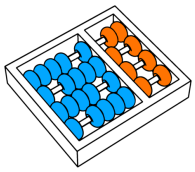
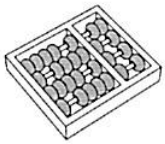


Lara Schibelsky Godoy Piccolo

"Motivational Aspects in the Design of Technology for Social Changes"

"*Aspectos Motivacionais no Design de Tecnologia para Mudanças Sociais*"

CAMPINAS
2015



University of Campinas
Institute of Computing

Universidade Estadual de Campinas
Instituto de Computação

Lara Schibelsky Godoy Piccolo

"Motivational Aspects in the Design of Technology for Social Changes"

Supervisor:
Orientador(a): Prof^a. Dr^a. Maria Cecília Calani Baranauskas

"Aspectos Motivacionais no Design de Tecnologia para Mudanças Sociais"

PhD Thesis presented to the Post Graduate Program of the Institute of Computing of the University of Campinas to obtain a PhD degree in Computer Science.

Tese de Doutorado apresentada ao Programa de Pós-Graduação em Ciência da Computação do Instituto de Computação da Universidade Estadual de Campinas para obtenção do título de Doutor em Ciência da Computação.

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Junia Coutinho Anacleto
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Prof(ª). Dr(ª). Júnia Coutinho Anacleto

Titular

Prof(ª). Dr(ª). Laura Sánchez García

Titular

Prof(ª). Dr(ª). Rodolfo Jardim de Azevedo

Titular

Prof(ª). Dr(ª). José Mario de Martino

Titular

Prof(ª). Dr(ª). Maria Cecília Calani Baranauskas

Presidente(a)

Institute of Computing /*Instituto de Computação*
University of Campinas /*Universidade Estadual de Campinas*

Motivational Aspects in the Design of Technology for Social Changes

Lara Schibelsky Godoy Piccolo

January 15, 2015

Examiner Board/*Banca Examinadora*:

- Prof[a]. Dr[a]. Maria Cecília Calani Baranauskas (Supervisor/*Orientadora*)
- Prof. Dr. Rodolfo Jardim de Azevedo
  Institute of Computing - UNICAMP
- Prof. Dr. José Mario De Martino
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  Institute of Computing - UNICAMP (Substitute/*Suplente*)

Abstract

By connecting people and being present in almost all aspects of life, when properly designed for that, technology can potentially influence the way people in a social group perceive and relate with things in their environment.

This PhD study in the Human-Computer Interaction (HCI) field investigates how motivational elements from Psychology can be applied to inform the design aiming at exploring this potential of technology for promoting a social change. The study is instantiated in the energy consumption domain, coping with the contemporary challenge of raising awareness among the society of the planet's natural resources usage and limits.

Informing the design with motivational aspects is a recent approach in HCI. When found in literature, it is mostly focused on individual and intrinsic aspects of motivation. However, as argued in this research, the sociocultural context evidences the importance of considering also the external factors that motivate people to be engaged with technology and the social issue.

By taking into account both intrinsic and extrinsic sources of motivation, the Self-Determination Theory is then considered the main theoretical background from Psychology in this investigation, and the Organisational Semiotics the methodological basis to analyse sociocultural elements that influence extrinsic motivation.

The situated analysis of sociocultural data with motivational lenses has led to the design of a *Socially-informed Energy Eco-feedback Technology* (SEET), an architecture that aims at establishing a "new pattern of behaviour", or a new way of perceiving collective energy consumption. The SEET is composed by an interactive system that promotes collaboration and The Energy Tree, a tangible and public feedback device for gathering places.

The SEET is evaluated in two complementary scenarios: an elementary school in Brazil, where the sociocultural data was collected, analysed and applied to inform design; and in the context of an university department in the United Kingdom. Motivational aspects of the SEET architecture are then analysed, as well as the impact of this technology to trigger the desired social change.

Resumo

Conectando pessoas e presente em todos os aspectos da vida, quando projetadas para este fim, as tecnologias têm potencial de influenciar a forma com que pessoas em um grupo social percebem e se relacionam com as coisas no ambiente.

Este estudo de doutorado em Interação Humano-Computador (IHC) investiga como elementos motivacionais da Psicologia podem ser aplicados para informar o design, explorando esse potencial da tecnologia em promover mudanças sociais. O estudo é instanciado no domínio de consumo de energia elétrica, lidando com o desafio contemporâneo de conscientizar a sociedade dos limites naturais do planeta no que diz respeito ao uso de recursos naturais.

Informar o design com aspectos motivacionais é uma abordagem recente em IHC. Quando encontrada na literatura, comumente tem foco em aspectos individuais e intrínsecos da motivação. Contudo, como argumentado nessa pesquisa, o contexto sociocultural evidencia a importância de considerar também os fatores externos que motivam as pessoas a se engajarem com uma tecnologia e com uma determinada questão social.

Por considerar tanto fontes intrínsecas quanto extrínsecas de motivação, a Teoria da Autodeterminação é então considerada o principal referencial teórico da Psicologia nessa investigação, e a Semiótica Organizacional é a base metodológica para analisar os elementos socioculturais que influenciam a motivação extrínseca.

A análise situada dos dados socioculturais por uma perspectiva motivacional levou ao design da *Tecnologia Socialmente Informada para Eco-Feedback de Energia* (sigla SEET, em inglês), uma arquitetura que tem por objetivo estabelecer um novo padrão de comportamento, ou uma nova maneira de perceber o consumo de energia coletivamente. O SEET é composto por um sistema interativo que promove colaboração, e pela Árvore da Energia, um dispositivo de feedback tangível para locais onde há encontro de pessoas.

O SEET é avaliado em dois cenários complementares: uma Escola de Ensino Fundamental no Brasil, onde os dados socioculturais foram coletados, analisados e aplicados para informar o design; e no contexto de um departamento de uma universidade no Reino Unido. Aspectos motivacionais da arquitetura do SEET são então analisadas, assim como o impacto dessa tecnologia ao desencadear as esperadas mudanças sociais.

Acknowledgments

Writing a PhD thesis is much more than structuring chapters to report a study. It means putting into words a long way of shared experiences that day-by-day have shaped my beliefs, plans, ideas... That is the time to say thank you to everyone that enlightened this journey with knowledge and partnership and, beyond that, made it possible and "tangible". Cecília, the guide, master, friend, mother. The always present and super collaborative InterHad family: Roberto, Heiko, Elaine, Vanessa, Samuel, Romani, Fabrício, Leonardo, Amanda, Wagner, Leonello, Ciça... Special thanks to Rodolfo, whose enthusiasm and spirit of cooperation gave life to the Energy Tree. Lucas Yamashita, who from the conception to the case study worked on that as it was his own project. Diego and Matheus that also became partners in developing hardware and software, and to everyone else that helped me to conceive, handcraft, develop, fix, export, rebuild, transport, install, etc. My family for being my ground, my pillars. PV for sharing his wisdom along this work. Arno, the far away friend that expanded my horizon. The brilliant KMi team in the Open University that offered me the perfect environment to improve my studies: Harith, Miriam, Anna, Chris, and all KMi friends that became my international family. To Cemig and Light for the opportunity to join forces. To the Jovelino Lanza school staff in Sete Lagoas for welcoming me and hosting my study case. To all my ex-colleagues and forever friends at CPqD that taught me a lot, supported, and collaborated with my studies. Microsoft Research for providing us the development kit, GEO for the energy monitors in the UK. The super friendly and helpful staff at IC/Unicamp. To CAPES for the internship opportunity and the partial financial support. And last but not least, the biggest thank you to the case studies participants for the trust and the willing to make a difference in the world.

"If we could change ourselves, the tendencies in the world would also changes. A man changes his own nature, so does the attitude of the world change towards him. ... we need not wait to see what others do.."

Mahatma Gandhi

List of Abbreviations

CAPS	Collective Awareness Platforms for Sustainability and Social Innovation
EFT	Eco-feedback Technology
IHD	In-Home Displays
IMI	Intrinsic Motivation Inquiry
OS	Organisational Semiotics
R&D	Research and Development
REFS	Residential Energy Eco-feedback Technology
SAM	Self-Assessment Manikin
SDT	Self-Determination Theory
SEET	Socially-inspired Energy Eco-feedback Technology
SEETree	SEET applying the metaphor of a tree

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Chapter 1

Introduction

The presence of technology mediating our relationship with the world has increased day-by-day. There are interactive applications available for any purpose, sensors have assumed our control in many situations, and the online world has become social by default. This current scenario favours the potential of technology to promote different world views, triggering desired social changes.

While technical challenges and achievements are continually emerging from this reality, old concerns related to human aspects remain as open questions since the first interactive system was launched. Identifying forces that guide people's action towards technology is an example that refers to human *motivation*, an ancient notion that only recently was brought to technology design, according to Shneiderman in [146].

Motivation emerged as this PhD research topic during the evaluation of an interactive TV application by people completely unfamiliar with technology [128], as described in Chapter 3. Participants were asked to type a short text by using numeric keys in the TV remote control, a task that required patience and dexterity. But the socio-political moment led those users to overvalue the application. Even being aware it was a prototype, the opportunity to express their feelings about the current scenario motivated them to write very long and complex texts without expressing any discomfort, against the researchers' expectations. Such experience suggested that understanding motivation from Psychology perspective could help identifying and considering in design the forces that are in play when people get engaged (or not) with an interactive system, reasons evidenced as being beyond usability aspects, but also influenced by intrinsic reasons and the social context.

This investigation associates motivational aspects to the design of a technology that aims at triggering change among a social group. Instantiated in the energy consumption domain, and in line with the Socially Aware Design approach [11], this study analysis encompasses how people in a social group make sense of technology and how they are

impacted by it.

Although motivation is the core of this investigation, potential users of a new technology cannot be seen exclusively from this perspective. How people feel also influences their motivation. This boundary between Motivation and Emotion and how they interplay in shaping peoples' action are not clearly defined in literature. Beyond that, the environment, both in terms of social groups' behaviour or elements of interaction, also set challenges and opportunities that influence action. These complementary concepts from other fields are also considered along this study for providing a wider perception of users as complex social human beings, as summarised in Table 1.1.

Table 1.1: Human aspects considered in the study

because people...		**Associated concept**	**Field of study as main reference**
feel	fear, happiness, enjoyment, boredom, ...	Emotion	Cognitive Psychology, Neurosciences
want	well-being, novelty, challenge, respect, ...	Motivation	Psychology
believe	in family, teachers, friends, brands, ...	Culture	Anthropology
are part	of a family, city, society, of the world, ...	Ecology (and affordances)	Environmental Psychology

In different ways, Emotion, Motivation, Culture, and Affordances were studied, analysed and considered to inform the design and evaluation of an Eco-Feedback Technology, more specifically the Social Energy Eco-feedback Technology (SEET). Along the research, the acronym SEET was redefined as *Socially-informed* Energy Eco-feedback Technology to better represent the design approach. The SEET then became the SEETree in reason of the metaphor applied aiming at establishing a stronger connection between energy and the natural environment. Informed by those motivational aspects identified in the research scenario, the SEETree is an interactive system composed by a tangible feedback of engagement with energy awareness issue. Situated in a public area and promoting collective and collaborative reflection and action, the artefact aimed at promoting a change in the way people in a social group perceive and consume energy towards savings. How this concept was developed and evaluated considering motivational elements is the mainstream of this PhD study, as described in next subsections.

1.1 Problem

Electricity has been one of the humanity development foundations. And the world faces the contemporary challenge of supplying the increasing demand for energy coping with the more evident natural limits of the planet. Advances in the energy field have provided more sustainable alternatives of generation and distribution, but the way people in general perceive and consume energy has not evolved at the same pace. Even though, most of the technical innovation still relies on individuals, the end consumers, to be successful [47].

Energy is mostly perceived as intangible and hard to measure, which usage is guided typically by habit instead of conscious action [40] [132]. Providing appropriate consumption information is the main necessary step to raise energy awareness. But interestingly, as pointed out in literature and reinforced in this research, even nowadays when technology has been present in nearly every aspect of life, the lack of information is still an important reason that prevents people to understand how they consume energy individually and how they could review everyday practices.

The design of Residential Energy Feedback Systems (REFS) has then emerged as a key and growing area of interest within HCI & Sustainability [52]. Savings of 7-15% have been attributed to the use of REFS in the US [132]; however, little is known about the effective impact of the feedback on engagement and consequent impact in raising awareness.

According to Pierce & Paulos' analysis of literature [130], the studies have been mostly focused on providing feedback of consumption to individuals. Just more recently, in the last three years, building awareness collectively, such as by exploring online social networks, started to emerge in the HCI domain. Currently, connecting people for raising awareness of problems and possible solutions requesting collective effort has been recognised as strategic to promote social innovations in the European research and innovation scenario [1].

In the context of technology design for promoting individual and societal changes, like REFS, studies addressing individual motivational aspects are found in literature, such as Kelsey and Gonzalez [80], He et al [66], Scott et al [142]. But generally speaking, addressing motivation in technology design is a recent and still scarce initiative in the HCI domain.

This PhD study also brings motivational aspects to inform the design of an energy eco-feedback technology, but instead of considering only individual aspects, motivational forces influenced by the social context are also taken into account in order to promote technology adoption and consequently, the desired social change.

[1] Collective Awareness Platforms for Sustainability and Social Innovations (*https://ec.europa.eu/digital-agenda/en/collective-awareness-platforms-sustainability-and-social-innovation*)

1.2 Objective

The objective of this research is to investigate the introduction of human motivation aspects in interactive products design that aims at promoting a social change.

Both intrinsic and extrinsic motivations, which are culturally influenced, are taken into account in the study. Since this approach involves sociocultural aspects, the evaluation of the technology goes beyond the individual interaction with it, involving also the possible consequences of the design among the social group behaviour.

The following set of questions synthesises these design concerns and drives this investigation:

- How to evoke motivation with device features?
- How to identify motivations of different people to adopt (or not) this new technology?
- How to consider different motivations when evaluating the adequacy and the impact of the solution?
- How to propose user interfaces that make sense to as many people as possible, considering cultural differences?
- How to model and represent aspects of culture reflecting them in the user interface in order to promote a social change?
- How to promote a good affective quality in the user's interaction with this new device, aiming at keeping their motivation?
- How to raise awareness of energy consumption by means of a technical device?

1.3 Research Scenario

This research was benefited by a "smart grid wave", a modernisation process of the energy system that impacts generation, distribution, and consumption not only technically, but also in formal aspects, such as in terms of regulation, and culturally. This new grid establishes a two-way communication between consumers and the energy providers. Among other benefits, it creates more alternatives to access consumption data and, consequently, new possibilities for raising energy awareness among consumers by providing appropriate information. Worldwide, the effects of the new technology on individual consumption have been investigated. More specifically in the HCI area, the consumption feedback has been the centre of attention.

Following this world trend, the Brazilian utilities are investing in research to understand the impact of smart grid on their business. Some of them defined their relationship with consumers as a strategic approach to be evaluated and improved. In this context, two Research and Development (R&D) projects funded by ANEEL, the Brazilian Electricity Regulatory Agency, related to Smart Grid deployment contributed to this PhD study research scenario:

- The Smart Grid Program by Light [88], the electricity company of the city of Rio de Janeiro. Non-payment and fraud (irregular connections for receiving energy) are typical cultural problems – approximately 40% of the distributed energy is not paid by final consumers. The Smart Grid Program scope is wide, including development of energy monitoring devices for a diversity of socioeconomic scenarios. Along this PhD research, the main focus was deploying a pilot of smart grid at Morro da Formiga, a community that used to be dominated by the illegal drug trade and now is under police control.

- Cidades do Futuro (Cities of the Future) [22]. An R&D project executed by CEMIG, the power generator and distributor in the Brazilian state of Minas Gerais. This project was centred in the city of Sete Lagoas and surroundings. The approximately 200.000 city inhabitants comprehends upper and middle classes, socially deprived and rural areas, which is a representative sample of the Brazilian society. Fraud and non-payment exist, but are not so relevant concerns.

These projects were executed by a set of partners that included the Centre for Research and Development - CPqD. As a researcher responsible for the studies related to Interaction with Consumer of both R&D projects at CPqD, qualitative investigations and quantitative surveys designed for both programs were adapted to contribute to this PhD study, including specific data related to motivations towards energy saving, interactive technology usage, etc.

Both scenarios together contributed to inform the SEETree design. The evaluation took place in the Cities of the Future context, in an area of Sete Lagoas represented by a low-income community, common characteristic of both projects.

Additionally, this investigation also contributed to the conception and elaboration of a project proposal for the European Commission under the topic Collective Awareness Platforms for Sustainability and Social Innovation (CAPS). Engagement with energy savings through social media as a way to tackle climate change is one of the core targets of the project DecarboNet [2].

[2] A Decarbonisation Platform for Citizen Empowerment and Translating Collective Awareness into Behavioural Change (*www.decarbonet.eu*)

Once approved and officially launched, DecarboNet was then the scenario for the second experiment executed during the internship in the Knowledge Media Institute of the Open University[3], United Kingdom, institution that coordinates the project.

Even though the experiment scenarios are very different in sociocultural aspects, the Energy Tree and the collective and collaborative approach connect both experiments, pointing out that even situated in a socioeconomic and cultural reality, the technology design does not lose its location in the world.

1.4 Context and Method

Situating this thesis in the HCI field, the conceptual investigation and the SEETree design are at the convergence point among:

- Motivation in design, considering the theoretical background from Psychology. Despite not being a frequent approach in HCI, it is more commonly found when related to Eco-feedback Technology (EFT) design.
- EFT design, which comprehends residential energy feedback systems (REFS).
- Socially-aware Design Approach [11], which aggregates concept of Sociology and Anthropology considering the social context where technology and users are.

Figure 1.1 illustrates this positioning, representing the main research domain areas of this study. The areas size are just illustrative, do not represent proportionally the number of publications found in the literature review or any other quantitative aspect.

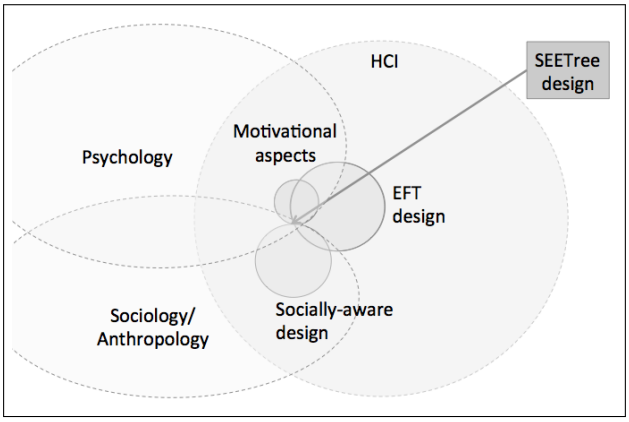

Figure 1.1: Research areas involved in this PhD

[3]Scholarship granted by CAPES PDSE, process 3355-13-6

In such research context, the study is organised in three main parts: Theoretical Framework, the Design in a Situated Research Scenario, and the Evaluation.

As part of the Theoretical Framework, the work includes:

(i) Literature review of Emotion and affective quality evaluation, Affordances, Culture, and Motivation (theories from Psychology);

(ii) Informed analysis of Emotion and Affordances;

(iii) Literature review of Motivation applied to design and Residential Energy-Eco-Feedback Technology.

Composing the Design in Situated Research Scenario:

(i) Analysis of cultural aspects in the Brazilian scenario;

(ii) Analysis of motivational design of REFS in the Brazilian scenario.

(iii) Quantitative analysis of sociocultural data from the research scenarios;

(iv) Semiotic analysis (in the OS perspective) of quantitative data in (iii);

(v) Social norms analysis;

(vi) SEETree: users-interfaces and tangible artefact design.

And the Evaluation:

(i) Experiment evaluating the design in a representative Brazilian scenario;

(ii) Experiment in the workplace scenario in the United Kingdom;

(iii) Final analysis and conclusions.

For providing appropriate methods to analyse technical, individual and sociocultural aspects, the Organisational Semiotics was adopted as the methodological basis along the research.

Figure 1.2 represents the work architecture. The research method is a case study, establishing a context along the development. The theoretical framework starts wider and gets narrower towards the situated design. The ellipses represent the parts mostly focused on literature reviews with informed analysis. The SEETree design in situated research scenario is informed by motivational aspects, sociocultural data and social norms. The lighter rectangles in the Design are study contributing to the design proposal, while the darker rectangles are experiments to evaluate the proposal. A reflection on the experiments results together led to the thesis conclusion.

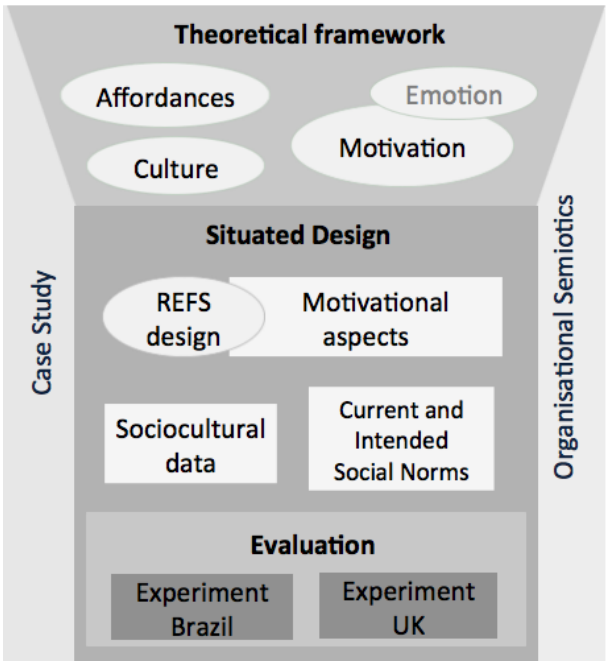

Figure 1.2: The work organisation

1.5 Outline and Contributions

This text is composed by a collection of eight papers published or submitted for publication. From chapter 2 to 9, the original introduction-development-conclusion structure of each paper is totally reproduced. The chapters sequence does not necessarily represent the publication order by date. Instead, it refers to the study evolution considering:

- The theoretical framework: Chapters 2 - Affordances; 3 - Motivation; and 4 - Culture. The study of the Emotion set the basis for understanding motivational forces. Due to this complementary role, this study is presented in the Appendix A instead of being part of the core of the thesis.
- Design in the situated research scenario: Chapters 5 - REFs design; 6 - Sociocultural data; and 7 - Social norms.
- Evaluation: Chapters 8 - Experiment in Brazil; and 9 - Experiment in the UK.

