built around five areas in the IT business process: Plan, Build, Run, Enable and Manage. In this framework, we find one competency dealing with sustainability:

#### A.8. Sustainable Development

Estimates the impact of ICT solutions in terms of eco responsibilities including energy consumption. Advises business and ICT stakeholders on sustainable alternatives that are consistent with the business strategy. Applies an ICT purchasing and sales policy which fulfils eco-responsibilities.

European e-Competence Framework version 2.0, September 2010. See <http://www.ecompetences.eu/>

Depending on the line of work and the complexity of the job, a competency may be practiced on different *proficiency levels*. In this paper, we will use a scale of 0 to 4 meaning:

- 0) *Awareness*: aware of the basic facts, but not capable of applying these in practical situations.
- 1) *Basic*: able to apply knowledge and skills to solve straightforward problems.
- 2) *Advanced*: uses knowledge and skills to solve problems within a predictable context.
- 3) *Professional*: uses knowledge and skills to solve complex problems within a (sometimes unpredictable) context.
- 4) *Expert*: can transfer knowledge and skills to solve complex problems within a new context.

The levels 1 to 4 correspond with levels e-1 to e-4 of the EeCF. We added a level 0 (awareness) as this is the first level to be reached in any topic and as such an important step in education.

The competency on sustainable development of the EeCF, as given above, has been categorized in the Plan-area of the EeCF; and in the report, it is advised to strive for a proficiency level of 3 to 4. While we welcome the explicit recognition of the importance of sustainability for IT, we feel that sustainability issues are relevant in the other areas of the EeCF (Build, Run, Enable and Manage) as well. However, in most current competency sets for IT, the topic is not included at all or only in very general terms that are not IT-specific. A concise overview of sustainability competencies (not restricted to IT) is given by Willard et al. (2010) who have interviewed professionals in industry concerning top skills needed by sustainability professionals for success. From these interviews, they learned that strategic planning, systems thinking and project management were considered as the most important hard skills while communication with stakeholders, problem solving, inspiring and motivating others were considered as the most important soft skills. These are important domain-general competencies and as such should be included in the sustainability competencies for IT curricula as well.

As the course described in this paper is introductory, we aim at proficiency levels 0 (awareness) and 1 (basic), both for the domain-general as for the profession-specific competencies. To develop the competencies for this course, we have used the model developed by Roorda (2009), who discerns six categories for the domain-general and one category for the profession-specific sustainability competencies:

1. *Responsibility*: sustainable professionals take responsibility for their work
2. *Emotional Intelligence (EQ)*: sustainable professionals identify with values and feelings of others

3. *Systems Thinking*: sustainable professionals think and work from the vision that things influence one another
4. *Future oriented*: sustainable professionals think and work from a future oriented perspective
5. *Personal commitment*: sustainable professionals are personally involved in sustainable development
6. *Action Ready*: sustainable professionals are decisive and capable of action
7. *Disciplinary*: the profession-specific competencies for sustainable development.

Proficiency Level Competencies (Roorda, 2009)	Awareness (0) of basic facts, but not capable of applying these in practical situations	Basic (1) ability to apply knowledge and skills to solve straightforward problems
<b><i>Responsibility</i></b>		
Construction of stakeholder analysis		Able to construct concerns of all stakeholders
Critical evaluation of own actions		Able to systematically reflect on own (professional) activities
<b><i>Emotional Intelligence</i></b>		
Discerning between facts, conjectures and opinions		Able to determine if an assertion is a fact, a conjecture or an opinion
<b><i>Systems Thinking</i></b>		
Functional, innovative, creative, out-of-the-box thinking	Recognize when a problem cannot be solved in a standard way	
Supply-chain thinking	Aware of the fact that the products and services from professional activities are part of a supply-chain or life-cycle	
<b><i>Future Oriented</i></b>		
Thinking on different time-scales; distinguishing between short and long term	Aware of operational methods for construction and maintenance	
Assessing consequences (range and period) of decisions	Aware of consequences of professional activities for stakeholders	
<b><i>Personal Commitment</i></b>		
Sustainable development as a professional attitude	Able to explain what is comprised in sustainable development	Able to designate causes of non-sustainability in practical situations
<b><i>Action Ready</i></b>		
Comparing the Incomparable and making choices		Able to describe incompatibilities in professional activities
Handling uncertainty	Aware of uncertainties in professional activities	

**Table 2: Domain-General Competencies for a Starter's Course on Green IT.**

In every domain-general category, corresponding competencies are gathered by Roorda. For our (starter's) course, we have chosen the competencies depicted in table 2, as a start. For the profession-specific competencies, we have formulated competencies regarding the use of energy and materials in IT, e-waste and the use of IT to gain in sustainability in projects and other domains. Table 3 gives an overview of these competencies.