Chapter 2 brings to light the concept of Affordance. As part of the theoretical framework, this chapter analyses how this concept has been transformed in the HCI field since the original idea from Ecology until the Social Affordances, related to patterns of behaviours. An observational study was conducted to identify different types of affordances among physical, perceived, social, and motivational of the iPad® and of

a Tablet-PC.The study clarified how the different types of affordances can explain the relation between human and technology in this new technical and social scenario named 3rd HCI paradigm. Although the analysis was not contextualised in the energy domain yet, the theoretical basis provided by this study was fundamental to conceive the SEETree as an artefact that aims at promoting a different perception of the physical and natural environment among a social group.

Chapter 2 has been published as:

Piccolo, L.S.G. Baranauskas, M.C.C. (2010) Making Sense of the Affordance Concept in the 3rd HCI Paradigm. In WWW/Internet'10: Proceedings of IADIS International Conference WWW/Internet 2010, 183-191. (Qualis B2).

Chapter 3 visits theories of Motivation in the Psychology domain and presents a literature review of motivational design approaches. Main concepts of the The Self-Determination Theory (SDT) [35], a theory that considers both intrinsic and external factors as sources of motivation, are then mapped in order to make sense of them in design. The analysis associates main motivational elements of SDT with design requirements for Residential Energy Feedback Systems (REFS), taking into account different motivations people in the Brazilian research scenario might have.

Chapter 3 has been published as:

Piccolo, L.S.G., Baranauskas, M.C.C. (2012). Basis and prospects of motivation informing design: requirements for situated eco-feedback technology. in IHC'12: Proceedings of the 11 th Brazilian Symposium on Human Factors in Computing Systems. SBC, Brazil, 137-146. (Qualis B4).

Chapter 4 is dedicated to understand Culture from an anthropological view. The concept of culture encompasses the way people relate to the environment and to technology, as well as their perception of control, guiding individual and collective behaviour. This chapter analyses relevant cultural aspects of the Brazilian society according to Hall's areas of culture [61] in terms of the relationship with technology and the environment, and initiates the discussion about how considering those cultural aspects in design can improve the impact of eco-feedback technologies individually and collectively.

Chapter 4 has been published as:

Piccolo, L.S.G., Scharl, A., Baranauskas, M.C.C. (2012) Design of Eco-Feedback Technology to Motivate Sustainable Behavior: Cultural Aspects in a Brazilian Context. In Conf-IRM'12: Proceedings of Conf-IRM. International Conference on Information Resources Management (Qualis B4).

Chapter 5 presents a literature review of Residential Energy Eco-Feedback Systems (REFS) with motivational lenses. Theoretical background supports the ambitious goal of changing a culture by means of a new technology, evidencing the importance of addressing social aspects, beyond those traditionally related to technology. While typical REFS studies targets sustainable attitudes and fine-tuning the effectiveness of REFS solutions, the Brazilian scenario addressed by this research requires a deeper analysis of culture to understand particular issues that might impact perception and adoption of technology, such as fraud and the growing of local economy for the design of a feedback system. By applying Organisational Semiotics artefacts, different motivations were identified leading to a preliminary set of design guidelines and requirements for REFS.

Chapter 5 has been published as:

Piccolo, L.S.G. Baranauskas, M.C.C. (2011) Motivational Aspects in Energy Feedback Systems Design. In CLICH + IHC'11: Proceedings of the 10th Brazilian Symposium on Human Factors in Computing Systems and the 5th Latin American Conference on Human Computer Interaction (IHC+CLIHC 2011), Brazilian Computer Society, Porto Alegre, Brazil, 313-322 (Qualis B4).

Chapter 6 investigates the design of eco-feedback technology drawing on how people relate to energy consumption in Brazil. It describes a quantitative data analysis acquired in a survey via face-to-face interviews with people from the two research scenarios (280 interviewees around Sete Lagoas and 165 in Rio de Janeiro) in terms of how they relate to energy, to technology and their motivations to change behaviour towards conservation. The Semiotic Ladder, an artefact of the Organisational Semiotics consisting of six steps representing views in a communication process shapes the analysis. The results have led to design guidelines and to the SEETree collaborative approach.

Chapter 6 has been published as:

Piccolo, L.S.G., Baranauskas, M.C.C. (2013) Climbing the Ladder with Energy: informing the design of Eco-Feedback Technology with a Social Approach. In ICISO'13: Proceedings of The 14th International Conference on Informatics and Semiotics in Organisations, 185-194 (Qualis B5).

Chapter 7 relies on the concept of social affordance to analyse and shape a behaviour-patterns model to propose the Socially-informed Energy Eco-feedback Technology. It aims at establishing this relation by promoting a new social affordance (behaviour pattern), favouring a new way of perceiving energy. Artefacts of Organisational

Semiotics were extended to consider not only current social behaviour, but also the intended behaviour promoted by the technology design.

Chapter 7 has been published as:

Piccolo, L.S.G., Hornung, H., Baranauskas, M.C.C., Pereira, R. (2013) Designing to Promote a New Social Affordance for Energy Consumption. In I3E'13: Proceedings of 12th IFIP Conference on e-Business, e-Services, e-Society, 213-225 (Qualis B3).

Chapter 8 reports the evaluation of the SEETree in the Brazilian scenario. In an elementary school of a low-income area in Sete Lagoas, students interacted with the SEETree for a week, spreading the energy saving message among their social group. The impact of technology in raising awareness was evaluated, as well as the motivational aspects addressed in the design. The evaluation sheds light on social aspects and dynamics related to a socially-aware design approach hard to be predicted.

Chapter 8 has been submitted to an international journal.

Chapter 9 refers to the experiment applying the Energy Tree as a feedback of engagement with an online debate on energy consumption by a different social group, an academic department in the United Kingdom. In such different sociocultural context, motivational aspects were also evaluated, as well as the role of the Tree and of the debate tool to raise energy awareness.

Chapter 9 has been published as:

Piccolo, L., Alani, H., De Liddo, A. Baranauskas, C. (2014) Motivating online engagement and debates on energy consumption. ACM Web Science 2014, Bloomington, US, 109-118 (Acceptance rate 20%).

Chapter 10 presents the conclusion by providing answers to the initial research questions and also analysing the impact of technology in both research scenarios.

Not all publications resulting from this research have been considered in the core of thesis. Those that somehow contributed to development are then complementary presented as Appendices:

Appendix A is the theoretical study of Emotions and affective evaluations of interactive systems. The analysis was contextualised in the inclusive social software Vila na Rede, a system developed under a participatory design approach with the purpose of building a Web based community among the less favoured segment in the Brazilian society.

Appendix A has been published as:

Hayashi, E., Piccolo, L.S.G., Baranauskas, M.C.C (2013) Perspectives on the evaluation of affective quality in social software. International Journal of Web Based Communities - IJWBC 9(4), 519-534 (Qualis B3).

Appendix B is a complementary analysis of the study case in the United Kingdom focusing on the online debate content. In the technical, formal, and informal perspectives, the results pointed out the where the lack of information is and what are the most relevant topics to be discussed in an energy awareness initiative.

Appendix B has been published and received **the Best Paper Award** at IHC 2014 as:

*Piccolo, L., Baranauskas, C., Fernandez, M., De Liddo, A. and Alani, H. (2014) Energy Consumption Awareness in the Workplace: Technical Artefacts and Practices.*Proceedings of IHC 2014 - Brazilian Symposium on Human Factors in Computer Systems.

Appendix C provides some additional information on the Ontology Chart, an Organisational Semiotics artefact for modelling social activities, applied in Chapters 6 and 7.

Appendix D presents the Consent Form signed by participants' parents or guardians in the Brazilian experiment with children (in Portuguese). The signed versions have not been included in order to protect personal data (address, name, and reference number for the utility) of the participants.

Appendix E presents the permission from the Publishers for including Chapter 7 and Chapter 9 as part of this thesis.

As a collection of papers, the chapters and the steps of the research method are not strictly correlated. The literature review, for instance, is mainly concentrated in the theoretical framework, but it is also updated and better contextualised along the following chapters. The theoretical background also generated initial requirements and guidelines for the SEETree development. The chapters' main contributions to the method are then described in the Table 1.2.

Table 1.2: Main contribution to the method per chapter

#	**Literature Review**	**Theoretical Framework**	**Problem Definition**	**SEEtree Design**	**Evaluation**
2	Affordance in design	Affordances			
3	Motivation in HCI	Main concepts related to motivation by the SDT	How motivational aspects can inform design	Preliminary requirements in a motivational perspective	
4	Eco-Feedback Technology	Hall's areas of culture	How cultural aspects can potentiate EFT design	Cultural design implications	
5	Residential Energy Eco-Feedback System (REFS)		.Stakeholder's concerns .Users' profiles x motivations	Design strategies from literature	
6			Sociocultural data analysis (quantitative survey)	.Design elements .Contextualised design guidelines .The social architecture	
7		.Social affordances .Extension of OS artefacts to add intended behaviour	Behavioural norms analysis	Models of "current reality" and "intended reality" with the technology introduction	
8	.Energy eco-feedback systems .Energy saving initiatives in schools			.User interfaces design .The Energy Tree	.The impact of the Energy Tree to raise awareness in a social group .Reflections on the socially-inspired design approach
9	.Energy initiatives in workplaces .Energy initiatives applying collaborative and competitive approaches		How the Energy Tree as a motivational device, can be applied in different context	Association of the Energy Tree with a collective knowledge building tool	Impact of the online debate, the Energy Tree, Energy monitors in raising awareness

Chapter 2

Making Sense of the Affordance Concept in the 3rd HCI Paradigm[1]

2.1 Introduction

The field of Human Computer Interaction (HCI) has developed along its last 30 years motivated by the need of understanding our relationship with computers and artefacts of technology in general. This relationship has changed dramatically along that time, as a consequence of the technology design, which extrapolated the limits of work environments, now being part of our life in almost all aspects of it. As a consequence, mainstream concepts should be rethought, as user and technology are part of a larger system - or set of systems. This movement of understanding design as a systemic issue has raised several debates with implications on the fundamentals, methods and goals both for research and practice in the discipline.

As Sellen et al [144] suggest in redefining the "H", the "C", and the "I" in face of the transformations the field has passed through, several levels of interaction should be taken into account: interactions on and in the body, among people, between people and objects in the spaces of kiosks, rooms, buildings, streets and other public areas. Central to the understanding of interaction in all these levels are the physical and social "affordances" that technology can potentially enable.

Since that Norman [109] appropriated the concept of affordance from Gibson's definition [58] and applied it to the design of products and technologies, this concept has been transformed and has fed a debate about its meaning and use. This discussion originated a number of publications that explore the differences between approaches, such as Mc-

[1] **Article published as "Piccolo, L.S.G. Baranauskas, M.C.C. (2010) Making Sense of the Affordance Concept in the 3rd HCI Paradigm. *Proceedings of IADIS International Conference WWW/Internet 2010*, 183-191"**

Grenere & Ho [99] which compared Gibson's and Norman's concepts and expanded it in a framework, and O'Neill [110] which elucidated how Gibson's affordance works, aiming at emphasising what he considered some author's misappropriation of the original definition.

The purpose of this paper is not to create a new comparison, but to shed light on how this term has been transformed in keeping with the evolution in the way the human has been related to technology and the changes in the HCI field. It is organised as follows: Section 2 presents a panorama of HCI evolution through the three paradigms and relates it to the transformations of the concept of affordance. Section 3 discusses four different categories of affordance considered in an observational study, described in Section 4. Discussion on results is presented in Section 5, and, Section 6 concludes and points out future works.

2.2 A Panorama of HCI Evolution

The HCI history has been reviewed through three main dominant paradigms built in continuous transitions, motivated by the technology available at the time, the influence from related science fields and models and theories used to explain those realities.

The relation between humans and computers started in the 60's, within the scenario provided by mainframes. As the computer graphics emerged, some usability requirements were recognised as necessary to improve the relationship of the computer with its many users [62]. This technical scenario had hardly changed in the 80's, when the Personal Computer was launched, bringing to HCI aspects of engineering associated with human factors. All this period constituted what Harrison et al [63] named the HCI **1st paradigm**, whose main goal was to optimize the fit between humans and machines, developing pragmatic solutions in coupling them.

In the 90's, computer networks and mobility were part of the technological domain, moving the focus to groups working together, which constituted the focus of a **2nd paradigm**. *"Theory focused on work settings and interaction within well-established communities of practice. Situated action, distributed cognition and activity theory were important sources of theoretical reflection, and concepts like context came into focus of the analysis and design of HCI. Rigid guidelines, formal methods, and systematic testing were mostly abandoned for proactive methods such as a variety of participatory design workshops, prototyping and contextual inquiries."* [20].

Many questions related to the 2nd paradigm, as well as its models and theories are still current issues in the HCI field, as Bødker argues in [20], while a **3rd paradigm** started to emerge: *"technology spreads from the workplace to our homes and everyday life and culture."* [62].

Current phenomena related to the use of technology are transforming the society: the

hyper-connectivity – by keeping people closer to the others, it may mobilize crowds in a global way; the techno-dependency in any kind of activity; the desire to be in touch and capture information about everything; and the creative engagement, building a society where everybody can be a content producer. People are increasingly appropriating new digital tools, including illiterate and impaired users [62].

Towards 2020, the technology will also be changing, according to ITEA [73]: proliferation of embedding technology in multiple devices; sensors as input; 3D or 4D as output; augmented (AR) and virtual reality (VR) applications; and physical machines sometimes replacing humans in interaction and decision making. Some consequences of these changes are that *"new elements of human life will be included in the human-computer interactions such as culture, emotion and experience."* [20] [63]. Emotions are going to be part of context or input [73]; meaning is already constructed collaboratively and interaction is influenced or perhaps even constructed by its varying physical and social situations [63].

In a different scientific research scenario, by the end of the 70's, the concept of affordance was created by Gibson [58], in his ecological theory of perception. Once it was applied to HCI, it has been transformed following the main trends represented by the three paradigms. Nowadays, the concept of affordance has been applied to other domains such as cognitive robotics, supporting strategies when robots are interacting with objects [156]. This evolution in the concept is represented in Table 2.1, which summarises the main changes in HCI field from the 70's to what has been expected by the year of 2020 in terms of technology available, construction of meaning, predominant influence from other fields, the main question that directs HCI researches, predominant models and theories.

Starting from the original definition of affordance, the next section describes some of the main authors' views of the concept to improve our understanding on the relationship between humans and computers.

2.3 Transformations on the Affordance Definition

Gibson [58] defined the concept of affordances in the ecological context to mean *"(. . .) a direct result of the relationship between the objective physical properties of the environment and the subjective experience of the perceiving actor within that environment"*. What we usually pay attention to is what an object affords us. Based upon Gestalt theories, Gibson states that affordances are perceived with no cognitive processing, and it is the highlight of his definition when comparing it to derived approaches.

According to Gibson [58], an affordance is unique for one person or animal, which makes it different from a simple physical measure that is an object property. Affordances are objective, real and physical in a way that *"the affordance of something does not change as the need of the observer changes"*; we do not need to classify and label things in order

Table 2.1: Synthesis of the evolution of HCI field and the concept of affordance

	60-70's	80's	90's	2000's	2010's ...
HCI Paradigm [63]	1st		2nd		3rd
Technology [62] [20] [73]	Mainframes	Personal computers	Networks	Mobility	Ubiquitous computing, Web 2.0, VR, AR, Interaction based on gestures, sensors, 3D
Construction of meaning [63]	Users were professionals	Pragmatic approach. Ignore it unless it causes a problem	Meaning interpretation in terms of information flows		It is the focus, constructed on the fly, collaboratively, different contexts. Machines replacing human
Predominant influence [63]	Non-functional requirements (e.g. usability)	Engineering Human Factors	Cognitive science		Embodied interaction, Meaning making
Main question	Computer graphics emerged	How to optimize user's interaction with the machine? [63][144]	How users might interact with each other? [62]		How to address human values into research and design? [62]
Models and Theories [63]	Systematic methods of testing		Situated action, Distributed cognition, Activity Theory, Ethno methodology, Qualitative approach, Action Theory		Emotion, Aesthetics, Pragmatic/cultural focus on experience
Concept of affordance	Ecological approach, independent of cognition [58]	Applied to design, part of perception [106]	Can be associated with perception [56]	Social affordance, cultural context [151]	Social signifier [109] Motivational affordance [171]

to perceive what they afford.

To O'Neill [110], *"Gibson is attempting to describe an affordance as an emergent property of the perceptual process consisting of the properties of the object itself and the perceptual capacities of the perceiver"*. Different layouts afford different behaviours for different animals; a terrestrial surface, for example, is climb-on-able, fall-off-able, get-underneath-able or bump-into-able relative to a specific animal.

Gibson also defined the term **social significance** to describe what one person affords to other: *"what other persons afford comprises the whole realm of social significance for human beings. We pay the closest attention to the optical and acoustic information that specifies what the other person is, invites, threatens, and does."* [58].

Many authors appropriated Gibson's original term for their own uses with significant differences in the conceptualisation. The next section briefly explains some different author's perspectives on the concept.

2.3.1 Affordances in design

When Norman first applied the concept of affordance in design, he stated that his conceptualisation *"refers to the perceived and actual properties of the thing"* [106]. Those properties determine how the thing could possibly be used. Taking advantage of it, no labels or instructions are needed. In 2004, Norman [108] proposed a distinction between **real affordances**, those related to the physical properties of the world – which is close to Gibson's definition – and **perceived affordances** which are subjective representations

in the mind.

To Norman, the computer system, with its keyboard, display screen, pointing device affords pointing, touching, looking, and clicking on every pixel of the display screen – that is the real or physical affordance. E.g.: Figure 2.1a a portable computer by Sony® that suggests movement and to handling with both hands.

All that the user interface designer has available in graphical, screen-based interfaces are related to perceived affordances [103]. Affordance is not the simple presence of an element on screen, but a suggestion or a clue about how to use it. Figure 2.1b illustrates a perceived affordance highlighting a donation button in a web interface. As Norman explains [109]: *"(. . .) To Gibson, affordances did not have to be perceivable or even knowable – they simply existed. When I introduced the term into design in 1988 I was referring to perceivable affordances. (. . .)."*. Other distinctions between these approaches are listed in Table 2.2 [99].

Table 2.2: Comparison of Gibson's x Norman's affordances

Gibson's Affordance	**Norman's affordance**
Offerings or action possibilities in the environment in relation to the action capabilities of an actor	Perceived properties that may or may not actually exist
	Suggestions or clues as to how to use the properties
Independent of the actor's experience, knowledge, culture, or ability to perceive	Can be dependent on the experience, knowledge, or culture of the actor
Existence is binary – it exists or it does not exist	Can make an action difficult or easy

Norman brought the concept to HCI in the transition of the 1st and 2nd paradigms, when the influence of human factors (and cognitive psychology) and the goal to fit the relationship between the human and computer were dominant. The example of Figure 2.1c shows that in the 3 rd paradigm, when technologies such as augmented and virtual reality are present, the distinction between physical and perceived affordances is not so clear anymore. In this example, an interface may be projected anywhere, but the affordance to touch the dial with one finger is preserved.

Since Norman's view, Hartson [64], Vyas et al. [165], Gaver [56], Stamper [151], Zhang [171] among others considered cognitive aspects in their understanding of affordance and continued to expand the concept including human aspects such as experience, knowledge, culture, and the social characteristic.

Gaver [56], for instance, proposes that a combination of affordance with the perceptual information a person has about it suggests potentials for action, making interaction easy

to learn and use. According to him, *"affordances are properties of the world that are compatible with and relevant for the actors' interaction, which, when perceptible, offer a link between the actors' perception and action."*. Figure 2.1d is an example of an affordance oriented by a particular situation: a washing machine was used to build a dog house, an unusual application that would hardly be afforded without an external motivation. Gaver's proposal is also in the transition between the 1st and 2nd paradigms, still applied to optimize the human–computer interaction.

(a) Physical affordance of a portable computer

(b) Perceived affordance: highlight of button (www.paypal.com)

(c) Ex. of a gesture and augmented reality UI [101]

(d) Example of specific perceived affordance [155]

Figure 2.1: Examples of affordance

After years of confusion and misuse of the term by designers as Norman himself states [107], in 2008 he suggested replacing affordance with the term signifier. He argues that *"the perceivable part of an affordance is a signifier, and if deliberately placed by a designer, it is a social signifier"* and asks to *"forget the term affordances: what people need, and what design must provide, are signifiers. Because most actions we do are social, the most important class of these are social signifiers. (...) Social signifiers replace affordances, for they are broader and richer, allowing for accidental signifiers as well as deliberate ones, and even for items that signify by their absence."*. To exemplify, Norman [109] describes the situation where the absence of people on a train platform may be a social signifier indicating that the train has already left. The social signifier includes culture and experiences, similarly to Stamper's social affordance idea.

2.3.2 Stamper's social affordance

To Stamper [154], *"All organisms, including human agents construct their perceptions of the only world they can know through their actions; they have to discover (or be taught, or inherit by instinct) what invariant repertoires of behaviour the world affords them (= the affordances); then they populate their reality with those affordances that help them to survive"*. Stamper associates the physical affordances with Gibson's definition – linked to properties of the physical environment. They are social in nature, because they are

dependent on the knowledge that has been built up and handed down from generation to generation in a society. **Social affordances** are repertories of behaviour tuned to the social environment, valid for a certain community, with a start and finish time, and a starting and finishing authority [57].

The photos in Figure 2.2 illustrate the idea of a social affordance. Once a person is seen pointing to a map as in Figure 2.2a, it is clear that this person is localising himself/herself or indicating to someone else a specific point in the map; on the other hand, when a person is pointing to a map with an electronic device (2.2b), it is not clear what the social affordance is while this behaviour is not part of the repertory of the community yet. In this specific situation, one could guess that he is taking a picture, but he could be (actually is) using an augmented reality application on the map.

(a) (b)

Figure 2.2: Social affordances in pointing to a map

Social affordance is also related to the idea of how an artefact can stimulate individual or group usage. Figure 2.3 is a picture of people using an augmented reality application, which displays on the mobile overlaid information related to the printed map. Morisson [102] compared this solution based on the physical map with another application running strictly on the electronic device and verified that the physical solution had a great potential to group people and to engage a collaborative work due to the social affordance of the big printed map.

Stamper's Social Affordance and Norman's Social signifiers appeared at different times, but both under the 2nd paradigm influence, when culture, context, experience and life in society started to be taken into consideration by HCI.

Figure 2.3: Collaborative use of an AR application

2.3.3 Affordances and motivation

Motivation is an important aspect of human being, when analysing perception and action; it explains what causes behaviour and why behaviour varies in its intensity [171]. Considering that, Zhang [171] suggested the term motivational affordance that comprises the properties of an object that determine whether and how it can support one's motivational needs. She classified some of the most important human's motivational sources and needs to be considered in design to evoke motivational affordances: a) Psychological and social needs: autonomy and the self, which refers to the representation of self-identity; relatedness, leadership and followship, considering social and community life. b) Cognitive motives (beliefs and expectations): in respect to the user's competence and opportunities for achievement. c) Affects and emotions, which orchestrate human reaction.

The Piano Stair [163] shown in Figure 2.4 is an example of exploring humans' motivation to stimulate a behaviour. By playing sounds like piano keys, people feel invited to create their own song, which involves challenge, identity and also social interaction. These features attract people to choose this stair instead of the escalator most of the times.

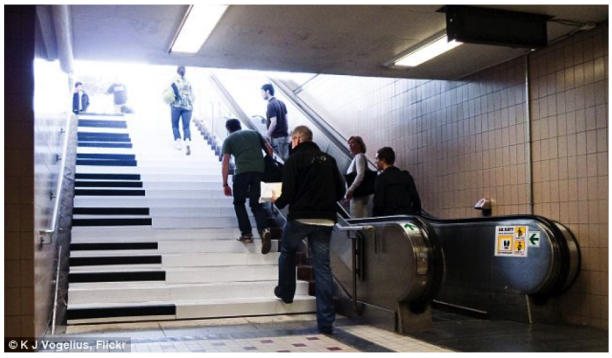

Figure 2.4: Motivational affordances in the Piano stair

Involving social, cultural and personal aspects together with affect on interaction, Zhang's definition of affordance goes beyond the 2nd paradigm, and may be important to address concepts related to the 3rd paradigm.

2.3.4 Relating different approaches

Gibson [58] first defined affordance as a property of the relationship between the actor and the object. Gaver [56] concurs with it, but he disconnects affordances from the perceptual information the person has about them. Both Norman [109], with his concept of physical and perceived affordance, and Zhang [171], consider affordances as properties of the object. To Stamper [151] and Norman, with his concept of social signifier [109], the social affordances are part of the culture of a society.

Aiming at understanding how these different concepts may be useful in design and taking into account the current HCI needs and paradigms, an observational study was conducted as described in the next section.

2.4 An Exploratory Study on Affordance

As part of an activity in an HCI class, 26 subjects were invited to identify the affordances of two different artefacts: a Tablet-PC (in tablet mode) and the Apple iPad®, both known but still uncommon artefacts. The study happened few days after the launch day of the iPad in the United States, providing a single opportunity to observe the first time interaction with the device. The students were already familiar with Norman's and Gibson's concept of affordance.

The classroom was split into 2 groups: the first one with 14 students analysed the iPad first; and the second group with 12 students analysed first the Tablet-PC.

Both groups first explored individually the artefact, passing it to each other in the same group; then they were asked to write down an adjective that expressed their first impression about the artefact. The first impressions were collected only for the first analysed device to avoid a comparative opinion. After exploring the first device they interact with, they were asked to identify affordances classifying them according to the criteria described in Table 2.3. In the second moment, they changed the devices to repeat the analysis and to identify affordances of the second artefact.

Table 2.3: Criteria to observe the four types of affordances

Type of affordance	Criteria to observe
Physical	Physical properties of the object
Perceived	Mental representation, design
Social	Related to life in society
Motivational	Satisfaction of motivational needs: autonomy, identity, challenge, feedback, social relations, to influence and to be influenced by someone, emotions.

2.4.1 Preliminary results

The identified affordances of both groups were compiled according to its category. A summary of the most frequent mentions is presented in Table 2.4 ordered by number of occurrence and illustrated in Figure 2.5. Negative aspects are preceded by the symbol (-).

Clearly, the students considered other devices as reference in their first interaction. Both artefacts were compared with a traditional Laptop ou PC ([1]) and the iPad with a mobile phone ([2]) – referred to as "a big iPhone" by some students – on identifying affordances and also on declaring their first impressions (i.e., big, light and agile for the iPad and heavy, malleable, and flexible for the Tablet-PC).

The interaction with the iPad created expectations and curiosity. It may explain why the iPad had a stronger influence in the Tablet PC analysis than the opposite ([3]). Some affordances of the Tablet-PC were observed to be more frequent when the iPad was analysed first. This fact, in addition to the number of identified affordances of the Tablet-PC that explicitly compared it with the iPad, was not noticed on the iPad analysis when the Tablet-PC was analysed first.

The novelty aspect of iPad was predominant in declaring the first impressions of it, and most adjectives could be classified as motivational or social (strange, stylish, fresh, modern, discovery, motivating, funny). It is interesting to notice that the novelty sometimes was referred to as "strangeness", which can be explained by the fact that both artefacts were taken as a working tool by some participants([4]). False affordances are the represented by ([5]).

Table 2.4: Summary of identified affordances

Affordance	iPad	Tablet pc
Physical	Touch screen (Fig 2.5a) Hold with both hands (Fig 2.5b) Fragile, Weight that suggests strength/value/complexity Look for buttons[1], Handwriting, Big[2] Button: sensor or press? (Fig 2.5c) Different[1,2]	Pen, on table using[3] (Fig 2.5d), Heavy[3] Swivel screen. Like a laptop[1] Excessive number of buttons[3] Drawing (Fig 2.5e), Less light and practical than iPad[3] Save space hiding the keyboard[1] Cannot be used like a book or notebook[3]
Perceived	Apple's mental model Unique button (Fig 2.5c) Inviting icons (Fig 2.5f) Lack of information[1] More options than iPhone because it is bigger Missing references or interaction standards[1,2] Feedback of movements, Look for a keyboard[1] Photos (Fig 2.5g)	Keyboard/touchpad[1] (Fig 2.5e) Size of icons does not suggest Touch screen[1], Notes in presentations[4] Screen swivel only to one side (Fig 2.5h) Work[4] Cannot be touched with another objects (Fig 2.5i) Less strange compared with PCs[3]
Social	Multiple users Symbol of social status (and segregation) More powerful than iPhone[2] and more restrictive than a PC[1], Inhibitor to be used on public (fear of being stolen) Screen rotation to share content (like a paper) (Fig 2.5b) Share personal stuff (Fig 2.5g).	Using in classroom[4] Its physical aspects do not invite to a shared interaction although it is bigger than iPad[3] Swivel, Screen allows to share information (Fig 2.5h) Experience with pen and touch screen Can be touched by multiple users (Fig 2.5j) Work/study[4] Photos/videos/music like iPad[3]
Motivational	(-)Indifference, Portable[1], Toy Novelty, Apple's prestige (-)Missing control of applications and operating system[1,4] Challenging when discovering its functionalities Motivates touchscreen (Fig 2.5f) Showing personal stuff (Fig 2.5g) (-)Limited to some tasks[1] (-)No software to communicate[2]	Good to draw (Fig 2.5e), Work activities[4] (-)Artificial writing (-)Frustration: it's not possible to use on the table as a tablet because the angle of view A little bit more than a laptop[1] Touch screen makes it different[1] Pen attracts curiosity[1], Fragile (-) No-Linux friendly[1] Good to avoid repetitive stress injury[1,4]

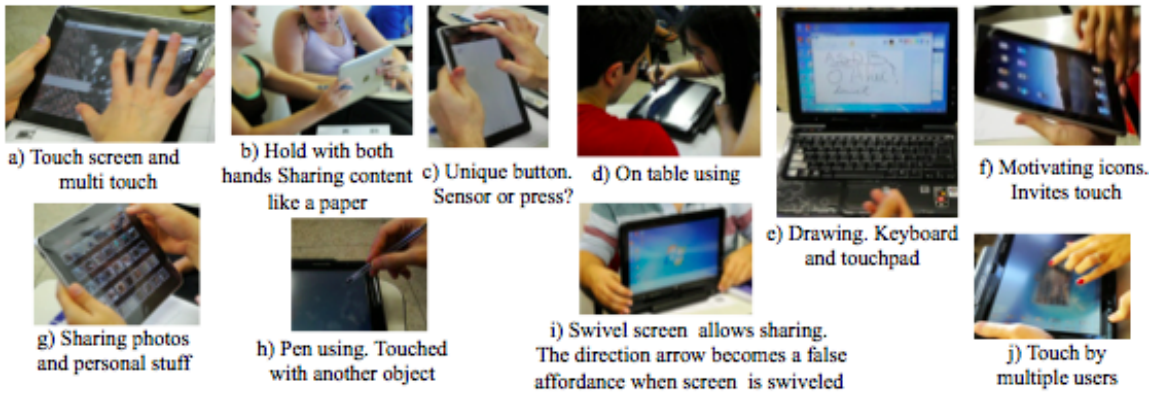

Figure 2.5: Examples of identified affordances in the exploratory study

2.4.2 Discussion

Although they have some similarities, such as the multi-touch mechanism, these artefacts have completely different purpose: the tablet-PC is a laptop with some drawing functionality, while the iPad is neither a laptop nor a mobile phone, it has a new concept originally designed for ebook reading and experiencing the Web.

This physical affordance of the iPad clearly influenced the identification of the perceived and motivational affordances (which includes expectations): because it is bigger

than the iPhone, people tend to expect more features on it − considered a motivational affordance in a negative way. On the other hand, the aesthetic of iPad was the first most present positive motivational affordance and the natural interaction (feedback of movement) observed in the perceived affordances also influenced the motivational aspects.

The Tablet PC was more associated to their pen based experience (from drawing and writing on paper). Seen as a working tool, it was referred to as "a laptop with something else". Although considered heavy also on first impressions declarations, aspects of fragility appeared as physical affordances. Physical aspects created limitations on social affordances: even being bigger than the iPad, it does not suggest sharing interaction, mainly because of the angle of screen viewing that is restrictive. The size of icons suggested the use of the pen in the laptop mode (instead of tablet mode) on perceived affordances. The subjects also considered it "less strange than the iPad" taking into account its similarity with a tradicional laptop.

The social affordance of iPad was mostly associated with the brand and social status. Some physical aspects reinforce the idea of a valuable device. Recent phenomena like hyper-connectivity and techno-dependency, which can be still more present into the group of participants − Computer Science students −, were taken into account on social affordance and, once again, reflected on motivational affordances.

Besides drawing, the tablet's social and motivational affordances are repeatedly related to its formal and work-related uses in classrooms, presentations and in taking notes. Relating it with the declared first impressions, the device can be seen as a more versatile laptop.

The identified motivational affordances suggested that this concept should not be taken in isolation; it may have direct consequences of the other three concepts of affordance, as exemplified below:

- Physical: related to attractiveness and affection. Aesthetic, flexibility, portability (weight and size);
- Perceived: associated to challenging, feedback: Invitation to use touch screen (or the pen), natural interaction, friendly user interface;
- Social: related to identity, autonomy and social relations: prestige associated to the device or the brand, identification of being a technical or digital arts working tool, sharing or not information.

The current trends like using portable devices and ubiquitous technologies highlights the importance of physical affordances that the desktops do not have. Aspects like how to handle, carry or manipulate artefacts are critical to the technology acceptation and appropriation. The iPhone 4® is an example of the importance to consider the physical

affordance on design process. Holding the iPhone at the bottom left-hand corner causes signal reception problem. This constraint frustrated users and compelled Apple to offer a special case and to advise users to hold it in a different way.

According to this analysis, the four different views of affordances were seen as important and complementary to understand and evaluate the first impression a person may have on exploring a new technology. Physical and social affordances are central to understand the main aspects that were noticed and perceived by the person, and as Sellen [144] states, to understand several levels of interactions. The perceived affordance is a warranty of understandability of the user interface. And the motivational affordances can help aggregating them, making it possible to understand how these affordances can contribute to interaction being part of each person's motivations and social interaction in the 3rd paradigm.

2.5 Conclusion and Future Work

The 3rd HCI paradigm brings a set of new challenges to the field, such as aggregating human values to the user interface, but some aspects of the 1st and 2nd paradigms still need to be considered when designing interactions. The perceived affordance is strongly related to some aspects of the 1st and 2nd HCI paradigms that must be preserved in designing interaction that makes sense to its target audience, creating technologies that are easy to use and easy to learn. The concept of motivational affordance seems to be suitable to the 3rd HCI paradigm, once it is associated with human values and their desires and concerns, in a social, economic, and political ecology [144].

The concept of affordance has been applied to the interaction design in different ways since Norman's first appropriation, and it has been transformed according to the technical and social contexts of using technology in daily life. The observational study made it clear that different views of affordance may co-exist, such as physical, perceived, social, and motivational affordances, and their correlation can be especially useful to understand how the main aspects of a technology can be associated to each human's motivation, an important mechanisms that drives humans' choices.

In continuity to this work, we intend to focus on motivational affordances, the way they correlate to the others, how they might explain humans' affective reactions, impacting on interface design and evaluation.

Chapter 3

Basis and Prospects of Motivation Informing Design: Requirements for Situated Eco-feedback Technology [1]

3.1 Introduction

Motivation theories have the purpose of explaining why people show great effort and persistence (or none at all) on doing things. In the context of digital systems, motivation can be understood based on Reeve's [135] as an internal force that gives energy and direction to the interaction. In this sense, motivation could be evoked by the system, changing the user experience and, in a broader sense, potentially impacting the user's attitude and behaviour in society.

Why focus on motivation? Results of an e-government prototype evaluation for interactive TV made us realize the importance of the user's motivation in the acceptance of technology, especially for those unfamiliar with it. That study aimed at understanding how first-time users made sense and might interact with this new media in Brazil [128]. The prototype provided a communication channel allowing people to write text messages to the city mayor. The typing times and users' spontaneous interest on using the functionality were measured and we expected to confirm the hypothesis that text input in the remote control is not adequate and should be avoided in interactive TV. Contrarily to the expectations, we observed that an external reason – people were particularly unsatisfied with the current political scenario and especially with the mayor – strengthened the

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participant's motivation to interact and changed the affective relation of the user with that artefact. Despite the difficulty of inputting text – the average time for typing each character was 7,4s – a significant number of participants considered that the possibility of expressing their feelings to the mayor would compensate the effort: *"As the goal is important, there is no discomfort"* [128], mentioned a participant, even being informed that the prototype actually would not send the message to the mayor. This is suggestive of the relation the user's motivation with other topics of the Human-Computer Interaction (HCI) discipline, such as the affective quality of user interfaces and traditional usability requirements.

Besides an indication that this subject should be better investigated, as also stated by [171] and [157], this is also an opportunity to rethink mainstream concepts of the HCI field, taking into consideration the user as a "complete being" [119], which requires new elements of human life [63], aligned with the 3rd HCI paradigm that regards technology as part of our life in almost all aspects [20].

This work aims at shedding light on considerations of motivational aspects in the design of interactive products, taking into account intrinsic and extrinsic motivations, as aspects influenced by culture. We situate the study within an energy provider company research and development project, which intends to optimize the way electricity is distributed and consumed by households in Brazil, investigating the following questions:

- How to consider people's intrinsic motivations for adopting a technology that intends to promote a behaviour change?
- How to consider cultural aspects that generate extrinsic motivations, which may influence the technology adoption and usage?
- How to identify and propose design requirements to address these mentioned motivational aspects?

The study is instantiated in eco-feedback technology, an emerging area of interest within HCI community [52], more specifically Residential Energy Feedback Systems (REFS) [132]. By feeding information about electricity consumption and educating people via interactive TV, mobile devices and the Web, this technology aims at changing the way people relate to energy, as a motion of social change. The scenario encompasses a diversity of experiences the participants in the study have in terms of culture, education, and technology usage, including people not familiar with interactive systems.

Although addressing motivation in design is a recent initiative in the HCI domain, we understand that this approach brings to light essential information when the purpose is to introduce and to evaluate technology that intends to change attitudes by developing a conscious behaviour of deeply absorbed and culturally-influenced habits of everyday life.

By considering motivational issues in design, we would be able to provide a better fit of REFS with people within their surroundings.

The paper is organised as follows: The next section presents the theoretical background, looking closer to the Self-Determination Theory. In the sequence we present an overview of motivation models applied to HCI, including some motivational approaches in the design of REFS. The following sections present a preliminary analysis about motivation in our study scenario and, based on the analysis results, we suggest requirements to the design of REFS. The last section concludes.

3.2 Motivation: a Conceptual Background

Along the history, motivation studies changed radically from a philosophical beginning focused on the will, passing through grand theories with a biological conceptualisation. Differently, the current approach is based on a number of different theoretical views concerned with the direction of behaviour by a multitude of co-acting influences, including social aspects and the interaction with the environment [135]. Consequently, this literature is fragmented and non-consensual, making it difficult to apply in the design domain [65]. Among the most referenced theories of motivation are:

- The Achievement Motivation Theory [98]: it envisages that people have, in different degrees, a need for achievement, for power and for affiliation. This theory is usually applied to management contexts, to motivate employees.

- Flow Theory [30]: flow is defined as a mental state in which people are so involved in an activity that nothing else seems to matter. It requires a perfect balance between challenge and the person's skills, and also immediate and clear feedback. This theory has been applied mainly to the educational context.

- The Maslow's Need Hierarchic Theory [97]: it establishes an order of importance for human needs in a pyramid which starts from physiological needs in the base, passing through psychological needs – safety and security, social, self-esteem –, until the self-actualisation, the top of the pyramid representing a person's full potential and the desire to become what one is capable of becoming. Although there is few empirical support to the needs hierarchy, this theory has been adopted as a modus operandi in education, business, management, psychotherapy [135], with some applications in the marketing domain and in technology, such as Duval et al in [43].

- The Self-Determination Theory (SDT) [35][36]: a meta-theory for framing motivational studies. It defines intrinsic and extrinsic sources of motivation and their

roles in cognitive and social development, focusing on how social and cultural factors facilitate or undermine people's resolution and initiative towards behaviour. Autonomy, competence and relatedness are important aspects of the framework to foster well-being. It has been applied in several domains, such as education, sports, health, relationships, etc., including the motivational design of ICTs, as will be described in the next section.

To build a deeper and broader view of the concept of motivation, we start from the physiological model by Lindsay and Norman [89] originated in cognitive psychology, and then analyse Reeve's framework [135] that is based on SDT. By aggregating important aspects of several fundamental theories of motivation [135][35][36], and focusing on how social and cultural factors facilitate or undermine people's initiative towards a behaviour, SDT seems to be a promising theoretical frame of reference to our aims.

3.2.1 The physiological basis: brain mechanisms and the emotion arousal

In their explanations on the brain mechanisms of motivation, Lindsay and Norman [89] show that the study of biological motives involves systems for which the chemical state of the body is one of the most important inputs. They propose a model that describes the logical mechanisms involved in a motivational control system. The general function of a motivational control system is to regulate the availability of chemical substances, which make up the biochemical state of the organism. Although the model is an extreme simplification of real motivational processes, it organizes, around few components, initial thinking on how motivational control processes might work. According to this model, motivational control systems operate through a combination of neural and chemical mechanisms that monitor the overall performance of the animal and regulate his internal reserves. The types of response produced by the organism will depend on the response repertoire of the animal and the environment in which it finds itself. This is the point at which motivational factors interact with learning experiences. Thus, there are also many non-biochemical factors that enter into the system and must be considered.

This model is consistent with the Human Information Processing paradigm, in which an organism, be it human or nonhuman, acts as if it had an internal model against which to compare the events of the external world. For Lindsay and Norman [89], emotions and arousal result from the inadequacies of the model when the predictive apparatus fails; memory and cognitive factors are intimately interlinked with the motives that underlie human behaviour. In this model, the components work in both directions: the cognitive aspect of fear, for example, can cause biochemical (hormonal) effect on the body and the

inflow of hormones can lead to fear; cognition and emotion are intimately intermingled with each other.

Summarising, all motivational systems monitor biochemical and neural states. The cognitive system can control biological emotional processes and, similarly, the biochemical system can control actions, constituting a circular feedback control system. If actions are not going well, the cognitive system is likely to make chemical stimulation (e.g. it may shoot adrenaline into the system) and the human might notice the physiological changes occurring (e.g. increased heart rate, sweating).

3.2.2 SDT and Reeve's framework

According to Reeve [135], a motive status is influenced by an antecedent condition and can be triggered by one's needs, cognition, emotion, or also – initially exerting less energy – by external motives. This status creates a sense of "wanting to" (or not wanting to) and the urge to move toward and engage (approach) or, in a negative sense, to escape from and disengage (avoid). This process is biologically controlled as described previously. Behaviour and engagement are expressions of the motivation.

A central concept to understand motivation according to the SDT [135][35] and to make sense of this model in the HCI domain is the **Person-Environment Dialectic**. The relationship between a person and the environment is bidirectional, and both are constantly changing each other. Psychological needs, interests and values stimulate the individual to engage in activities and to be connected with social groups. On the other hand, environmental events affect the individual by offering challenges and interesting things to do, providing feedback, imposing goals, and containing relationships that support (or frustrate) the psychological needs and necessary features for the person's development. In other words, a person's arousal level varies as a function of how stimulating the environment is and people engagement increases or decreases the level of arousal.

Thus, the environment, the individual, and the relation between them – the person-environment dialectic – have elements that need to be considered to promote a motivating interaction. To get the whole picture, in Figure 3.1 we represent some relevant concepts to HCI based on to Reeve's [135] model.