Proficiency level Competency	Awareness (0) of basic facts, but not capable of apply these in practical situations	1 – Basic (1) ability to apply knowledge and skills to solve straightforward problems
<i>Disciplinary</i>		
Energy consumption of hardware, software and infrastructural components	Aware that software has its influence on energy consumption	Able to measure the energy consumption of hardware and infrastructural components
Usage of various materials in hardware and infrastructural components and recycling thereof (e-waste)	Aware that IT-components may contain valuable and scarce materials	Separating electronic components for re-use and recycling
Use of IT in projects to gain in sustainability		Able to use IT in projects for communication, information, planning, etc.
Use of IT to gain sustainability in different domains (greening by IT)	Able to give examples of greening by IT	

**Table 3: Profession-Specific Competencies for a Starter's Course on Green IT.**

Before showing how these competencies are implemented, we will discuss the possibilities of virtual worlds in education in the next paragraph first.

### VIRTUAL WORLDS IN EDUCATION

As stated in the introduction to this paper, the use of IT in education and, more specifically, gaming, simulation and virtual worlds, is not new. From the beginning, virtual world environments have been used in education because

The sense of immersion within 3D multi-user virtual environments can provide educators and students with the ability to connect and communicate in ways that greatly enhance the learning experience. These innovative methods of teaching place the student at the centre of the learning by involving them in the experience itself (Bignell, 2011).

However, the use of virtual worlds does have its challenges. In this section, we will describe two aspects of virtual worlds that are important when developing a new course that uses a virtual world environment.

First, whenever a virtual world is used in education, it is important to determine the way in which students will work together. Chen, Sager, Corbitt and Gardiner (2008) advocate the opinion that students should get training in virtual teamwork processes. Especially when they

need to collaborate with students who they have never met face-to-face. Table 4 shows their model that describes the learning process of students, which techniques they should use and the role of the lecturer in this process.

Learning Process	Learning Techniques	Teaching Approach
Abstraction Conceptualization (conceptual learning at the beginning of the class)	Students learn by reading, listening, and discussing the following knowledge areas: <ul style="list-style-type: none"> <li>• Face-to-face teamwork</li> <li>• Virtual teamwork</li> <li>• Computer mediated communication (CMC)</li> </ul>	The instructor supplies relevant reading material, gives well-organized and informative lectures, and encourages teams to discuss relevant materials.
Active Experimentation and Concrete Experience (learning by doing the project)	Students learn by doing the following activities: <ul style="list-style-type: none"> <li>• Engaging virtual teamwork by following the known effective practice</li> <li>• Engaging virtual teamwork by trial and error</li> </ul>	The instructor designs the virtual teamwork with appropriate level of project complexity and task interdependence so that team members have to engage in serious virtual collaboration to complete the project.
Observational Reflection (learning by reflecting on project execution)	Students learn by reflecting and discussing effective/ineffective virtual team practices	The instructor encourages individual and group reflection via team discussion, team report writing, and online forum discussion.

**Table 4: Learning Process, Learning Techniques and Teaching Approach**  
(Chen et al., 2008).

Second, a much discussed topic in relation to virtual worlds is how to assess the competencies that students should acquire. Ibáñez, Crespo, & Kloos (2010) state that specific characteristics of virtual world environments should be used in developing courses in order to use the potential of those environments fully. They state that virtual worlds are different compared to classroom teaching in two main aspects:

1. *Interfacing*: in a virtual world students are able to interact with objects which, based on the manner of interaction, can guide students through different scenario's (thereby customizing the learning process).
2. *Monitoring*: a virtual world can be monitored continuously. All activity can be logged and used for analysis and assessment.

Thus, quoting from Ibáñez et al., (2010):

3D virtual scenarios can be filled with information through text, audio, and images and also through 3D scenarios, smart objects, and non-playing characters (NPCs). Technical elements used in video-games such as small-map, cursor



indication and NPCs playing dialogues are useful to aid in orientation, to show extra information and to transmit knowledge respectively.