There are three sources of motivation: the Quasi-needs, in the context of the Person-Environment Dialect, Extrinsic motivation in the environment, and those motivations intrinsically generated. Emotions, Cognitions, and Needs are types of Intrinsic motivations. Emotions are preceded by appraisal. Cognition encompasses the individual's Expectations, Self-efficacy and the Self, which is associated to one's identity. Needs can be Physiological, Psychological, or Social. Autonomy, Competence and Relatedness are psychological needs, the most important needs to lead the well-being. Affiliation, Power,

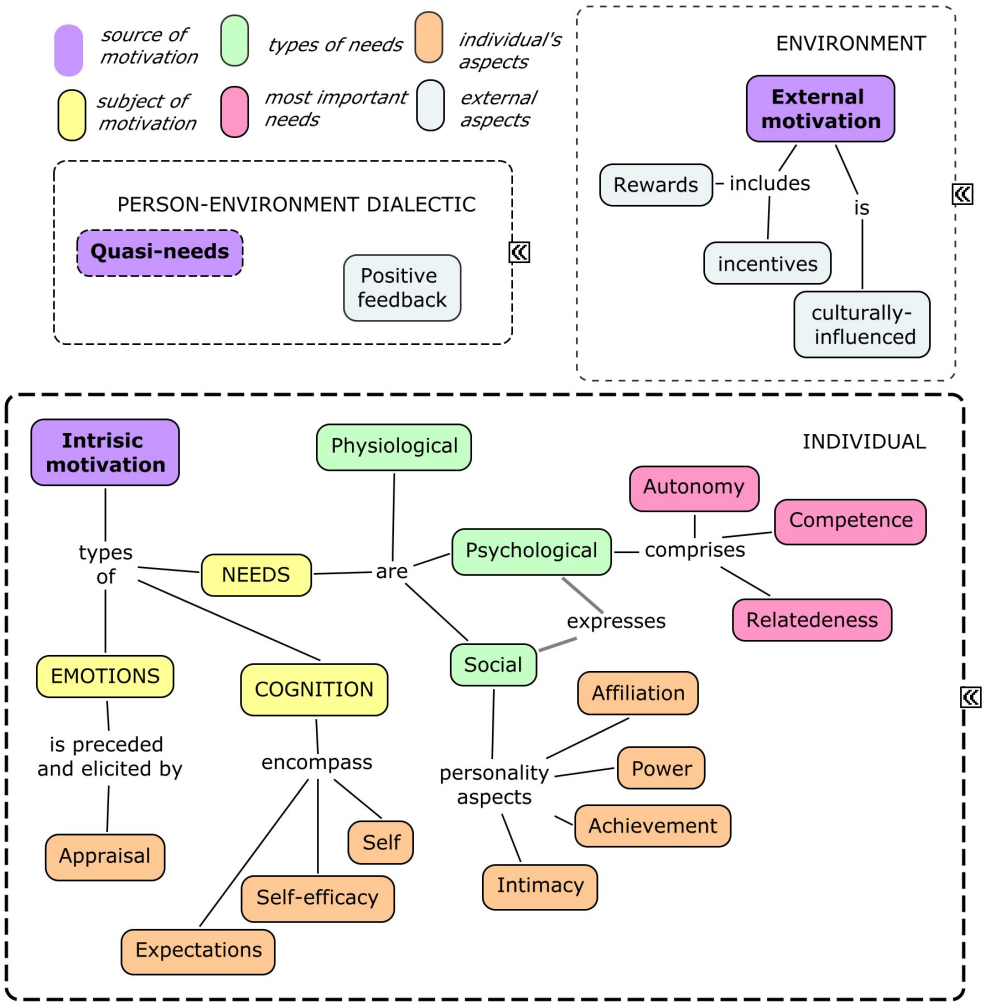


Figure 3.1: Conceptual map related to motivation

Achievements, and Intimacy, are personal aspects that affects how a person interacts with the environment.

Quasi-needs are a source of motivation, although not so strong, meaning a social force that affects how we think, feel and act, changing the behaviour to meet a specific demand from the environment, which persists until the need is satisfied. This concept explains why people may adopt or make an effort to use a digital system to solve a specific practical problem, for example. The positive feedback interacting with the environment, or with a technology, for instance, is important to promote the motivation triggered by a quasi-need.

Extrinsic motivation arises from the environment. It is influenced by culture and refers to doing something because it results in incentives or rewards. It is not a strong force. Some authors argue that extrinsic rewards may even undermine intrinsic motivation

in some situations [81][111].

The **Intrinsic motivation** is the strongest force to drive a behaviour – more than pursuing extrinsic goals or responding to external pressures – resulting in persistent improvement, high-quality learning, creativity and consequently higher well-being. They refer to doing something because it is inherently interesting, or enjoyable. Emotions, Cognitions and Needs are types of Intrinsic Motivation:

Emotions emerge from information processing, social interactions and cultural contexts. Appraisal is a central concept in the cognition-emotion relation. It consists on an estimate of the personal significance of an event – "Is this event significant?" "Does this event have implications for my well-being?" – Once appraisals precede and elicit emotions, changes in the appraisal modify the emotion and, consequently, the perception of the affective quality of a system.

Cognition is another source of motive that directs the behaviour. It bands together beliefs, expectations, goals, plans, judgment, values and the self-concept. We are motivated by our expectancies. Related to esteem, both efficacy ("can I do it?") and outcome ("will it work?") expectations must be reasonably high before behaviour becomes energetic and goal directed. Other relevant aspects of cognition in this context are concepts of self-efficacy and the self:

- **Self-efficacy** is a person's judgment of how one will cope with a situation, considering the person's skills and the circumstances. It is affected by the physiological state, the personal history, observations of others who also try to execute the behaviour and verbal persuasions. It differs from the psychological need for competence, as it is specific for a situation and regulated during the interaction process. It is an important concept related to achieve an user's behaviour change.

- The **Self** reflects how people mentally represent their personal characteristics. Energy for confirming and regulating the self-view and for relating it to the society generates motivation. A person's identity captures the essence of the self in the cultural context, so that when people act in line with their identity, social interactions flow smoothly. Similarly, the congruence between one's self and goals enhances effort to potential need-satisfying experiences and well-being. Self is also related to the desire to pursue a cognition determined goal: self-concordant goals are embedded in a context of positive affect and "wanting to", while self-discordant goals emanate out a sense of pressure, in which the personal effort is based on an obligation to others.

Needs are essential conditions for the maintenance of life. Satisfying a need leads to a state of well-being, in other words, to positive affect. It can be physiological, psychological

or social, the last culturally influenced. Physiological needs drive human's behaviour and includes hunger, thirst and sex. At first, these needs do not seem related to HCI, but statistics about Internet access, for example, show that almost 30.000 people access pornography per second [111]. The psychological needs are the most important sources of motivation:

- **Autonomy** is the psychological need that plays the main role in a motivating interaction with the environment, internalising external motivations. A behaviour is said to be autonomous (or self-determined) when one's interests, preferences and wants guide the decision to act; on the contrary, it is determined by others when an outside force pushes the person to think, feel, or behave in a particular way. The degree of autonomy determines how motivated a person is – the more autonomous, the more motivated the person could be. Taking the example of why a person would be concerned with saving energy: a completely externally motivated person would argue "to save money"; a somewhat externally regulated: "because I should, I am going to feel good about myself"; a somewhat internally regulated: "because it's important for the environment" and, finally, a personal commitment, or autonomous and internalised motive: "because it reflects and expresses who I am and what I believe (my values)". To internalise a value or behaviour, the person needs to make sense of why the value or way of acting has merit.

- **Competence** is another psychological need that reflects our interest in applying and developing our skill in performing a task. In line with the Flow Theory [12], it implies offering an optimum challenge according to the person's skills, and requires rewards, communications, and positive feedback to satisfy the need; but in order to enhance intrinsic motivation, competence needs to be accompanied by a sense of autonomy.

- **Relatedness** is the need to establish close emotional bonds with other people. Satisfying relatedness need goes beyond starting new relationships. We need to perceive that the other person cares about our welfare and that our "true-self" has been shown and has been considered relevant by the other. Thus, communal relationships, those between close friends, family, and romantic relationships satisfy the need, while exchange relationships, i.e., between people who do business together, do not. Relatedness may also be a reason to internalise extrinsically motivated behaviours since people are willing to have the behaviours valued as significant by others to whom they want to be connected, whether a family, a peer group, or a society.

Thus, a person's motivation cannot be separated from her/his social context. Characteristics of personality such as achievement, affiliation, intimacy, and power are naturally developed through social experiences that activate good emotional responses. Social needs come to light only when the opportunity of need-satisfying appears. So, the environment (or interaction) can support or undermine these social needs. They can be seen as the expression of psychological needs to the social context: achievement consists on doing something well to show competence; affiliation is the opportunity to please others and gain their approval, while power shows impact on others; and intimacy is the need to establish warm and secure relationships.

3.3 Motivation in HCI

Although it seems obvious to state that people use (or not) a technology because they have a main purpose, this main intrinsic reason has not been clarified and taken into account in designing digital systems, as pointed out by some works. In [43, p.399], the authors observe that *"systems exist for some physiological and safety needs but few - if any - satisfy self-esteem or self-actualisation needs although it would greatly benefit individuals and societies"*. Arguing that universal needs are ignored in this field, they brought to light the potential role of Maslow's hierarchy of needs [97] to ubiquitous computing.

Scialdone and Zhang [141] proposed a Motivation Model that took into account concepts of the Activity Theory [87], as well as concepts from law, HCI, information systems and psychology domains. The purpose of this model is to increase adoption and use of ICT by creating contexts that make one aware of wishes to fulfil psychological or biological needs. The authors analysed the motivation of a student who lives abroad for using a specific social network system, which was triggered by the relatedness need.

Targeting the satisfaction of people's motivational needs, Zhang [171][170] suggested the term **motivational affordance** to the properties of an object that determine whether and how it can support one's motivational needs. A set of motivational affordances comprises psychological, cognitive, social, and emotional needs. Aspects such as autonomy and the self, optimum challenge, feedback, facilitation of human bonds, the desire to be influenced and to influence others and emotions involved in the interaction are taken into account. Applying these affordances to design would attract the users to an object that raises the desire to use and adopt it.

Regarding a framework for design, Thew and Sutcliffe [157] are developing a method called VBRE − Value Based Requirements Elicitation, which draws attention to individual stakeholders' values, motivations and emotions in the Requirements Elicitation process. The framework is supported by a website with a list of motivations, values and emotions, and structured reflections about interviews, meetings and observations to

support the requirement analyst work.

3.3.1 Motivation and behaviour change

The study of how digital systems can be applied to change attitudes and behaviours in a persuasive way was named by Fogg as captology [48]. By considering how people are persuaded when interacting with computing, the design of persuasive technology intends to make desired outcomes easier to achieve. The persuasion strategy differs according to the role the technology plays: 1) as a tool: providing information for decision making, increasing self-efficacy and changing mental models; 2) as a medium: providing learning and understanding of cause-and-effect relationships by simulations, insightful visualisations and sensations; and 3) as social actor: establishing social norms and invoking social rules, by applying the same persuasion principles that people use to influence each other, such as rewarding, modelling a target behaviour or providing social support [48][49].

Although not much is found regarding motivational aspects in design, some recent works addressing them specifically in REFS design have appeared. The sustainability wave brought to HCI the need to connect technology to people's behaviours towards the environment, and motivational aspects started to appear in recent investigations related to the eco-feedback design.

He [65] proposed a motivational framework based on the Transtheoretical Model – TTM, or the "Stages of Change" Model [100]. It states that intentional behaviour change is a process occurring in a series of stages, rather than a single event, and motivation is required for the focus, effort and energy needed to move through the stages. The authors propose design strategies and recommendations to deal with individual motivations at each stage of behavioural change, but without considering social influences.

Scott et al [142] have applied the Goal Setting Theory [91] − according to the authors an established framework for understanding how to motivate behaviour change − to analyse how people decide to reduce energy consumption. That study evidenced that people had a poor understanding of how to set goals that have significant effect on energy consumption and preferred specific and contextual goals instead of generic ones. The authors argue that additional benefits will emerge through appropriately designed techniques based upon the theory.

Part of the same research group, Barreto et al. [13] applied the Social Translucence [45] − a way to design digital systems by making participants and their activities visible to one another − as a theoretical framework to investigate how eco-feedback interfaces can integrate with and support existing communication practices towards a consumption behaviour change in a family. They described an ethnographical study with 12 families in Portugal that revealed how they collectively interacted with the device and how

the information was applied to motivate discussions and make the family aware of their consumption behaviour.

Research results from US and UK evidenced the lack of motivation to change attitudes towards electricity consumption, even when fostered by technology. Discussing the ineffectiveness of REFS, Pierce et al [129] observed that minor inconveniences and discomforts, such as setting a different temperature for refrigerators or frequently turning off devices when they are not in use, prevent people of changing behaviour to save energy. Even when this motivation exists, it does not imply people will actually save energy, especially when acting against their comfort.

Kelsey and Gonzalez [80] observed the motivation for regulating energy usage in the UK and stated that monetary reasons usually are the main motive for people to save energy and adopt the technology, although many marketing campaigns to adopt the device emphasize the environmental impact. By observing the REFS adoption by 6 families, they noticed that the feedback the device provided was considered relevant to implement electricity usage regulations and it was valuable as an educational tool when integrated to existing domestic routines. However, the motivation to use the device was reduced over time and in the majority of cases, the interaction completely stopped in a period of weeks.

According to Shipworth's social study that investigated the change of behaviour on electricity consumption [145], the feeding of information has little impact because actions are also influenced by personalities, attitudes, income, attitude of their friends and associates, and by the community and culture(s). Money is a poor motivation that might even discourage actions to save energy in the long run. Some identified aspects that may explain that result include:

- Self-esteem: people may associate conserving energy with being poor, so positive connotation expressions, such as greenhouse action or energy efficiency, instead of "energy conservation" have better impact. Moreover people who grew up in poverty may feel better behaving as consumers.

- Choice & control: the concept of "locus of control" from psychology may inform how people see themselves in the control of their lives. People that have an "external locus of control" believe that actions of powerful others, such as God or government, create change. On the other hand, people with an "internal locus of control" believe in the consequence of their actions and are more likely to take environmental actions.

3.4 Understanding People's Motivation in Our Scenario

As part of a local energy provider Smart Grid program, a quantitative survey was conducted in the countryside of the Brazilian State of Minas Gerais to understand, among other issues, how an universe of 6000 consumers in that area relate with energy, with technology, and with the environment. The survey was set up to address the Smart Grid program [22]. For the energy company reasons, 280 participants' households were split into two samples of 140 households, according to their geographical region. This group constitutes the subjects in this study scenario. The 280 subjects responsible for the energy bill at the household answered a structured interview. Among other questions, they were asked what would be the main reasons (two at most) for them to save energy. The spontaneous resultant answers were:

- 58,20% to save some extra money;
- 15,88% to preserve the environment;
- 14,02% to afford the bill;
- 5,82% to avoid a system blackout;
- 3,44% to consequently save water;
- 1,32% to be considered a good example for kids;
- 1,32% other different answers.

Then, they were asked to choose 2 statements among 5 that better represented their thoughts about saving energy; results of their choices are described in Table 3.1.

Table 3.1: Participants' choice about statements that better express their mind about saving energy

	Statement "I would save energy to. . . "	**% of the answers**
1	have some remaining money in the month	37,45
2	preserve the environment	30,73
3	afford the bill	20,36
4	be considered as a good example	9,64
5	feel him/herself a better person	1,82

Analysed separately, the two groups of participants had differences regarding education, familiar income, relationship with neighbourhood, and technology usage. Group A

is geographically concentrated in the urban area of a city with more than 200.000 inhabitants, and Group B encompasses also households from smaller cities or surrounding villages.

As illustrated in Table 3.2, Group B, with considerable lower income and lower educational level, prioritised the desire to afford the bill instead of the environment preservation, suggesting a correlation between environmental concern and socioeconomic aspects. Other relevant differences are related to how much they know about their neighbours and their Internet usage.

Table 3.2: Significant differences between groups

	Group A	**Group B**
afford the bill as reason to save energy	9,7%	31%
preserve the environment as a reason to save energy	41%	20%
know well the neighbourhood	55%	82,3%
are Internet users	50,7%	27,9%

Extrinsic motivations represent the main declared reason for people to save energy also in our scenario – around 72% of the answers. For a consumer in bad condition regarding debt, affording the bill may be considered a quasi-need, another weak motivation. Feeling a better person or being considered as good example for others are answers that could represent some degree of autonomy; the number of answers was not significant as presented in Table 3.1.

The environment may be considered the most evident connection to evoke an intrinsic motivation. However, the answers to the question "how do you think that saving energy could contribute to the environment?" revealed that the link between electricity consumption and the environment is not part of their common sense, suggesting that this motivation may not be enough to change behaviour in the first moment: 49% declared to not know the answer; only 20% associated to the new power plant construction; 11% related to forests and rivers, and 19% made far associations with other issues of the Brazilian context, such as water consumption or air pollution. When asked about actions they usually make to preserve the environment, the answers do not suggest a consensual concern. The three most frequent spontaneous answers were: waste recycling (33%), not throwing trash on the ground (20%), and saving water (15%). Among those who declared the environmental motivation, the most frequent answer was "not throwing trash on the ground", reinforcing that the motivation may not be strong enough to change unconscious habits such as the electricity consumption. These results made clear that environmental motivation must be widely worked in our scenario.

Complementing this quantitative view, previous work considering sociocultural issues [125] identified a set of electricity consumers' profiles as described in Table 3.3.

Table 3.3: Users' profiles regarding motivation

Extrinsic motivation	MMON: Mindful about energy consumption for saving money. To be considered a motivation indeed, the amount of saved money has to be enough to compensate the discomfort for saving. People who receive governmental social benefits are example due to the considerable discount they get in the bill consuming below a target.
Quasi-need	DEB: Debtor that must be aware of the consumption to afford the bill payment. Their motivation is not the energy consumption indeed, but to the money they do not have.
"Intrinsic" motivation	MENV: Consumers mindful for environmental issues. Besides individual interests, this profile wants to conserve natural resources, according to their values. However, the quantitative survey evidenced the need for education and development of environmental values, since this motivation is not consensual in our scenario. Those people who really have this intrinsic environmental motivation are important to influence others and to spread this value into the culture.
Intrinsic motivation (well-being)	IND: Indifferent. People who are not concerned with the money they spend on energy bills neither with the natural environment. Usually they believe that the comfort the energy provides is worth the money and do not want to worry about that. This kind of motivation is in fact a strong force in the opposite direction from the REFS proposal.
No identified motivation	FPL: Fraud for paying less. Official customers that make a fraud for paying less than the real consumption. Cultural reasons and impunity make them believe that they would never be caught. Usually spend too much energy.
	ILC: Completely illegal costumer. Both for cultural ("everybody does") or urbanistic reasons, sometimes this kind of fraudster is not completely aware of the criminal attitude and just need a good opportunity to be educated and regularize their connection. Usually spend too much electricity since they do not pay for it.

The importance of extrinsic aspects and also of quasi-needs cannot be neglected as a starting motivation, especially in the scenario under consideration, where the intrinsic motivation is almost inexistent. To transform an extrinsic motivation into an intrinsic one, it is necessary to develop a sense of autonomy [135]. As a first step, by improving the Self-efficacy, the design must consider people's culture in such way users make sense of the value of individual attitudes that have been promoted and conclude by themselves that using technology and changing habits are worthwhile.

Nevertheless, people declared they are interested in learning how to make a more adequate consume of energy (98%); they would like to share with others their achievements on saving (95%), and stated that they already had some habits for saving energy (95%), such as adopting energy saving lamps (90%); but, clearly, they do not know the consequences of individual behaviour, for instance, the impact of the hot showers costs in the households to the monthly bill (81% got surprised when informed about the value).

3.5 Motivation Informing the REFS Design

How Cognition, Emotion, and Needs could foster the user's motivation in our scenario? How to inspire (with technology design) those who are not motivated towards environment issues? How to enhance the existing motivations?

By provoking individual attitudes and providing an autonomous interaction with technology we intend to promote the Self-efficacy, a Cognitive aspect. Emotion is related to the user's interfaces affective quality, expressed in the SDT model as the concept of Appraisal.

Psychological Needs must be fulfilled to promote users' interest in using technology in a scenario such as the considered. Social Needs may also promote some kind of motivation associated with the interest for the environment (ex: sharing information and individuals achievements potentially promotes affiliation, power, achievement personality aspects).

In our previous work [125], we defined a preliminary set of design requirements for REFS, inspired by the design strategies proposed by [129], aiming at setting out conditions to promote a behaviour change.

These requirements are now analysed from a motivational perspective based on the SDT: Autonomy, Competence, and Relatedness − the three main Needs that contributes to the well-being −, drove our analysis; new requirements were established extending the initial setting and categorised based on theoretical background of Motivation theories, as follows:

i) Exploring Autonomy and Competence needs with an inclusive purpose Considering that Self-efficacy when using technology is usually underestimated by the unsophisticated users, developing features that satisfy their competence needs is crucial in this scenario where technology is still not part of everyone's daily life. Offering options for customising screens or adding assistive technologies when necessary are mechanisms that may improve the autonomy especially for people with disabilities or first-time users that depend on other people to interact with digital systems.

Table 3.4 describes the design requirements that aim at fitting the information presented by a REFS to the user's needs and abilities. The most benefitted user profiles

for each requirement are identified. As the purpose here is to build an inclusive solution, most of the identified design requirements benefit all users' profiles.