This also holds true for the way in which assessments are done.

Assessing knowledge is typically done by asking questions that demand answers from students. While this is basically the same in a virtual world, the way in which a question is stated may be quite different (for instance, an assignment or puzzle in the virtual world). Ibáñez et al. (2010) provide additional insight: “The role of NPCs in the assessment process is especially important when the question is stated; when the student requires some help to answer it and also when feedback is provided.”

NPCs can be used to counter one of the possible drawbacks of a virtual world, the fact that communication is not necessarily synchronous.

To be able to assess skills we need to determine whether a student can execute certain tasks or solve (complex) problems. In virtual worlds, scenarios can be embedded that students must follow as part of a learning sequence and in which tasks and problem solving are an integral part. In such a learning sequence, it is possible to incorporate “physical resources . . . that must be used by students following a set of constraints such as limited time to carry on the activity, amount of money to spend on it, or the quality and quantity of human resources” (Ibáñez et al., 2010).

An important advantage when using 3D virtual worlds as part of an assessment is the possibility to adapt the learning process and subsequently the following assessments based on the outcomes of earlier assessments (Nussbaumer, Gütl, Albert, & Helic, 2009). Where this functionality is quite common in e-learning environments, it is however not present in current virtual world environments, such as Second Life.

In order to achieve adaptation, guidance, and feedback, an adaptation module is needed . . . . In this place the algorithms for creating learning paths and for calculating the current skill state are implemented. Furthermore domain and user model are located there which the algorithms need for their calculations. (Nussbaumer et al., 2009, p. 106)

In the next section, we will describe how, based on the competencies presented earlier, and the findings from this section, we developed GreenIT, a virtual world, to educate students on sustainability and IT.

## **BUILDING A VIRTUAL WORLD FOR ACQUIRING GREEN IT COMPETENCIES**

As stated in the introduction, the actual building of GreenIT, the virtual world, the second phase of the project, was done by a group of five third-year students, as their project in a minor program. We will refer to these students as “the builders.”

Without a predefined plan, the builders started creating a virtual world. One of the first problems was *what* to build in this world, followed by the challenge to create a virtual world that felt *real*. At first, the builders developed a few assignments that were scattered throughout the world, each assignment located in its own building. Next, scripts were added to enable interaction within and with the world. Still the world felt empty and the builders were not satisfied with the result. To overcome these difficulties the builders showed their world to other students. These students were asked to find and complete the assignments in the world. The outcome of this experiment was that the assignments were hard to find and it was not clear what was expected in an assignment. In fact, the students reacted to the builders that the purpose of the world as a whole was incomprehensible.

To deal with this problem the builders decided to define seven themes and seven corresponding tasks. To guide the users, a storyline—as is customary in many games—was designed, though in this case the element of competition was left out. The seven themes were chosen in order to increase the accessibility of the assignments as well as allowing for a complete coverage of the different competencies (as described on page 65—the Competencies for Green IT). The seven chosen themes are:

1. *Sustainability* this theme focuses on awareness about sustainability: making sustainable choices and contributing to a greener world.
2. *Power Saving* this theme aims to increase the awareness of power usage as well as finding opportunities to save power.
3. *Carbon footprint* is defined as "*the total sets of greenhouse gas emissions caused by an organization, event, product or person*" (Carbon Trust, 2009). In this theme, the goal is to reduce one's carbon footprint.
4. *Understanding* is where users learn that actions have results—wanted but unwanted as well.
5. *Buying decisions* where users decide on how to balance sustainability issues when a set of products have to be bought within a fixed budget.
6. *Recycle* addresses garbage and the importance of recycling garbage.
7. *Re-use* is where users have to learn which products are fit for a second life.

Next, assignments were developed in accordance with these themes:

1. For the sustainability theme, a data centre was build where too many servers were being used with inefficient cooling systems. For a second assignment within this theme, a gas station has been developed where different tasks have to be performed in order to make the station more sustainable and to complete the assignment. The last assignment in this theme involves printing. It is meant to create awareness on the costs of printing, the costs being money, energy or materials.
2. For the Power Saving theme an office building was built with many computers. The goal of the assignment is to turn computers and screens off when they are not being used.
3. For the carbon footprint theme a carpool, assignment was build where the car tells you it is better to share the car with others and not use it alone. In a future update, this theme will be extended.
4. For the Understanding theme a multiple choice centre was built (see Figure 1). In this building, correct answers give access to the next room with the next question. Wrong answers send you back a couple of rooms/questions.