Table 3.4: Design requirements regarding Autonomy and Competence with an inclusive purpose

Design requirements regarding Autonomy and Competence	**MMO**	**DEB**	**MENV**	**IND**	**ILC**	**FPL**
Show the current level of consumptions in an attractive way (good affective quality of the device), exploring different sensations such as colours and sounds	X	X	X	X	X	X
Show the current level of consumptions in a customisable way, fitting the users' system configuration	X	X	X	X		
When showing the current level of consumption, invite the user to interact with the device	X	X	X	X	X	X
Make it possible to execute assistive technology when necessary	X	X	X	X		X
Show consumption in different ways: money, relation with environment, kWh	X		X			
Apply metaphors contextualised in user's environment to relate the energy consumptions with the impact (positive and negative) to the environment	X	X	X	X	X	X
Fit the consumption information (level of details) and look-and-feel to explore the strength of the device (Web, interactive TV, smartphone), considering the screen size and interaction models	X	X	X	X	X	X
Keep the consistence between the user interfaces of different devices	X	X	X	X	X	X

ii) Improving Self-Efficacy, Autonomy and avoiding Control

To provide autonomy, it is important to take the user's perspective and values, to create growth opportunities, such as encouragements, and also to change the person's negative affect into something more compliant. In the opposite side, providing control may lead to a negative affection, once control is associated to be pressured by another to act in a specific way, or to target a prescribed outcome [135]. Some autonomous actions of a digital system may evoke this kind of feeling. Creating an optimum balance is also necessary to provide an autonomous behaviour, and it may represent a hard task to the designer when it is necessary to consider a wide variety of users' skills. For example, first-time users need to learn concepts that are already internalised by experienced ones. So, tailoring and incremental features to introduce interaction concepts might be considered. In line with the idea of Autonomy, the Self-Efficacy, a situational aspect of Cognition, may also be considered in establishing feasible targets of energy consumption and mainly connecting the impact of individual behaviour to the global impact. These concepts are represented by the requirements in Table 3.5.

iii) Exploring Social Software (SS) features to satisfy Relatedness

Relatedness may also be a reason to internalise extrinsic motivation due to the willing

Table 3.5: Design requirements to improve Self-Efficacy and Autonomy

Design requirements to promote Self-efficacy and Autonomy	**MMO**	**DEB**	**MENV**	**IND**	**ILC**	**FPL**
Show consumption patterns in accessible and attractive look-and-feel (evoke a positive emotion)	X	X	X	X	X	X
Do not rely only on charts to represent consumption patterns	X	X	X	X	X	X
Provide a feature to establish an adequate consumption target for each user	X	X				
Highlight the collective benefits to the environment regarding this level of target			X			
Guide the target establishment in order to avoid unfeasible reductions		X		X		
Stimulate consumption below the target	X	X	X	X	X	
Show alerts of bad debt and over consumption	X	X			X	X
Configure preferential media to receive alerts	X	X	X	X	X	X
Configure the frequency of receiving alerts				X	X	X
Associate collective consumptions with new dams building needs			X	X	X	
Show total consumption level for lights on a public place, such as illuminating a touristic attraction, whether in virtual or real world				X		
Explore the association between illegal attitudes and the energy price					X	X
Show individual achieved economy	X	X		X		X
Publish global results of individual attitudes (in a community, city, state) whether in real or virtual world			X	X		
Design Games that stimulate and motivate lower consumption, i.e. about how to choose new electronics to buy	X	X				
Promote well-being with home-automation features that optimize energy usage				X		X
Make fun the interactions with devices to learn concepts associated to energy generation and distribution	X	X	X			

to have the behaviours valued as significant by others. It is an important aspect to disseminate culture by means of a technology or by personal contact in social groups.

People around the world have used SS to express their identity, strengthening relatedness satisfaction. Numbers show that the value of virtual communal relationship in Brazil seems to be higher than their privacy concerns [105] – people usually do like to share personal stuff, and also are interested on sharing achievement on saving energy, as reported by the study. Be recognised by others as a good influence is another important aspect.

Besides counting on the relationship with the neighbourhood as a way to disseminate collective commitments and knowledge, the Internet access certainly represents a powerful way to spread a value in a social group. Social networks are reaching people that have never had contact with technology before. Table 3.6 presents the sharing requirements.

Table 3.6: Design requirements regarding Relatedness

Design requirements regarding Relatedness	**MMO**	**DEB**	**MENV**	**IND**	**ILC**	**FPL**
Share public commitments trough social software		X	X		X	
Design Games that stimulate collective playing	X		X	X		
Show stamps and awards in social networks or in the houses			X			
Offer educational tools to influence other people, such as for teachers or community leaders	X		X	X		

Other requirement sets still to be considered involve issues regarding autonomy for those somehow intrinsically motivated for the environment, aggregating also models from environmental psychology [52]. Next steps of this scenario investigation consists in starting the iterative process of creation/evaluation of design elements with household's members representing our potential REFS users, taking into account the specific requirements.

3.6 Conclusion

We understand motivation as a force that moves the interaction, which belongs to the person, but could be evoked by the system and considered in procedures of evaluation with users, providing a more realistic view of the potential impact of the system in the user's life and in his/her environment.

In this paper we presented a review on concepts of motivational theories from Psychology, making sense of them in the HCI domain.

An exploratory quantitative survey within a specific scenario evidenced a lack of intrinsic motivation towards the conscious consumption of electricity, suggesting that extrinsic motivations, even those towards the environment, must be developed and internalised by promoting autonomy and self-efficacy, which means the association of individual attitudes to global consequences. Moreover, relatedness is a crucial concept to stimulate a change in the social group, and could be supported by social software as a tool to disseminate new values. In this context, we proposed and categorised design requirements for *Residential Eco-Feedback Systems* that aims at supporting the conscious consumption of electricity in a Brazilian context. Next steps in this research involve formalising the development of a design framework for situated REFS.

Chapter 4

Design of Eco-Feedback Technology to Motivate Sustainable Behaviour: Cultural Aspects in a Brazilian Context[1]

4.1 Introduction

Despite credible warnings, emissions and related environmental problems have continued to grow. From the policy-making level down to personal voting and purchasing decisions, the observable actions have not been commensurate with the extent and threat of environmental problems. Although public concern has risen dramatically in the past few years, a much smaller percentage is actually taking action [44]. Reasons for this discrepancy include the widespread perception that risks such as climate change will predominantly impact geographically and temporally distant people and places [27][96], and the lack of personal efficacy – i.e., the belief that the own actions will not make a difference and one's voice will not be heard. Personal efficacy is a critical motivating factor in behavioural change [16] that can be supported by Eco-Feedback Technology (EFT) to share knowledge, motivate sustainable behaviour, and coordinate environmental action. Properly designed, EFT not only provides information, but can also stimulate attitudes change in a sustainable manner [49]. This technology aims at creating awareness and understanding

[1] **Article presented at Conf-IRM 2012 and published as "Piccolo, L.S.G., Scharl, A., Baranauskas, C. Design of Eco-Feedback Technology to Motivate Sustainable Behavior: Cultural Aspects in a Brazilian Context.** ***Proceedings of Conf-IRM (2012).*** **International Conference on Information Resources Management. http://aisel.aisnet.org/confirm2012/34/**

about the way everyday attitudes impact on the environment. Mobile phones, ambient displays or online visualisations inform about individual or group behaviour related to energy, water and other resources, in order to achieve an environmental impact reduction.

To properly design persuasive technology it is necessary to go beyond traditional usability concerns mostly related to efficiency, effectiveness and learnability; it is important to consider the user as a complete human being [63][119], who has emotions, individual's motivations, and also is part of social groups.

Among the most important design challenges to motivate users is to take into account cultural elements of a society, since culture guides even unconscious behaviour, influences learning, awareness, affect, and attitudes towards change. In a social approach, culture embraces people's assumptions about the society and economic systems, aspects that influence decision-making and attitudes towards the environment. Larouche et al [85], for example, analysed cultural aspects of French-speaking and English-speaking groups in Canada, and evidenced significant distinction in eco-literacy and people's concern for local environmental.

The culture of a society is not only learned but also acquired, being composed of three modes of behaviour that alternate in dominance [61]: the *informal mode*, which is made up of activities done automatically, learned in everyday life; the *formal mode* that is regulated by rules, for this reason resistant to change from the outside; and the *technical mode*, where artefacts support and reinforce behavioural patterns. According to Hall, the more acceptable way to introduce cultural change is at the technical mode, where changes are easily observed and transmitted to others, establishing the basis for new formal systems. When accepted and adopted, this change becomes embedded in the informal mode.

Thus, people from different cultural backgrounds may require different forms of feedback technology to motivate pro-environmental behaviour change, for example, emphasising collective aspects instead of individual ones for more socially oriented groups [24].

This work focuses on challenges associated to the design of eco-feedback technology to motivate a sustainable behaviour in the Brazilian scenario; conceptually the paper sheds light on how culture influences the perception of the impact on the environment, how people associate it with everyday attitudes, and how people relate themselves to technology. This effort is part of research that aims at introducing motivational aspects in the design of consumption displays for promoting a social change, initially instantiated in the electricity utilisation. The paper is organised as follows: the next section sets the background for the work on culture and motivation; section 4.3 presents an analysis of the Brazilian scenario based on Hall's ten areas of culture; section 4.4 discusses implications of the findings on design issues, and section 4.5 concludes pointing out further work.

4.2 Culture and Motivation

Humans' behaviour is guided to achieve the well-being, and motivation is a culturally influenced force that gives behaviour energy and direction [135]. An often-repeated pattern of behaviour may become someone's habit, which is usually exhibited unconsciously. When repeated by the social group, these patterns of behaviours are reinforced, being rarely questioned amongst community members [83].

Intrinsic motives, such as physiological, psychological, and social needs, are the stronger sources of motivation. When in line with personal values an external reason, such as money and prize, may also start motivation, but to internalise it, a person needs to make sense of the value or the merit of the attitude, acting in autonomous way [35][135][123]. As Figure 4.1 illustrates, autonomy is the force that internalises an external motivation, which is influenced by culture.

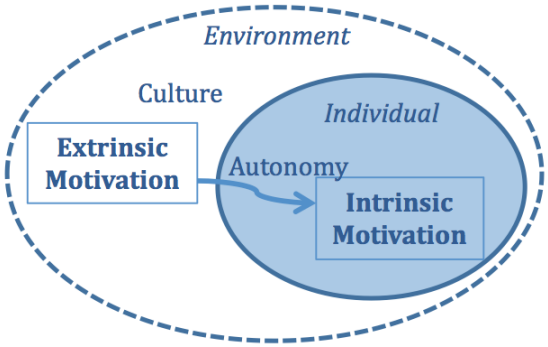


Figure 4.1: Concepts related to motivation

This research hypothesis is that mapping some cultural aspects may help designers to identify what are the most present intrinsic motives, values or beliefs that could contribute (or undermine) the internalisation of external motivations. Informing the design process, this approach may firstly contribute to the adoption and appropriation of an eco-feedback technology, and then to the promotion of autonomous pro-environmental behaviour by means of the technology.

According to Hall [61], a culture is a complex series of interrelated activities. The taxonomy he proposes – the Primary Message Systems (PMS) – allows mapping a culture in such way that it makes possible to identify the main aspects that make a culture different from others [61][83]. The ten categories of implicit behaviour of PMS are:

- Interaction is a central cultural term that describes the specific relation of people with their environment.

- Bisexuality refers to the behavioural differentiation according to gender, age, race, etc. Kolkman [83] renamed bisexuality to Classification when applying the model to evaluate how innovation affects a culture.
- Association: refers to how people interact with others, the social organisations.
- Learning and acquisition: means how the knowledge is transmitted from a biological origin to formal and informal learning processes.
- Defence: concerns how people defend themselves from hostile forces from nature and within the human society; includes religion, medicine and law enforcement.
- Play: time and places are associated to play. Play and learning are closed intertwined.
- Exploitation: refers to adaptations, including the material ones, to exploit the environment.
- Temporality: involves cycles and rhythms, how people deal with time.
- Territoriality: regards taking possession, use and defence of a territory.
- Subsistence: includes from individual food habits to the economy of a country.

The PMS has also been applied to guide design by considering human values and cultural aspects in other contexts, such as by [83], [114], and [115].

4.3 The Brazilian Scenario: Findings of a Cultural Analysis

Following the PMS [61], the cultural analysis presented in this paper classifies typical behaviours that might influence technology appropriation of an EFT, both those related to technology usage, and the related to the environment. As Hall [61, p.57] states, *"each PMS is obviously so rich and complex that it can be made the subject of a lifetime's work"*, this analysis has not the pretension of being complete, mapping all the complexity of the Brazilian culture; quite the contrary, it intends to be a simplified, although helpful, view with the purpose to guide the EFT design, highlighting aspects that should not be easily observed in traditional design processes.

Besides a literature review about socioeconomic aspects, preliminary results of a quantitative survey subsidised this analysis. The survey happened in the Brazilian State of *Minas Gerais* on November/December of 2011, in the context of a Smart Grid Technology

deployment project called "Cities of the Future", which encompasses the design of electricity consumption displays for the Web, tablets, and smartphones. Among other issues, the survey had the purpose of providing information about how people relate to energy. The participants were those responsible for the energy consumption in the households, which were randomly selected among those households that will be covered by the project. The survey methodology considered two groups of 140 participants each: the first group (G1) consisted of mostly rural or small cities inhabitants, 55% of respondents studied until primary school and 13% had higher education level; while the group 2 (G2) is mostly urban, 35% of higher educated people, with higher income compared to G1.

The following sections describe some findings according to the taxonomy of PMS.

4.3.1 Interaction

Interaction describes how people interact with the environment, with each other and with technology. Louv [92] observed that young people in the United States spend more time with electronic devices such as computers, mobile phones and television sets than in direct contact with natural environments. Consequently, nature has become an abstract concept for many of them, especially in urban areas. This phenomenon is not restricted to the United States; it can be observed worldwide. In Brazil, more than 84% of the population lives in urban areas [70].

However, our quantitative survey evidenced that the connection between individual attitudes towards consumption and perceived global consequences is weak or does not exist at all, even in rural areas. The two groups of 140 participants were asked how energy consumption reduction could contribute to the environment. In G1, almost 60% declared to not know the answer. About 22% said to save water, and only around 17% answered to avoid the construction of another power plant; 39% of G2 respondents did not know the answer; 24% said to avoid new power plant, 14% to save water and 14% do preserve forests. Considering that the connection is mostly unknown, the environment preservation represented only around 10% of declared motives to save energy in the first group, and 21% in G2, suggesting that the educational level influences the connection between electricity consumption and the natural environment.

New media and interactive technologies have an important impact on the way people communicate with each other. In 2010, 48% of the Brazilian population had already used the Internet [23]. This number is predicted to increase due to current political strategies of digital inclusion. Social networking platforms such as Facebook, Google+ and Orkut have reached more than 90% of Internet users as of 2011 [133]. Moreover, statistics on the adoption of mobile devices indicate that technology is pervading all social levels, with 78% of smartphone owners belonging to lower socio-economic layers [38].

This behaviour suggests that being digitally connected to other people is a popular intrinsic motivation. According to Nokia [105], people like sharing personal stuff – e.g., 95% of the survey respondents declared they are interested in sharing their energy saving achievements with neighbours, family and friends.

4.3.2 Classification

The most important dimension is age. Individual age and the values of one's generation impact the perception of climate change and the every-day use of technology. The Y generation – people born from mid-1970s to the late 1980s – started a change in the way people relate to technology. This generation is characterised, for instance, by the use of social media and digital content consumption [21]. According to CETIC.br [23], about 65% of people between 10 and 24 years old had already used the Internet in Brazil and 24% between five and nine years old.

While electronic devices are naturally present in all aspects of their lives, older people still see technology as a tool. This difference is highly relevant to EFT design decisions. Age also influences the perception of regulations and control mechanism that impact their lives, as described subsequently.

4.3.3 Association

In general, people agree with the necessity of central administration and governing structures, a trend that is amplified by education. 80% of illiterate people approve the view that "each person only has to care about what belongs to him/her, while the government cares about public issues", and almost 75% of the population do not support the view that everyone must care about public issues [5], suggesting a weak personal commitment for global resources.

4.3.4 Learning

The way people learn about the climate change or environmental impacts differs by age and location. Older people might have witnessed events in the last decades that reflect climate change, while young people probably studied it theoretically at school. The lack of connection between concrete individual attitudes and environmental impacts, however, may be considered a common issue. People from cities, for instance, perceive the environmental impact of air pollution, while people from the coast may easily notice the sea level rise.

Another aspect related to learning concerns the abstract concepts usually represented in EFT systems, such as amount of CO_2 emissions, charts, energy usage (kWh), carbon

footprint, etc. Considering that about 70% of the population has incomplete education, these representations may not make sense for a considerable number Brazilians [72][125].

4.3.5 Defence

Due to fear of threats such as traffic and crime, parents usually do not stimulate outdoors activities for kids, keeping them far from experiencing nature [92]. Religion is also associated with defence according to PMS. Although this trend changes with geographic area (people from the North and the Northeast tend to be more fatalist), 51% of low-literate people think that destiny is in God's hands, and people cannot change it [5]. This view seems to be connected with the concept of "locus of control" that stems from psychology. People that have an "external locus of control", on the one hand, believe that actions of powerful others, such as God or government, create change. People with an "internal locus of control", on the other hand, believe in the consequence of their actions and are more likely to take environmental actions [145]. While this simple classification does not convey the full spectrum of possible perceptions towards god, destiny, and change, it still helps explain a lack of personal responsibility for externally triggered events that impact the environment.

4.3.6 Play

Entertainment mediated through technology is an increasingly important cultural phenomenon. The ubiquitous presence of computers, online games and social networking platforms is pervading all socio-economic levels. Almost 90% of Internet users declared that they spend time online for leisure and the most popular activity among connected children is playing on-line games [23].

Games with a purpose motivate online users to participate in games that generate useful scientific data [4][134]. Examples that use the concept of "play" to promote environmental awareness include *UbiGreen* [53] shown in Figure 4.2, which uses activity inference to display transportation activity information on the background of an individual's mobile phone, *StepGreen* [95], which tracks the financial and environmental savings of simple green actions, *Wattsup* [51], which uses a social media application to motivate a reduction in domestic energy consumption. The Climate Change Collaboratory [140] (www.ecoresearch.net/triple-c) examines games with a purpose as an innovative and cost-effective means to provide indicators of environmental attitudes, lifestyles and behaviours from very large user groups. It builds upon Sentiment Quiz, a development framework and Facebook application developed to acquire multilingual language resources [134][166].

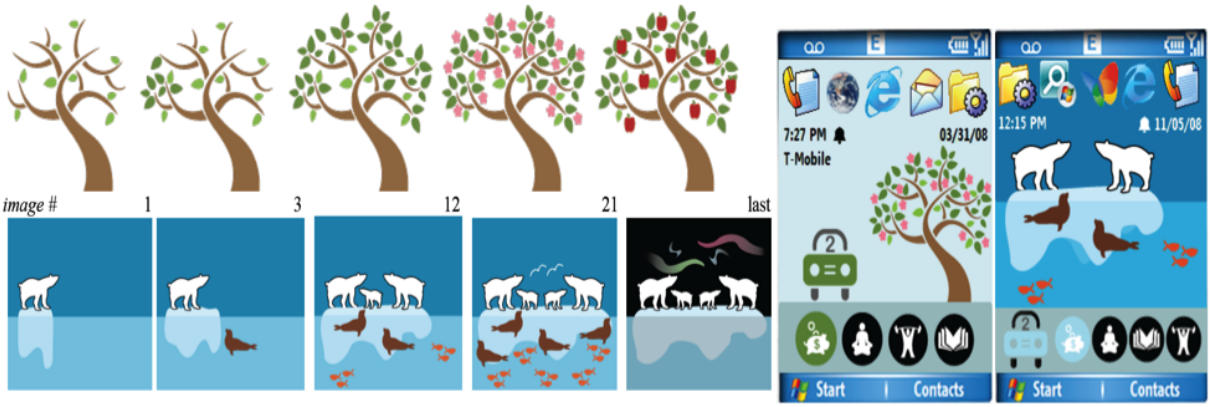


Figure 4.2: UbiGreen screenshots showing tree and polar bear theme progressions; the car windshields on the right indicate a user who recently carpooled [53]

4.3.7 Exploitation

Historic reasons and the abundance of natural resources in Brazil developed a "culture of waste". A restrained consumption of food, energy, water, and raw material is not part of the common sense. Although the green consciousness started to emerge, people keep wasting natural resources and confuse saving resources with being greedy or miser. Abrantes [2] estimated that 50% of food production; 40% of the distributed water and 30% of electricity are wasted, and only 11% of the waste is recycled.

In the quantitative survey we conducted, 88% of the participants declared they are worried about the environment. When asked about what people do to preserve the environment, the following three actions were cited most frequently: waste recycling, not throwing trash on the ground, and saving water.

4.3.8 Temporality

Temporality is concerned with people's relationship with time. The perceptions and (lack of) experience of young people represent a good example. Since nature remains an abstract concept for most of them, they tend to be not aware of the effects of climate change that have already happened, due to the lack of valid and observable variables to compare. Irrespective of the actual drivers of behavioural change (which might encompass both short-term and long-term goals), from a sustainability perspective a move towards lower resource consumption is a long-term investment that often lacks immediate individual benefits and involves interdependent processes of different timescales.

4.3.9 Territoriality

Territoriality refers to ownership and territory usage. Huge distances and road transportation by trucks is a typical an expensive combination in Brazil that can be tackled by promoting the consumption of local products. Additionally, taking advantages of ownership is a way to promote personal responsibility for a specific environment. Official and non-governmental organisations dedicated to socio-environmental issues usually develop local leaderships for spreading a sustainable exploration of natural resources within a community. Using the same approach, EFT can explore local social relations to educate, locally instantiating consequences of individual attitudes and demonstrating the importance of their environment for the global context. These issues are closely connected to the concept of learning and subsistence.

4.3.10 Subsistence

What are the overall resource requirements to sustain a particular lifestyle? The ecological footprint calculation, as shown in Figure 4.3, is an important approach to demonstrate individual impact for the planet subsistence. Most footprint calculators are based on averages and do not consider Brazilian particularities, such as hydroelectric plant, road transportation, and the value of specific biomes such as the Amazon forest.

When consistent with individual or a group reality, this tool can be more effective on guiding everyday attitudes, including purchasing decisions, when clearly informing the real value to produce or to transport everyday artefacts [113].