**Figure 1: The Multiple Choice Centre in Green IT.**

5. For the Buying decisions theme a computer store was built where users have to decide whether to buy a green computer or a lesser green one. The goal is to reach optimum sustainability within a given budget.
6. For the Recycle theme, an E-Waste centre was built. In the virtual world, users can find garbage. This garbage can be collected and recycled. When users recycle waste materials in the correct way, the garbage pile shrinks.
7. Finally, for the Re-use theme an assignment was built where heat from the data centre is used as an energy source to levitate a building. A pipe system transports water to the data centre where it is heated. After the water passes the data centre, it flows to a steam powered system that enables a building to rise into the air. Once the assignment is completed, the students can enter the building to learn more about using the excess heat of data centres.

In addition to the assignments as mentioned above, an information building was constructed providing information about various Green IT subjects and a map of the world with these themes was created so users can find their way (see Figure 2).

When entering the world for the first time, users need to complete a tutorial where they learn the skills needed to navigate in the world and to make assignments. When the tutorial is completed, students are presented with the map, to present the various possibilities of GreenIT.

After completing the tutorial, the user receives a Heads-Up Display (HUD) (Wilson, 2006) that is attached to the screen and registers the progress of the various tasks. When you pick up garbage that is scattered around the world, the HUD will show how many garbage you have picked. The HUD also shows how much energy the world is using and how much CO<sub>2</sub> is being produced. And finally, the HUD is used to store the progress of the user in performing the assignments.

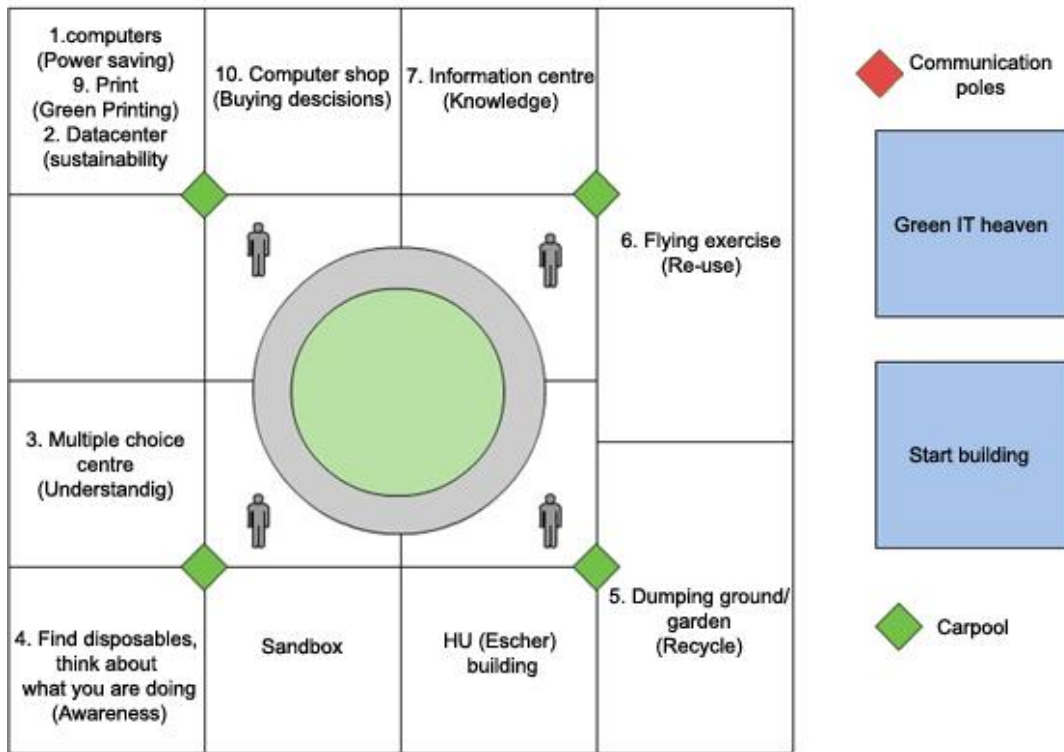


Figure 2: Map of the Virtual World.



Figure 3: Heads-Up Display (HUD).