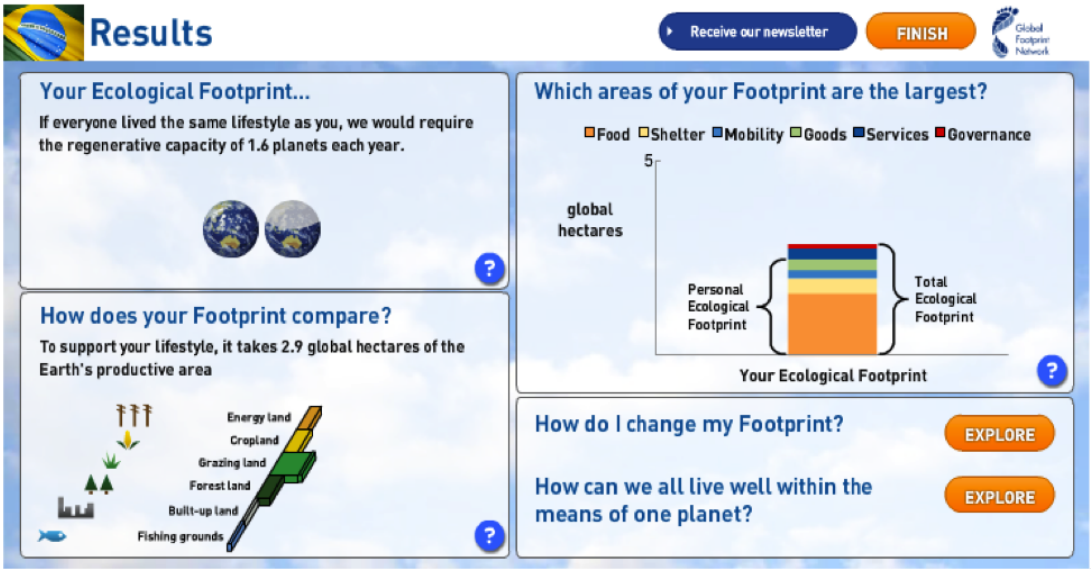


Figure 4.3: Footprint calculation (Source: WWF Brasil)

4.4 Discussion and Design Issues

By evidencing the disconnection between individual attitudes to global consequences in Interaction, Association, Defence and Exploitation cultural aspects, this analysis reinforces the lack of personal efficacy [16] in the Brazilian context. The intrinsic motivation to preserve the environment seems to not willing to embrace a behavioural change, so that the autonomous behaviour towards more sustainable attitudes must be developed by Learning and Play cultural aspects. Contextualised to a local culture both in terms of what information must be provided and how to best represent it, an EFT may be a promising tool to develop autonomy in this scenario, in which technology is reaching a considerable part of population. The same technologies that currently keep people away from nature can be applied to developing a sense of being part of the environment. Associations with social networks seem to be an important direction to change a culture, reaching out people who must feel responsible for the Subsistence in the future.

Table 4.1 synthesise some design concerns related both to form and content, taken into account some aspects of designing a persuasive tool as stated by Fogg et al [49].

4.5 Conclusion

Users need to make sense of a tool to adopt it and recognise its importance for everyday actions. Addressing cultural elements in designing and contextualising artefacts based on a user's reality is a first step towards developing EFT to motivate people to change their behaviour and promote self-efficacy. By analysing aspects of the Brazilian culture, this work highlighted two main consequences to the design of EFT: (i) the need to evidence the value of individual attitudes towards a more sustainable behaviour; and (ii) to explore social media influence for promoting this culture. In the context of this research, culture does not necessarily mean a country, but a group of people who experience the environment in a distinct way.

Future work will utilize the concept of games with a purpose as outlined in Section 3.6 to provide indicators of environmental attitudes, lifestyles and behaviours from very large user groups (e.g. citizen science projects, relevant Facebook or Google+ groups, etc.). *The Climate Change Collaboratory* (www.ecoresearch.net/triple-c) aims to gather intercultural data on environmental knowledge from these groups. Thereby, games with a purpose will complement conventional social surveys and shed light on public awareness as well as perceived collective and individual threats. This will enable us to identify extrinsic motivations in a broader sense, and to transform the acquired knowledge into design requirements that could, potentially, be translated into applications that increase intrinsic motivation and trigger collective action towards a more sustainable society. Designing

Table 4.1: Cultural design implications

Content	**Form**
Mapping traditional local habits with negative or positive impact to the environment. Examples: pollution by road transportation, consequences of wasting food.	Avoiding charts, such as the "Which areas of your Footprint are the largest" in Figure 4.3 and other abstract representations to include low-literacy users
Establishing social norms and invoking consensual social rules: developing a sense that the environment is not only a political concern, but that it depends on the attitudes and actions of individuals and communities.	Creating insightful visualisations and sensations by applying metaphors contextualised in users' reality. The polar bear in Figure 4.2 [53] is an example of a graphic metaphor, but not contextualised for a tropical area.
Sharing individual achievements.	Creating local connections with a user's location. For instance, adopting different representations such as forest, marine environment, and urban areas.
Associating natural resources with everyday consumption, e.g., establishing a connection between energy consumption and the environment.	Highlighting collective results of individual attitudes, such as the total amount of recycled waste in a city.
Providing tools that could be applied to influence others, such as educational games	Publishing achievements in social network platforms.
	Designing a non-web technical solution to reach those people who are not familiar with web technology, for instance, using short message services.

appropriate user interfaces for this type of application and evaluating the experience they evoke to specific stakeholder groups are important tasks to be pursued in follow-up projects.

Chapter 5

Motivational Aspects in Energy Feedback Systems Design[1]

5.1 Introduction

Whether for environmental, technical or economical reasons, the world is putting efforts in rapidly reconsidering how to supply, distribute and consume electric power. This new scenario, frequently associated with the concept of Smart Grid [158], may lead to new cost rate structure, for example, stating different rates per kWh according to time of the day, consequently changing habits and people's relation with electricity usage and control. Moreover, it usually brings to households a new technical artefact for measuring and displaying information about energy consumption per periods of time, estimated monthly consumption, and energy costs associated with appliances usage, among other features [80]. Mobile phones, Web, tablets and interactive TV may also be used as indirect displays for showing consumption information, leading to consequences to the HCI domain, especially in its 3rd paradigm, that considers technology as part of our life in almost all aspects of it [20].

Designing interactive systems to promote sustainable consumption behaviour has recently emerged as a key and rapidly growing area of interest within HCI community. Froehlich et al [52] draw upon other authors to define eco-feedback technology, as technology that provides feedback on individual or group behaviours with a goal of reducing environmental impact in a variety of domains including energy consumption. Eco-feedback

[1] **Article presented at CLIHC+IHC 2011 and published as "Piccolo, L.S.G. Baranauskas, M.C.C. (2011) Motivational Aspects in Energy Feedback Systems Design. *Proceedings of the 10th Brazilian Symposium on Human Factors in Computing Systems and the 5th Latin American Conference on Human Computer Interaction (IHC+CLIHC 2011)*, Brazilian Computer Society, Porto Alegre, Brazil, Brazil, 313-322."**

technology is based on the working hypothesis that most people lack awareness and understanding about the way their everyday behaviour (e.g. using automatic clothes dryer instead of air-drying their clothes) affect the environment. They argue that an "environmental literacy gap" may be bridged by automatically sensing these activities and feeding related information back through computerised means (e.g., mobile phones, ambient displays, or online visualisations).

Pierce et al [132] argue that, although energy savings of 7-20% have been attributed to the use of residential energy feedback systems (REFS), little is known about what specific conservation behaviours do or do not result in such reported savings, how individuals engage or do not engage with feedback, or why conservation does or does not occur in relation to various types of feedback or their design issues. As He et al [65] state, feedback informs, but not necessarily motivates a sustainable behaviour.

Field studies evidenced that beyond values and intentions, electricity consumption behaviour is embedded in habits and routines, which are patterns of unconscious actions guided by the environment [131][74]. As such, what would be the motivations for using or not such artefact in the context of a developing country, with diverse range of environmental awareness, technology literacy, and societal conditions?

Mentioning Bødker's work [20], Pierce et al. [131] suggest emphasising design' for non-work, non-purposeful, and non-rational uses of technology in the domestic context, according to the 3rd HCI paradigm; moreover they recommend to consider experiential, social and cultural aspects to create an awareness of energy usage, conservation and its relevance for well-being. Dillahunt and Mankoff [40] agree about the importance of addressing socioeconomic factors in design and evidence the importance of considering multiple stakeholders when creating REFS that intend to reach significant audience.

Considering an anthropological view, Hall [61] states that a technically introduced change in a culture opens the way to form the bases for a new cultural system.

Thus, this research aims at understanding the process of transforming the energy consumption by means of a technology introduction in a Brazilian scenario. More specifically we are considering the context of Minas Gerais and Rio de Janeiro states, which deal with a diversity of cultural aspects, and with issues such as nonpayment and fraud (illegal electricity connection) besides conservation for environmental reasons – motivation usually addressed in literature [52].

In accordance with [65] and [40], which argue that feedback technology design should consider different motivations for saving energy, this work explores the hypothesis that the motivation involved in technology adoption varies according to different needs and expectations of users. We analyse the situated scenario with Organisational Semiotics artefacts aiming at the consideration of motivational aspects in the design of REFS, as well as social and cultural particularities that influence the artefact effectiveness.

The smart metering deployment – recording, transmission and billing of electricity consumption – by two electric companies in Brazil has been considered the case study of this research that aims at developing a design framework informed by motivational issues. The analysis we present stands for a step towards this development.

This paper is organised as follows: the next section conceptualises challenges addressed in this research such as motivation and culture, and their relation with design; then we analyse the research scenario by applying Organisational Semiotics tools [90]; the next section discusses strategies and requirements for REFS design for this scenario, providing a set of design guidelines that may motivate different users profiles; it also points out further work and the last section concludes the paper.

5.2 Motivation, Culture and Design Issues

To make the introduction of this technology effective, personal motivations, cultural values and social issues must be addressed to be reflected in design. The introduction of the new artefact may represent an opportunity to change the relationship between people and the energy consumption, addressing also cultural peculiarities of this research scenario such as nonpayment and fraud.

5.2.1 Motivation

Motivation is as an internal force that gives behaviour energy and direction [135]. According to theories from Psychology [135], both external reasons, such as money, and intrinsic motives that involves physiological, social and psychological needs may be sources of motivation to achieve the well-being. In the energy consumption scenario, a completely externally motivated person possibly preserve energy to save money; a somewhat externally regulated: "because I should, I am going to feel good about myself"; a somewhat internally regulated: "because it's important for the environment" and, finally, a personally committed, or autonomous with internalised motive: "because it reflects and expresses who I am and my values".

The more an internal motive reflects a person's values, the more motivated the person is, and the degree of autonomy in behaviour determines how motivated a person is by an extrinsic reason. To internalise a value or a behaviour, the person needs to make sense of the value or the merit of acting.

User's (lack of) motivation

As noticed by [80], monetary reasons usually are the main motive for people to save energy and adopt the technology. However, this motivation fades away over time. The

theoretical view about motivation [135] leads us to argue that saving money cannot be considered a motivation enough for inducing a deep change in behaviour, unless the saved money contribute to well-being.

Thus, identifying and considering people's most internal motives in the design may stimulate a positive attitude towards the REFS introduction.

Ethnographic interview and contextual inquiry approaches were combined to analyse people's everyday interactions with energy-consuming products in the USA [131]. The study evidenced how challenging is to change user's behaviours once daily interactions with energy-consuming devices can be characterised as unconscious − "rules of thumb" − rather than the result of rational decision making. The REFS people received was not enough to change their interest on energy consumptions and values: none of the respondents knew the cost of 1 kilowatt-hour of electricity or their cost rate structure; although ~80% of respondents personally paid their monthly bills, only ~25% were sure about how much they paid. In the same way, people were uncertain about individual devices consumption.

That study also revealed that minor inconveniences and discomforts, such as setting a different temperature for refrigerators or frequently turning off devices when they are not in use prevent people of changing behaviour regarding saving energy, pointing out a lack of strong motivations to conserve. Even when this motivation exists, it does not imply people will actually save energy, especially when acting against their well-being [131].

5.2.2 Dealing with culture

According to Hall [61], cultural aspects embrace people's assumptions about state, economic systems, and so on, and they guide behaviour in persistent ways, many of which outside of awareness or beyond conscious control.

People's culture comprises three different modes – informal, formal and technical – that alternate in dominance and influence learning, awareness, affect, and attitudes toward changes. Technical aspects support formal behaviour patterns, around which there are certain informal adaptations. The informal is made up of activities learned in everyday life, which are done automatically. The formal mode is resistant to change from the outside, once it is regulated by rules. According to Hall, the opportunity to introduce a change in culture is at the technical mode, where changes are easily observed and transmitted to others, establishing basis for a new formal system.

This theoretical background highlights the importance of bringing design issues of the technical artefact into discussion.

5.2.3 Design issues

In order to design a technical device that properly evoke the desired change in behaviour, motivational and cultural aspects should be taken into account. The following set of questions synthesises these design concerns and drives this investigation:

- How to create a sense of awareness of energy usage by means of the device?
- How to identify motivations of different people to adopt (or not) this new technology? How to evoke them with device features?
- Considering the diversity of the Brazilian population, how to propose user interfaces that make sense to as many people as possible?
- How to model and represent aspects of culture reflecting them in the user interface in order to foster a behaviour change?
- How to promote a good affective quality in the user's interaction with this new device, aiming at keeping their motivation?

5.3 The Research Scenario Analysis

Grounded in Hall's cultural model [61], Organisational Semiotics (OS) [90] provides artefacts to analyse this research scenario from diverse points of view. Within the OS frame of reference, a technical solution is involved by a formal layer of information (e.g. rules, regulation), which by itself is involved by an informal layer (e.g. underlying intentions, beliefs). The technical layer impacts on the external layers and is also influenced by them, suggesting that an innovation introduction may fail when considered only at the technical level if it is not compatible with people's expectations, culture or current regulation.

Three OS artefacts were applied to support the analysis, which was based on meetings and interviews with electric companies employees and also on perceptions obtained by observing the customer care services. The call centres, on-line chat and in-person attendance offices were visited to provide an understanding of the relationship between the consumers and the companies from different points of view.

Figure 5.1 illustrates the first artefact, the Stakeholders Analysis Diagram. Based on the technical, formal and informal layers concept, this OS tool maps the stakeholders of the Smart Metering and REFS introduction according to their roles as interested parties.

Among the stakeholders in the different layers of the "semiotic onion" we can see those who **contribute** more directly with the system under analysis (e.g. the displays user interface designers), those who are **source** of information (e.g. the consumer himself/herself), those who represent the **market** (e.g. autonomous electrician technicians,

which are opinion makers about this technology), or the social forces of **community** (e.g. media, that can positively promote this change or not, and the association of energy distributors). Stakeholders identified in italic represent departments of energy companies.

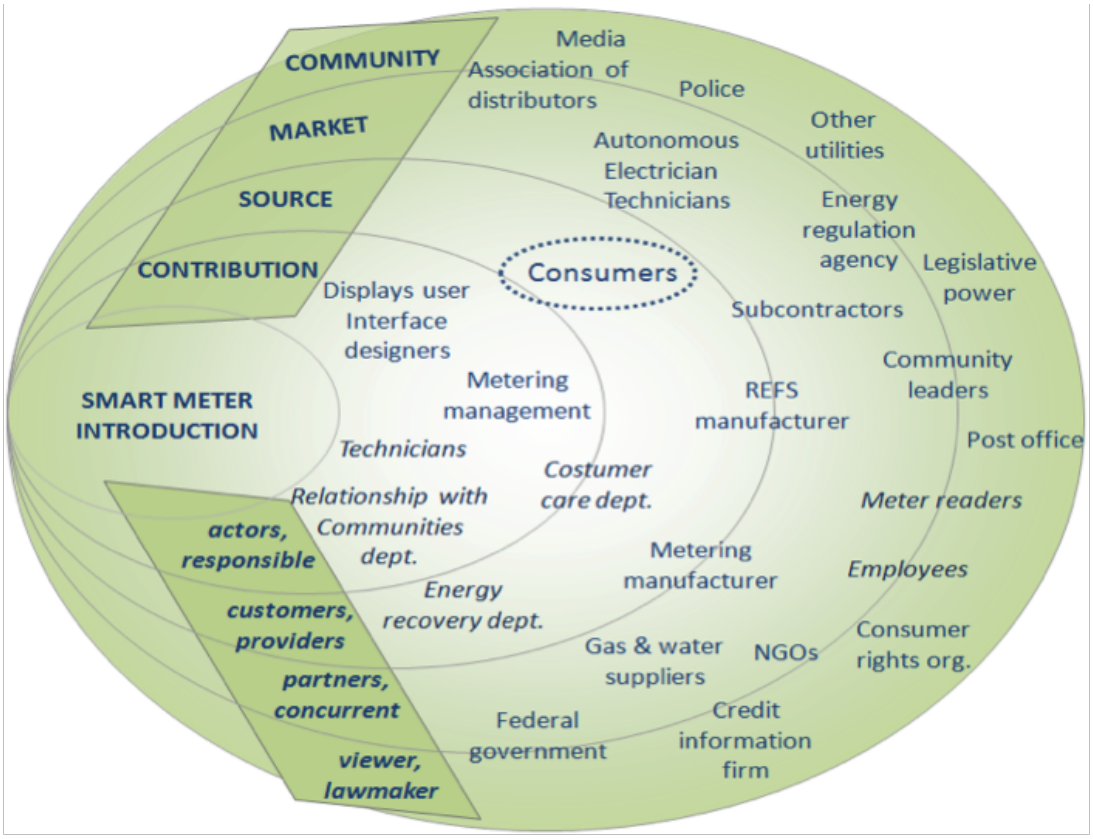


Figure 5.1: Stakeholders Analysis Diagram of the research scenario

The stakeholder analysis enables a systemic view of different forces of information regarding the interested parties. In addition to addressing technical, regulatory and social aspects that underlie this technological change, this analysis also considers commercial losses by the power provider mainly due to nonpayment and fraud, in a way to prevent those losses with the introduction of the new technology.

The second OS artefact is the Evaluation Frame [12], represented by Table 5.1, applied to identify the main concerns of stakeholders, prospecting potential problems the introduction of the smart metering display would cause to different interested parties.

Table 5.1: Evaluation Frame

Stakeholders	**Concerns**
Contribution level	
Meter management Display user-interface designer *Technicians* *Relationship with communities* *Customer care dept.*	• How to identify useful and necessary information to the consumer? • How to present this information in a way adequate to the diversity of users? • How to arouse user's interest in using the technology? • How to aggregate cultural and motivational values in the technology? • How to inform individual and collective benefits of a conscious consumption?
Source level	
Consumers *Costumer care dept* *Energy recovery dept.* Metering and REFs manufacturers	• How to stimulate regularisation for fraud situations with the technology introduction? • How to motivate a spontaneous usage of the displays by consumers? • How to promote environmental and ecological values associated with energy consumption? • How do the consumers perceive the new technology? • How to take advantage of different kind of displays (Interactive TV, mobile phones, and the Web) for different customers profiles?
Market level	
Autonomous Electrician Technicians Subcontractors Metering and REFs manufacturers Gas & water suppliers Community leaders *Employees* *Meter readers* Federal government Association of energy distributors Energy regulation agency	• How to involve technicians and installers to promote the technology? • What are other utilities providers (gas and water) interests on this technology? How to address these interests in the display? • How to educate and involve employees turning them into supporters? • How to tackle social benefits provided by the government on energy costs on device?

Community level	
Media Police Federal government Association of distributors Energy regulation agency Community leaders *Employees* *Meter readers* Post office Consumer right org Credit information Firm	• How to announce the benefits and implications of this technology for the customer? • How to build and keep a positive image of the change in society? • How to address meter readers' concerns about their jobs due to smart metering introduction? • How to map consumer protection agencies expectation in the solution? How can they contribute to the solution?

5.3.1 The informal level

To provide ideas or solutions to concerns identified at the Evaluation Frame, both cultural and motivational issues – represented at the informal layer [90] – must be taken into account to represent the way people tend to behaviour, their values and beliefs.

In this research scenario, both fraud and nonpayment by the consumers are responsible for a commercial loss to the energy distributors higher than a couple of billion dollars per year [7]. For this reason, these companies are strongly interested in educating people to consume energy more efficiently, in such way that they afford the bill. Also, it was evidenced by [55] that in some areas fraud incidence has not been related to economic aspects, but has been mainly associated to low level of urbanisation and violence, somehow related to values acquired at formal education, but strongly disseminated by informal aspects of culture.

Some low urbanised areas that used to be dominated by criminal organisations are now under the police control, streets and informal address have been regularised, bringing forth the sense of citizenship and providing unique opportunity to reestablish the relationship between the energy company and the population.

Within our scenario, the "green consciousness" is not a strong aspect of the culture, mainly due to recent growth of economy, allowing people to access more consumer goods, leading to higher consumptions of energy, fact that affects especially the economically less privileged people [78].

People usually valuate energy as expensive, having a high cost-benefit relation [8]. The conscious involvement people have with the energy usage usually happens only once a month, when they receive the bill. However, according to the INAF [72], a measure of the functional literacy level among Brazilians aged 15 to 64, 70% of the population has

incomplete literacy, which means no skills for reading charts, among other constraints; this may represent also low understanding of concepts applied on energy consumptions such as percentage and kWh.

Informal norms descriptions

As key concepts, we go further into socio-cultural aspects, describing them according to the Norm Analysis, the third OS artefact applied in this study. According to OS [90], an organisation is a social system in which people behave by conforming to a system of norms, defined as regularities of perception, behaviour, belief and value, that are exhibited as customs, habits, patterns of behaviour and other cultural artefacts.

Table 5.2 presents a formal description of these behaviour patterns of informal level in the format of norms [90]: WHENEVER <state> THEN <agent> IS <deontic operator: must, may, must not> TO <action>. This set of norms represents people's current behaviour regarding the subject.

Table 5.2: Description of some informal level norms

	whenever	**then**	**is**	**to**
Always	there is a governmental social benefit	low-privileged consumers	must	not exceed a consumption limit to get a considerable discount on energy bill
	want to buy a new appliance	low-privileged consumers	should	prioritize low-energy consumption appliance
	cannot afford the bill payment	consumers	should	learn how to consume less
Most of the times	in debt to the energy company	consumers	may	prioritise to pay other bills instead of paying off the energy debt
		consumers	may	take advantage of the company's criteria to suspend the energy to manage when to pay the bill
	asked about the value of energy	consumers	may	state that energy has a high cost-benefit relation

	whenever	then	is	to
Most of the times	lives in a non-urbanised community or a violent area	consumers	may	pay for an (illegal) organisation for using an irregular connection to receive energy at home
	surrounded by fraudsters	consumers	may	not evaluate fraud as a crime
	in contact with people who do not pay for energy	consumers	may	believe that they should not pay for energy too
	have incomplete education level	consumers	may	not understand the concepts associated with the energy consumption and its bill (kWh), %, charts
	find a fraud condition	technicians, employers or other consumer	should	denounce for energy company
Frequently	cannot afford the energy bill	consumers	may	adopt an illegal alternative to receive energy at home influenced by local culture
	have a household budget increase	low-privileged consumers	can	buy more new domestic electronic devices
	reflect about the energy provision service	consumers	may	associate the energy supply and distribution with a governmental service
	valuate governmental services	consumers	may	associate it with tax, misuse of public resources and corruption

Even though it has provided a broad understanding of the scenario, this analysis evidenced that a unique stakeholder representing the consumer does not express different kinds of motivation and relationship with the energy distributor. Based on analysis of customer care services (call center, chat and in-personal assistance), and also interviewing customer attendances, we identified five categories of consumers as represented in Figure

5.2.

Residential consumers may be regular – up-to-date with the payment of energy bills – or irregular, in fraud condition. In the intermediate state are the debtors, regular customers on nonpayment status, considered as potentially new fraudsters when they cannot control or afford their energy budget.

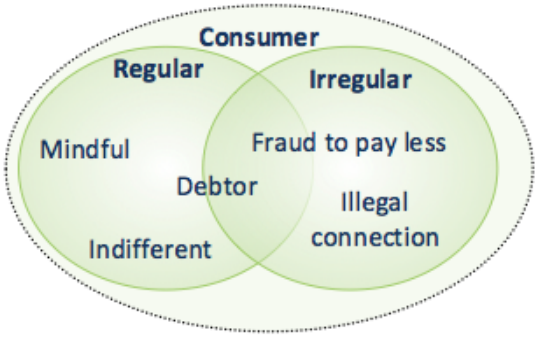


Figure 5.2: Consumer profiles

Analysing consumers' motivations, we identified different types of regular consumers according to the main reason why they control (or not) their energy budget:

- Consumers mindful about energy consumption for environmental reasons (MENV): besides individual interests, this profile wants to conserve natural resources. They act according to their values, representing a strong intrinsic motivation to keep this behaviour.

- Mindful about energy consumption for saving money (MMON). To be considered a motivation indeed, the amount of saved money has to be enough to compensate the effort for saving. People who receive governmental social benefits are examples of this profile, once they must consume below determined target to receive a considerable discount in the energy bill.

- Indifferent (IND): are people who are not concerned with the money they spend on energy bills neither with the natural environment. Usually they believe that the comfort the energy provides is worth the money and do not want to worry about that.

- Debtor (DEB): must be aware of the consumption to leave this condition and afford the bill payment. Usually they want to have no restriction on Credit Information firms to get credit for buying.

- Fraud for paying less (FPL): official customers that make a fraud for paying less than the real consumption. Cultural reasons and impunity make them believe that they would never be caught. In less privileged areas may represent informal businesses, such as popular hairdressers or laundries that would not afford the bill to keep their business. It may also represent influent people that believe in impunity.
- Completely illegal costumer (ILC): both for cultural influence ("everybody does") or due to the low level of urbanisation, sometimes this kind of fraudster is not completely aware of the criminal attitude and just need a good opportunity to be educated and regularize their connection.

For many people, monetary or environmental incentives may not be enough to motivate one to conserve or to adopt a technical artefact [74][65]. Thus, understanding each motivation to keep current behaviour, we intend to identify motivations specific of our scenario to change the behaviour towards the efficient and regular consumption by adopting a REFS. In Table 5.3 we describe these motivations and relate them to other stakeholders capable of influencing the success of the technology introduction.

Table 5.3: Motivations of identified user profiles

Most likely motivation to keep current behaviour		**Relationship with stakeholders to motivate a change of behaviour towards more efficient and conscious consumption**
Mindful	Environmental issues (intrinsic motivation)	May motivate people in the household and people in the society when associated or in the role of Community leaders from associations, schools, and/or NGOs.
	Save money (extrinsic motivation)	The Federal Government and other representative organs, such as regulatory agency, may stimulate consumption reduction by creating policies of benefits. The energy company needs to publish and stimulate this incentive.
Indifferent	Well-being	Features associated to home-automation when aggregated on the REFS may improve comfort and consequently reduce consumption. It must be considered by display manufacturers and all value chain.

Debtor	Lack of information about energy and electronics consumption	Need to be educated by the supplier (by Costumer Care Dept., Technicians – autonomous or not – and media) about how to keep energy consumption in an affordable level. Consumer protection agencies (PROCON, IDEC) should support initiatives to avoid nonpayment.
Fraud pay less	Culture + Subsistence	Employers, Technicians – autonomous or not – the Media and Subcontractors must educate about the consequences of fraud; Police, Law Makers and the society should learn that when everybody pays, the cost of energy could be reduced [7].
Illegal connection	Low level of urbanisation	Once living in a recently urbanised area, the customer can receive the regular service, including their bill properly delivered by the Post office. Well hosting new consumers, the relationship with community dept. should promote the advantages of being regular, such as better quality of service and the energy bill as an official proof of address, considered a meaning of citizenship by society.

Beyond orienting stakeholders actions, the identified motivations must be taken into account also in REFS design. To evaluate this impact, we considered strategies and requirements for design extracted from literature to analyse them according to the identified motivational aspects.

5.4 Strategies and Requirements for REFS Design

When designing a technical device, HCI researchers are traditionally concerned about the understandability, aesthetic, and perceived usefulness of the artefact. The design of REFS brings to light additional challenges such as users' motivation, attentiveness, cognitive load, information relevancy, and cost [52], as well as their effectiveness on influencing users' attitude towards the environment.

In the captology domain [50] – field that investigates how digital systems can be applied to change attitudes and behaviours –, a technical device may influence people in three different ways: 1) as a tool that provides information for decision making, increases self-efficacy and changes mental models; 2) as a medium: providing learning and under-

standing of cause-and-effect relationships, insightful visualisations and sensations; and 3) as social actor establishing social norms and invoking social rules. This set of *"persuasive affordances"* [50] should guide the design of the artefact.

The set of 8 design strategies proposed by [129] addresses these aspects also evidencing that an effective solution is not exclusively related to the REFS features, but to a set of complementary actions on the social domain. These strategies were analysed with our focus on the user motivation and the previous analysis of our specific scenario:

(1) Offer behavioural cues and indicators of current consumption

Feedback is a crucial component in learning, which may help all consumer profiles on creating the culture of thinking about energy consumption. The frequency the feedback system is updated is important to ensure credibility – a key aspect that increases the persuasive power of the device [52][50]. Debtors who need to learn how to consume are specially benefitted by this feature.

The granularity of the data (whole house, rooms, each appliance), the accessibility and consequent adequacy with the medium through which information is provided, such as Web, mobile phone, specific device, and so on [52], are also important design factors for consumption feedback.

The aesthetic of the artefact may stimulate its spontaneous usage, representing a possible motivation for the indifferent costumer as well, especially for the young people, who may influence the other family members.

According to [82], iconic and metaphorical images suggest more awareness and motivation for future behaviour changes through emotional attachment; although indexical representation is beneficial for informative purpose.

Choosing measurement units to represent consumption (i.e. colourful lights with meaning, currency, kWh, carbon footprint, etc.), as well as the possibility of customising the display with colours or symbols, for instance, may also promote aspects of autonomy, so that consumers act according to their values and self-identity. The device may lead to a positive feedback when the consumption is lower than expected, and induce positive emotions via initial exposure to technology [171].

Studies have indicated that it is possible to achieve savings in the order of 10% with real-time feedback [131], which is still considered a marginal effect[52].

(2) Provide tools for analysis; provide information about energy use patterns over hours, days, weeks, or months, as well as set target reduction goals to work towards.

To retrospective purpose, indexical representation was considered beneficial [129], which

may imply on charts and tables − representations that create barriers for functionally illiterate people (around 70% of Brazilian population). Thus, one of the challenges we will have to face is how to provide information visualisation aiming at promoting the user's competence – the design for optimal challenge – in interaction [171][125].

Art and aesthetics have been considered as important concepts for information visualisation [129], especially when the purpose is to achieve a good affective quality of user interface [125][67][67]. According to [162], traditional analytic and pragmatic visualisation tools have sought to minimize distortions and to foster immediate understanding, while an artistic visualisation has the power to keep users interest and also to express a point of view; this is supported especially when designers are dealing with *"valid reasons to want to change the way people think and it may be that much of the value of visualisation comes from its ability to change attitudes"*.

To achieve the ideal level of competence for each user, it is crucial to find the balance, showing charts in a simple way and applying metaphors – i.e., an amount of lamps to represent a number of kWh to help low literate people, for example, but also creating opportunities to analyse consumption and compare it with past behaviour [132] for those who are really concerned.

It is worth mentioning that modes of interaction and the information presentation also affect the effectiveness. The way a reduction target (or a baseline) is presented may stimulate users to maintain this level of consumption instead of reducing it [132].

(3) Create social incentive to conserve (i.e., competitions)

A study conducted by [116] resulted in 32% of reduction in electricity usage in a college when a competition was proposed [129]. Social software can also be applied for creating incentive to change behaviour. This approach to efficiency represents a new research topic to be explored [52], with an additional challenge in our research scenario to also include low digitally literate people.

Competitiveness in general is a cultural aspect that must be better evaluated in the considered research scenario. It addresses the following *"motivational affordances"* [171][123]: it represents human social bond; facilitates one's desire to influence others; facilitate one's desire to be influenced by others.

(4) Connecting behaviour to material impacts of consumption

This guideline suggests connecting individual actions (e.g. turning off the lights) with the negative consequences of our collective actions, such as consequences for the planet (global warming) [129].

Visual metaphors as well as visual appeal may help on creating a connection between consumption and environmental impacts [129][82].

It is important to investigate the common sense of environmental impact associated do energy consumption in Brazil, once the energy is mostly generated by hydroelectric plant, less polluting than thermoelectric plant, a common power generation worldwide. Probably the connection to the construction of new dams has a higher impact than CO2 emission, usually applied in most studies.

Creating this connection is a way to develop environmental values, promoting autonomous behaviour instead of developing a sense of control, the behaviour determined or pressured by others [135][125].

(5) Encouraging playful engagement and exploration with energy

In [129], the importance of designing for ludic activities, motivated by curiosity, exploration and reflections is highlighted. This guideline is also important as a learning tool, especially when acting in a collaborative way, as stated by [80]. Teachers and parents may use games for influencing others, facilitating human-human interaction [171], and promoting intrinsic motivations associated to relatedness [125]. It may also induce intended emotions via intensive interaction with ICT [171]. Home-automation features may also promote conservation leading to comfort and well-being, such as setting proper light according to the use of an internal environment.

(6) Project and cultivate sustainable lifestyles and values: the aesthetic form is something the owner would be proud to display, serving as a symbol of sustainable values and lifestyle to others

Both social networks and houses may promote one's identity (and the self [125]) when it is related to sustainable lifestyles. This feature also facilitates one's desire to influence others [171], a typical characteristic of the mindful for environmental reason profile in the role of a community leader.

(7) Facilitating discussion and raising public awareness

This guideline is related to (4), and suggests that aggregated data of small granularity can be effective in persuading people to conserve. Emphasising both aggregated economy of a house and showing the collective results helps on building values so that people may act with autonomy due to reducing consumption. Large displays in public places may contribute to the success of a local initiative of reduction.

Figure 5.3 illustrates an example of a panel in Rio de Janeiro, aiming at reducing the public garbage daily collected in the beach area. The panel displays how many grams of trash were collected per capita per day and the monthly total in tons. Similar initiatives on Web and social networks should also be evaluated. This guideline also contributes to develop environmental values, promoting autonomous behaviour instead of developing a sense of control [125].

Figure 5.3: Garbage collected panel in the beach

(8) Stimulating critical reflection

For [129], critical approaches to REFS design can also lead to more pragmatic behaviour and changes, as the example of a REFS that forces users to estimate how much energy is being consumed before displaying the actual usage [75].

This guideline should be associated with games and social networks usage facilitating learning on how to consume and specially how to buy new appliances.

5.4.1 Design guidelines

Based on the design strategies proposed by [129] and in the analysis of this research context, Table 5.4 presents design requirements, relating them to the consumer profiles that would be motivated by the requirement.

Table 5.4: Design requirements to motivate users

Requirement	**Most benefitted profiles**
(1.1) Show the current level of consumptions in an attractive (good affective quality of the device) and customisable way	DEB, IND
(1.2) Show consumption in different ways: monetary value, relation with environment, kWh	MENV, MMON
(1.3) Explore the strength of the device (Web, interactive TV, smartphone) to show consumption information, but aiming at keeping the consistence between the user interfaces	All users
(2.1) Show consumption patterns in accessible and attractive look-and-feel. Make it possible to execute assistive technology when necessary	
(2.3) Stimulate consumption below the target	
(2.4) Alerts of bad debt and over consumption	MMON, DEB, FPL, ILC
(3.1) Explore the association between illegal attitudes and the energy price	
(3.2) Share public commitments trough social software	MENV, DEB, ILC
(4.1) Associate collective consumptions with new dams building needs	MENV, IND, ILC
(4.2) Lights on a public place, for instance, such as an art object in a main square or even illuminating the Cristo in Rio, whether in virtual and real world, showing peaks of consumption	
(5.1) Design Games that stimulate collective playing	MENV, MMON,IND
(5.2) Funny interactions with devices to learn concepts associated to energy generation and distribution	MENV, MMON, DEB
(5.3) Promote well-being with home-automation features that optimize energy usage	IND, FPL
(6.1) Show stamps and awards in social networks or in the houses	MENV
(7.1) Show individual achieved economy	MMON, DEB, ILC
(7.2) Publish global results of individual attitudes (in a community, city, state) whether in real or virtual world	MENV, IND
(8.1) Design Games that stimulate and motivate lower consumption, i.e. about how to choose new electronics to buy	MMON,DEB

Although individual motivations are important aspects to be addressed in REFS design, it cannot be considered as a single user device. Participants of the study conducted by [80] found important to use it in collective way to evoke discussions about the interaction and energy usage, reinforcing the need to fit the device in the household routine.

For this reason, the same device should be featured to motivate different people (such

as children and parents) and to keep users' interest in the long term, highlighting the importance of indirect displays such as smartphones and the Web to envisage the differences.

The design guidelines we proposed are mostly represented at the technical level [61], but also pervade the formal and informal levels to promote a solution complemented by social actions. In particular, the social networks may represent an important aspect for an effective solution, due to the relevance of this kind of software to the society.

Froehlich et al. [52] argue that most HCI studies are narrowly concerned with the artefact design, while in environmental psychology, investigation is mainly related to the effect of the feedback intervention [161], evidencing a gap between the disciplines in linking achieved impact on behaviour to specific design aspects. This work represents the first step towards bridging this gap in the Brazilian context; in the sequence, proof of concepts for different kinds of displays and solutions in different real environments will be explored to analyse the intelligibility and motivational aspects of their user interfaces. Both qualitative experiments in the field and in the laboratory, and quantitative enquiring with real users will be conducted to analyse the potential consequences of this kind of technology introduction. Similarities and distinctions between consumption of electricity and water and gas will also be considered in future works, following the trend to present all utilities in the same device regarding the promotion of more sustainable behaviour.

5.5 Conclusion

Current HCI research on residential energy feedback systems design focuses on the design of displays mainly with sustainable or environmental appeal. This research aimed at identifying different possible user's motivation for changing behaviour towards energy consumption to reflect this on the REFS design.

Although we recognise cultural differences among specific regions of our scenario, e.g. fraud is more socially accepted in some places than in others, we intended to build a model that represents a developing society as a whole, making it applicable to other locations.

Five consumer profiles were identified in our specific scenario, reflecting their motivations and relation with the energy company, taking into account social aspects such as fraud and nonpayment.

A set of requirements for the REFS was established to guide the user interface's design and features that may promote positive social actions. The next steps in this work involve giving shape to REFS prototypes informed by the results reported here.

Chapter 6

Climbing the Ladder with Energy: Informing the Design of Eco-Feedback Technology with a Social Approach[1]

6.1 Introduction

The world has experienced several transformations in the way people relate to technology, which is now part of all kind of everyday tasks, influencing the way people interact with the environment, with each other, and consequently, potentially changing the society as a whole.

In line with this change, Human-Computer Interaction (HCI) mainstream concepts have been rethought under a new paradigm that considers users new contexts and expectations, supporting the understanding that people are not only "users" of technology, but they are part of larger systems that count on their own sociocultural particularities to make sense of technology.

Eco-feedback Technologies (EFTs) are examples of technologies specifically designed to incite the transformation of individual's behaviour and of the society towards the environment. Mobile devices, ambient displays and online visualisations have been created to foster awareness of the consequences of individual actions in the natural environment, aiming at achieving a positive impact (e.g. reduction of energy consumption) [52][125].

[1] **Article present at ICISO 2013 and published as "Piccolo, L.S.G., Baranauskas, M.C.C. (2013) Climbing the Ladder with Energy: informing the design of Eco-Feedback Technology with a Social Approach. Proceedings of The 14th International Conference on Informatics and Semiotics in Organisations (ICISO 2013). 185-194. ISBN: 978-989-8565-51-8"**

Technology may be designed in order to play different roles on how it influences people [49], as for example: designed as a tool, it provides information for decision making; as a medium aims at promoting learning and understanding of cause-and-effect relationships; as a social actor, technology may offer rewards and social support, modelling target behaviours.

Grounded on behavioural psychology, Fogg [48] proposes a set design strategies to persuade users to change their behaviour. In a broader sense, other design approaches that consider psychological aspects of humans' motivation are recent and still scarce topic in HCI [124]. However, narrowing the focus to EFTs design, more recent initiatives are found, i.e.: Petkov et al [117] propose a design strategy that fits the values involved in the way a person acts towards the environment, which can be egoistic, in benefits of him/herself, altruistic, for the good of other people, or biospheric, aiming at protecting the ecosystem. Scott et al [142] have applied the Goal Setting Theory [91], a framework for understanding how to motivate behaviour change, to design according to the way people make decision and set goals to reduce energy consumption. Froehlich [54] evaluated self-comparison, goal-comparison and social comparisons as motivational strategies in the design of water consumption display in the US, and discussed the strengths and weaknesses of these motivational approaches.

In line with these authors, this work considers that for achieving an environmental impact reduction, the EFT design and deployment must go beyond the technical domain; psychological aspects, especially those regarding human's motivation, must also be in scene. However, the diversity in the areas of this research scenario evidences that motivation is a force strongly influenced by the sociocultural context [35] [135], and this influence must be considered to inform a motivational design.

The Organisational Semiotics [90] provides methods and artefacts to analyse these technical, individual and sociocultural aspects, corresponding to ETF design demands and, in a broader sense to the HCI new paradigm. Since Semiotics is based on the subjectivist doctrine, it emphasises the abilities of individuals, their freedom to choose and the moral responsibility of their choices [90], essential elements to be considered when the design intends to deal with human behaviour and attitudes.

Aiming at addressing motivational aspects as well as the sociocultural context to propose a social EFT solution, an Organisational Semiotics concept – the Semiotic Framework or Semiotic Ladder – was applied to a quantitative survey regarding energy consumption within the Brazilian scenario. This paper shows how climbing the semiotic ladder contributed to develop an energy feedback architecture that fits this social context.

The text is organised as follows: in the next session the challenge of designing an EFT for this research scenario is introduced, followed by a summary of previous analysis with Organisational Semiotics artefacts. Then, the Semiotic Framework is instantiated

taking into account questions of a quantitative survey executed in two different regions in Brazil. These surveys answers are then analysed pointing out directions for design. Finally, this analysis leads to a preliminary proposal of design elements and to a social EFT architecture. Then, results are discussed, concluding the paper.

6.2 Designing an EFT for the Brazilian scenario

Coping with energy usage behaviour requires dealing with habits and routines, patterns of unconscious actions guided by the environment [131][74]. The frequency people turn and keep lights on without reflecting whether it is necessary is an easily observable evidence of this challenge.

This work addresses the problem of developing the conscious consumption of energy by establishing a connection with the environment through the design. The rationale behind this is that once promoting an awareness of energy usage individually and collectively, conservation is a value that potentially may be developed intrinsically.

Among the most important design challenges to motivate users is to take into account cultural elements of a society, since culture guides even unconscious behaviour, influences learning, awareness, affect, and attitudes towards change, among other aspects that also influence decision-making and attitudes towards the environment [61].

To address motivational aspects in the design, this research relies on the Self-Determination Theory (SDT) [35][135], which considers intrinsic and extrinsic sources of motivation, and focuses on how social and cultural factors facilitate or undermine people's resolution and initiative towards behaviour.

Extrinsic motivation, such as saving money, may play a role to trigger a behaviour change, although, as reported by studies related to energy conservation [125][80], it is not enough to develop or to keep a sustainable lifestyle. For SDT, rewards and prizes, instead of developing an autonomous behaviour, might even undermine intrinsic motivation in some cases [35].

According to this theory, three key concepts must be developed and promoted by the design to intrinsically motivate people and foster well-being [135][124]:

- Autonomy: it means acting in line with one's interests, preferences and wants. The degree of autonomy determines how motivated a person is.
- Competence: means to offer an optimum challenge according to the person's skills. It is related to rewards, and positive feedback.
- Relatedness: As a social being, individual's need to establish close emotional bonds with other people.