Now the world has been built and the assignments realized, the next step is to integrate it in the green IT course. This will be done in two phases. In the fall of 2013, a pilot will be conducted with ten students to detect initial problems. Starting spring 2014, the course will be fully operational.

### DETERMINING THE EFFECT OF THE COURSE

Apart from the competencies as explained before, an explicit goal for the course is to achieve a positive attitude and behavior for students regarding sustainability. In order to determine changes in competencies, attitude and behavior regarding sustainability, we need an assessment

instrument for pre- and post-measurement. For this purpose, Verheul (2012) developed a questionnaire that includes part of the existing questionnaire used by de Vries and Knol (2011) in the Enercities project and where specific questions regarding the Green IT competencies discussed in section 2 have been included. The questionnaire itself is available via the authors of this paper.

EnerCities is a European project that rolls out a serious game in which players are challenged to build a sustainable city. It runs online ([www.EnerCities.eu](http://www.EnerCities.eu)) and on Facebook (<http://apps.facebook.com/enercities>) and is currently available in six EU languages. The browser-based 3D technology of EnerCities is the Unity3D plugin. This 3D technology leads to 3D perspectives, smooth scrolling and zooming and animated graphics. In this way, EnerCities appears to the teenagers, in comparison with browser-based Flash games, as a modern browser game with attractive/nice graphics. The game and related educational materials are freely available for schools and individuals across Europe. Large-scale usage of the game on schools started in September 2010; in parallel, individuals are invited to sign up and play the game. Game players and control group members are asked to fill in questionnaires, the results of which will be used to ascertain the game's effectiveness in changing energy related attitudes and several household energy-related behaviors (de Vries & Knol, 2011).

To assess the possibilities of this instrument, we have tested it with the builders of the GreenIT world in relation to other students with the same background. Two measurements were conducted, one before the start of the building process and one three months later, during the building process. The results on attitude and behavior are given in Table 5.

<i>Scale: 1 to 7 (higher: more positive)</i>	<i>Builders (n=5)</i>		<i>Other Students (n=25)</i>	
	<i>Before</i>	<i>After</i>	<i>Before</i>	<i>After</i>
Attitude, (21 questions)	4,3	4,9	4,8	4,6
Behavior in the last two weeks, 7 questions	2,7	4,0	3,6	3,5

**Table 5: Changes in Attitude and Behavior towards Sustainability.**

While for the students not involved in the building of GreenIT, the attitude and behavior towards sustainability decreased slightly (but not significant), these aspects increased substantially with the builders. For this group the conclusion that attitude and behavior towards sustainability increases with increasing attention towards the subject, seems justified. This can be illustrated by a remark from these students: *“We were impressed by the impact daily usage of hardware, internet etcetera, has on the environment. We want the players in the virtual world to have the same experience.”*

The same effect was observed with Enercities, where *“playing the EnerCities game has resulted in higher attitudes towards saving energy at home in general, as well as towards performing specific energy-related household behaviours . . .”* (de Vries & Knol, 2011).

## CONCLUSION

We started this project with the goal to develop a course that would contribute to a positive attitude and behavior on sustainability and IT. Furthermore, we tried to answer the research question: “*How can virtual educational environments contribute towards sustainable and high quality teaching and learning processes about sustainability in higher education in the Netherlands.*” Thus, we also wanted to know whether virtual worlds could be used to reach our desired goal.

If we look at the outcome of the effect measurement with the first group of students that tested a beta version of the developed world, we should conclude that we haven’t reached our goal yet. However based on the change in awareness and behaviour of the students that designed and developed the world we are hopeful that the final version of the virtual world GreenIT will reach the desired effects (this is also based on the observed effects from the EnerCities survey). The seven themes and the different assignments are all aimed at making students aware of the basic facts in relation to sustainability and IT and giving students the opportunity to apply that knowledge in exercises that are meant to acquire skills that can be used in their future jobs.

Now the virtual world is finished, we will test it thoroughly with a new group of students during the fall of 2013. Based on the outcomes of this pilot, enhancements to the virtual world can be made before implementing it in the curriculum of our first year IT bachelors.

The authors like to thank the builders: Henk ter Harmsel, Peep van Puijenbroek, Vincent Schoenmakers, Bas Terwee and Niels Verlaan for their efforts and never-ending optimism.

The GreenIT world itself can be found on OpenSim, grid 3Dles.

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