Taking into account this motivational approach, this study considers that both users and technology are part of a larger system that has a specific culture, which influences the technology adoption and use, and is also influenced by it. Motivational aspects to adopt and engage with the technology are the focus of the analysis, which encompasses also emotional aspects, as well as user's relationship with their environment, strengthening their feeling of being present and active in their social group.

According to the Semantic Analysis Method of Organisational Semiotics [151], Figure 6.1[2] illustrates the relationship between the concepts involved in the study as an ontology model, in which a repertory of behaviour exists during the co-existence of others, establishing an ontological dependence [151] [57]. The society, with its specific culture, is the root agent of this model. Individuals with their intrinsic emotions and motivations are agents in that society and are part of social groups (families, neighbourhoods, etc.). EFTs are affordances of this society. The conscious consumption is an affordance that ontologically depends on the existence of this social group and on the EFT.

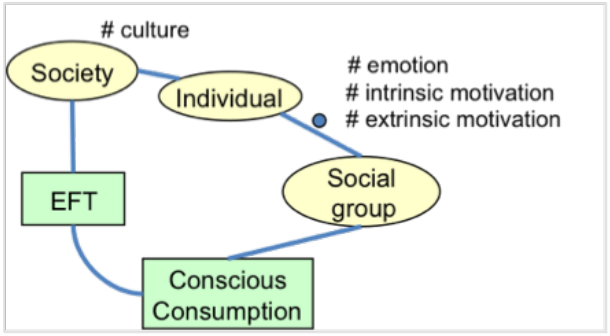


Figure 6.1: Ontology model[2] of concepts related to this study

6.2.1 The research scenario

This research is contextualised in two Smart Grid deployment projects, the first one in the Brazilian state of Minas Gerais [22], and the second in the city of Rio de Janeiro. In Minas Gerais the "Cities of the Future" research and development (R&D) project involves 7.000 households in a 200.000 inhabitants city and its surroundings, which is mostly rural. Regarding the human aspects, the project main challenge is to provide energy consumption feedback to low-digitally literate people in such way the users feel engaged with the new technology and make sense of the innovation in their daily life.

[2]**Thesis edition note:** More information on the ontology model notation is provided in Appendix C

The project in Rio de Janeiro [88] intends to comprise 1.000 households, including low-income areas that have received smart meters. Non-payment and fraud (irregular connections for receiving energy) are typical cultural problems in the city – approximately 40% of the distributed energy in the energy company domain is not paid by final consumers [55], influencing the way people make sense of energy in their daily life.

Besides evaluating technical aspects related to smart metering, both projects rely on quantitative research to understand their consumers' habits, trends to accept and use technology and how they value and relate to electricity at home. Preliminary results of these quantitative researches subsidise the analysis presented subsequently.

The challenge addressed by this paper is complementary to the Smart Grid deployment issues addressed by both R&D projects. It is specifically concerned with a cross cutting issue, which is a new approach to design aiming at fostering the conscious consumption of energy.

6.2.2 Preliminary findings

Aiming at analysing sociocultural influences, people's expectation and the impact of current regulation in the new technology introduction, in previous work [125] the Stakeholder Analysis Diagram [90] and the Evaluation Frame [12], OS artefacts, were applied to identify stakeholders' main concerns and to prospect potential problems. This analysis was based on literature review and mainly on data from interviews with energy company employees; the findings point out some crucial aspects in setting this research context.

Among other results, the study indicated the lack of involvement people have with energy in daily life. The tangible contact occurs monthly with the energy bill, which is made of incomprehensible signs for people with low literacy (which may reach almost 70% of the Brazilian population), such as charts and kWh measurements. Another important aspect noticed was related to the culturally accepted behaviour of stealing energy that started as the consequences of the low urbanisation, and influences of criminal organisations in some areas. The weak "green consciousness" associated to recent growth of economy also represent a force against the purpose of this research. The recent purchasing empowerment makes people more willing to buy new household appliances, increasing the demand for energy.

Finally, this analysis also evidenced that a unique stakeholder representing the consumer does not express different kinds of motivations and relationships with the energy usage: there are regular and irregular consumers. Among the regular are those mindful about the money or about the environment, some indifferent, and some debtors, which are regular consumers in eventual bad conditions; the irregulars may have a fraud for paying less or have a completely illegal connection.

Some typical behaviours according to the interviews were described as preliminary norms [90], leading to a set of guidelines to further work of this research.

In order to build an overview of some related cultural aspects in the national context, in [122] an analysis based on Hall's blocks of culture [61] was conducted, highlighting:
(i) the need to evidence the value of individual attitudes towards a more sustainable lifestyle, improving user's autonomous behaviour;
(ii) the potential power of social media in Brazilian society for promoting the green consciousness.

In this work, results of a quantitative research in both research scenarios are analysed based on the Semiotic Framework artefact, informing an EFT preliminary solution proposal.

6.3 Instantiating the Semiotic Framework

Aiming at finding a way to define *information*, Stamper [148] argued that it should be understood as signs, which could be operated in distinct levels. Each level means different operation a person can do upon the sign and it is represented as steps of a semiotic ladder, or views of a *semiotic framework*.

The Semiotic Ladder consists of six steps representing views on signs from the perspective of physical world, empirics, syntactics, semantics, pragmatics, and the social world. The physics, empirics, and the social world are Stamper's contribution upon the traditional semiotic approach. The social world states that information use is always a part of human behaviour in a social context [148][57]. The physical world indicates the features and physical signs that can be measured by physical analysis and engineering. Their representatives are the electrical signals, markings and other real means. The empirics studies the properties of the signals.

In a top-down view, the upper steps are concerned with social consequences of the signs use and how they communicate intentions and meaning, while the lower steps provide answers to how signs are structured and used in language, how they are organised and transmitted, as well as the physical properties they have [90]. So, each step of a semiotic ladder can be understood as follows:

- **Social world:** where the social effects of signs are, as well as the beliefs, expectations, culture, norms, and social conventions that might be affected by the sign usage.

- **Pragmatics:** consists of intentions, negotiations, and the persuasive power of signs. Where the motivational aspect of this study domain are.

- **Semantics:** how a person makes sense of signs, their meaning, propositions, and denotations.
- **Syntactics:** the language, formal structures of signals representation.
- **Empirics:** related to patterns, efficiency of signs, channel capacity, and other measures of the communication.
- **Physical world:** refers to physical properties of the signals, such as size, format, media, etc.

6.3.1 Prospecting the design context with the Semiotic Ladder

Data collected by quantitative surveys in the State of Minas Gerais, more precisely in the city of Sete Lagoas and its surroundings, and in two low-income areas of the city of Rio de Janeiro subsidise this analysis. Interviews were conducted face-to-face by a research institute in November-December of 2011 in Minas Gerais, and in October of 2012 in Rio de Janeiro.

The complete questionnaire was composed of 140 questions enquiring about how people use energy at home, propensity to change habits and to adopt new services provided by the Smart Grid technology, levels of satisfaction with the energy company services, information and communication technologies usage, among other aspects.

Some of the questions related to social life, environmental concerns, motivation, and how they relate to energy in daily life were selected to this analysis shaped by the steps of the semiotic ladder. Table 6.1 situates these questions in the Semiotic Ladder.

6.4 Answers influencing design

6.4.1 Quantitative research configuration

The surveys target universe was the households that will receive smart meters in the near future in the scope of the mentioned projects. Locations and samples configuration were defined complying with each Smart Grid project definitions and constraints. In Minas Gerais, householders of 280 residences were interviewed. A confidence interval of 95% was considered to define the sample. In Rio, the survey comprised two initial areas of the project, totalising 165 houses as the sample, with a confidence interval of 90%.

Table 6.1: The questions reorganised according to the Semiotic Ladder steps

Social
.How do you know your neighbours?
.Do you talk to other people in the household about saving energy?
.Are you member of the residents' association?
.What do you do to protect the environment?
.What do you do to save energy?
.In case of reducing your energy consumption, would you like to tell this achievement to your friends and neighbours?
.Are you a social network user?

Pragmatics
.What are the two main reasons for you to save energy?
.Do you consider yourself concerned about the environment?
.In case of having a competition with prizes for those who most save energy, would you participate?
.Would you be interested in learning about conscious consumption?
.Among a set of statements, choose two that most reflect what you think about saving energy. You would save energy to: 1) preserve the environment; 2) to have some remaining money in the month; 3) to afford the bill; 4) to feel him/herself a better person; 5) to be considered as a good example for other people; 6) if everyone saves, I will save too (asked only in Rio).

Semantics
.Why saving energy could contribute to the environment?
.In your opinion, the amount you pay for having energy at home is: too expensive, expensive, neither expensive nor cheap, or cheap?
.Do you trust the value of your energy bill?

Syntatics
.Do you have any problem to understand[3] your energy bill? What is the main problem to understand it?
.What does this chart mean[3]? (a column chart representing daily consumption during a month was showed)

Empirics
.How many kWh does your household consume per month?
.Are you an Internet user? For how long have you been an Internet user?

Physical
.Do you read your power meter?
.Do you have a mobile phone?
.Through what media would you like to receive more information about energy consumption and smart metering?

(3) **Thesis edition note:** In the sense of the syntatics aspects of the bill content.

6.4.2 Analysis

Instead of highlighting differences between the two areas, the main purpose of this analysis is to understand how people in our scenarios make sense of energy consumption in a broader sense, and how the technology could play a role in this process. As much as possible, the analysis intends to unify common aspects, pointing out differences when it is relevant to the investigation and to the design main goal, which is to foster the conscious consumption of energy. The same way, numbers are rounded sometimes to provide a better overview of the results.

Social World

According to Liu [90], the interpretation of the communication produces social consequences. So, how people act towards the environment, towards the energy, and how they might spread the idea of a conscious consumption are aspects analysed at the Social Word step.

An EFT application may take advantage of the fact that 70% of people from both scenarios declared they know well or very well their neighbourhood, by promoting and creating incentive for collective results.

Regarding reducing consumption, 95% of people in Minas Gerais wanted to share this achievement with neighbours and friends, and 73% in Rio. These numbers reinforce the importance of social aspects, despite of privacy concerns, a typical problem reported in eco-feedback [54], and Smart Grid reports worldwide [14]. The EFT design must find ways to share achievements without exploring private information.

Besides sharing, the application must stimulate the energy consumption as a subject to be treated within the family. It has already happened in Minas Gerais: 83% talk to each other about saving energy in the household, while in Rio it happens only in 37% of the interviewed households.

Resident's association may not be a representative leadership to spread the values of energy. 88% of respondents do not participate of the association. Other type of associations such as churches and schools should be evaluated as a promising stakeholder to promote a transformation.

Current pro-environmental behaviour was strong correlated to trash: "not throwing trash on the ground" and "waste recycling" together represent around 50% of the answers about what people do to preserve the environment. Typical behaviours are slightly different on each location: in Rio 62% of declared behaviours are somehow related to trash, 52% in Minas Gerais. Saving water represented 16% of the answers in Minas Gerais and 8% in Rio. Preservation of the green represented only 5% of answers in Minas and less than 2% in Rio, where a considerable number of people declared they do nothing for the

environment (19%). Although the direct correlation between energy and trash does not exist, this idea was also presented by a group of HCI students challenged to propose a contextualised design for a residential energy feedback system [126], reinforcing this connection. Figure 6.2 illustrates this approach with the text written in Portuguese: *"x kWh = y kg of trash. You produced the trash a person would produce in (days/months/years)"*, by representing the energy consumption.

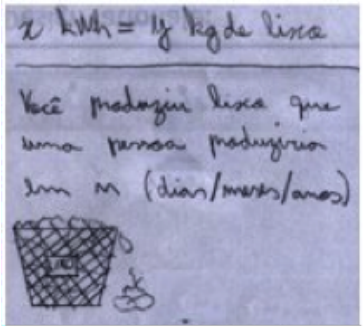


Figure 6.2: Approach to design associating energy with generated trash

People declared they already have behaviours aiming at saving energy, such as using energy saving lamps and turning off them when not in use (more than 30% of the answers), and reducing the number and time of hot showers (around 20% of the answers). Although studies from environmental psychology [67] point out that behaviour is many times unconscious, the survey answers may not represent it in a realistic way.

Regarding technology usage, a segmented analysis evidenced that being part of a social network is still related to the socioeconomic level. In a wealthier area, 50% of Internet users are members of a social network, while around 25% of users from other areas. This characteristic evidences the need to approach the user interface to an inclusive style.

Pragmatics

Within a social community, there are shared knowledge and assumptions that influence the meaning of the signs [90]. The Pragmatics step is where the values and intentions that might change understandings are. This analysis takes into account the motivational aspects inquired.

A total of 95% of the participants declared to be interested or very much interested on receiving more information about conscious consumption. The design must take advantage of this willing by proving a good affective experience in interaction as a way to keep this motivation.

Most of people consider themselves concerned about the environment. 88% of people in Minas Gerais answered they are concerned or fairly concerned (10%), while in Rio, a

bit less but still considerable number of people (71% said yes and 14% fairly concerned).

However, regarding reason for saving energy, money is the most important. In Rio, they represented 82% of the answers about reasons for savings, and 57% in Minas Gerais. The environment protection represented only 15% of the answers in Minas Gerais and 6% in Rio.

Connecting with the Self-Determination Theory approach for understanding motivation according to extrinsic and intrinsic sources [135], people were asked to choose two among five statements that reflect their motivations to save energy. The result is described in Table 6.2.

Table 6.2: Motivation for energy saving

You would save energy for...	**MG**	**RJ**
having some remaining money in the month	37.5%	45%
protecting the environment	30.5%	14%
affording the bill	20.5%	30.5%
being considered as a good example for other people	9.5%	0.5%
felling him/herself a better person	2%	5.5%
if everyone saves, I will save too	-	4.5%

The interest in participating of a competition with prizes and rewards to reduce consumption was declared by 89% of people in Minas Gerais and 55% in Rio.

The results collected in Rio evidenced still more the lack of intrinsic motivation [124]. As described in Table 6.2, 75% of the answers were related to extrinsic motivations. In a generic way, people initially would not act in line with values towards the environment. Such intrinsic motivation should be developed by improving autonomy, relatedness, and competence, by reinforcing the importance of the environment and of the individual attitudes and sharing good consequences.

The last possible answer "if everyone saves, I will save too", part of the interview in Rio, still needs to be better investigated as a motivational aspect in the design. Studies from psychology [25] argue for the power of this motivational strategy. For this reason, a higher result was expected.

Semantics

Semantics step is related to meaning, the link between signals and practical affairs [90]. The analysis considers how people connect the environment and energy, and how they make sense of the bill. Do people trust it?

The predominant hydro plant generation in Brazil makes the meaning of connecting energy consumption and environment protection not so evident, differently from most

countries where the energy generation produces CO_2 directly. Although the pollution for generating energy in Brazil is said to be 10 times lower compared with the world average, the construction of new dams might threaten current green areas. In the next five years 71 new power plants are expected to be built to supply the increasing demand [18]. Some commercial energy consumption displays worldwide represent the environmental impact as amount of CO_2 emitted due to the energy consumption, number that would be unclear and even negligible for the Brazilian population.

Results of the survey inquiring how people believe that saving energy contribute to the environment, evidenced in Table 6.3 how weak this connection is, representing the main point to be tackled by the design.

Table 6.3: Answers to the question "why saving energy could contribute to the environment"

Answers	**MG**	**RJ**
Declared to not know	48%	85%
It avoids new plants construction	29%	7%
Others (mostly saving water)	23%	8%

A total of 58% in Minas Gerais and 50% of respondents in Rio evaluate the amount they pay for energy as expensive. Most of people trust the value of the bill (70%). Those that do not trust, usually refer to having few appliances and using them rationally, indicating that people do not know each individual appliances consumption contribution to the amount they have to pay in the bill. Even being possible to have this information by means of smart plugs at home, an interactive EFT may provide information about the costs of individual hot showers, time of air conditioning, and other critical appliances usage to develop this understanding.

Syntactics

Syntactics refers to encoding, structures of the information [90]. According to this view, the representation of the energy usage by the bill, the way energy usage is made tangible, is analysed.

21% of respondents in Minas Gerais and 12% in Rio assumed to not understand the bill, and described that the kWh value and calculations as the main difficulties. Beyond this 12%, other 24% of people affirmed that they do not use to read the bill, reinforcing that the kWh may not be the most consensual unit to make energy usage more understandable. Aware of this constraint, in an experiment reported in [126], another group of HCI students suggested to associate the kWh consumed with the time of a TV turned on, a typical local

habit. Figure 6.3 illustrates this proposal with the text: *"Be careful! You have wasted energy equivalent to 5 hours of TV turned on"*.

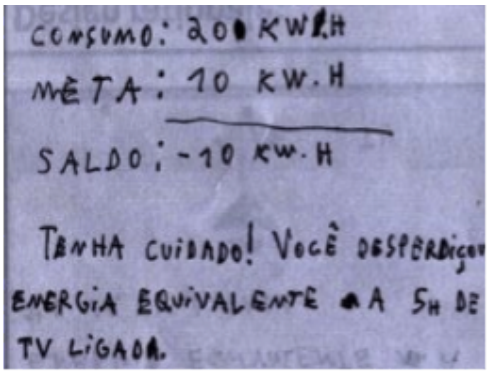


Figure 6.3: Design proposal relating the kWh to the time a TV was turned on

When asked about the chart meaning, which is a typical way to represent consumption in the bill, 24% of respondents in Minas Gerais and 38% in Rio did not answer correctly or declared to not know the meaning, evidencing that other representation approach must be addressed by the design.

Empirics

The empirics step handles statistics properties, measurements of the communication channel [90]. The energy consumption in kWh and time people are Internet users are considered here.

As previously indicated in the Syntactics step, the unit of kWh to refer to consumption is not efficient. Most of respondents in Rio de Janeiro (90%) declared not to know the average of their consumption in kWh, while 60% in Minas Gerais.

Regarding the Internet, 46% of respondents in Minas Gerais are users, while only 25% in Rio. Among those people, 78% have used the Internet for less than five years. Analysing this data segmented by areas, it is possible to notice once again that the digital inclusion is still related to socioeconomic aspects. To reach most the EFT users, it is essencial that the user interface design provides information enough to guide unfamiliar users.

Physical World

Physical refers to the concrete, the media. It has shape, size, intensity, etc [90]. Besides the bill, the power meter is another way to be "in contact" with energy.

Around 80% of people have never read the power meter, suggesting that the way it presents consumptions information is not known by most people (or it is not to be known/read). To receive information about energy consumption, people declared that printed letters or flyers and the TV as preferred media. In the traditional familiar habits, TV still plays an important role to aggregate members in the same room. So, it may play also an important role to disseminate information among the family and the community.

Regarding physical artefacts, mobile phones are the most consensual, 84% of people own a mobile in Minas Gerais and 70% in Rio. Most of users use to read short messages, half part use to send it.

6.5 Preliminary Proposal of Design Elements and Architecture

Each step of the semiotic ladder pointed out directions to potentially fit users' expectations and needs for the EFT design. Considering that this technology proposal intends to promote a transformation in the society, climbing the ladder is a way to ensure that the design has considered all steps of a communication process to achieve this goal.

In previous work [125], a set of preliminary design requirements were established based on literature and improved to address motivational aspects. Most of the requirements are represented by the set of guidelines in Table 6.4, now more specifically accordingly to this research scenario social context. So, Table 6.4 summarises the analysis findings as design elements and functional requirements definition of an EFT proposal.

Table 6.4: Summary of contributions to design from the Semiotic Ladder

Step	**Design guidelines**
Social	.Establish collective saving challenges .Promote collective saving results .Consider privacy aspects when dealing with private consumption data .Consider community stakeholders to promote the conscious consumptions, such as schools
Pragmatics	.Promote user autonomous behaviour by reinforcing the importance of individual attitudes to the group achievement .Reduce the importance of monetary advantages of saving in order to promote intrinsically values instead
Semantics	.Connect the natural environment with energy consumption through the design .Inform about the potential damage of new dams construction .Provide information about the costs of individual appliances usage, at least for the higher energy consumer equipments
Syntactics	.Design for low digitally literate people
Empirics	.Create alternatives to represent energy consumption beyond using kWh units.
Physical	.Provide alternatives to make energy tangible .Take advantage of the strength of different technologies to provide information, such as using TV as a collective media and mobile phone for private information

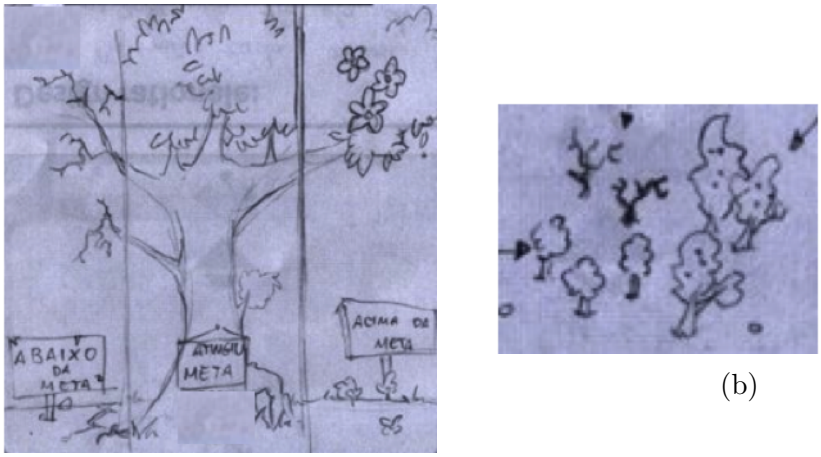
Considering these resulting aspects, some design elements proposed by HCI students [126] were considered to drive a next phase of user interface prototyping.

Both the health status of a tree representing the connection with environment and the individual impact "to the forest" are interesting design elements to be applied and evaluated. This approach is illustrated as proposed by the students in Figure 6.4.

6.5.1 Architecture of a social solution

The guidelines originated from the steps of the ladder analysis pointed out some consideration that led to a preliminary architecture of an energy feedback solution, which emphasises social and collective aspects.

A *Social Eco-Feedback Technology* goes beyond a *Residential Energy Feedback System* (REFS) [132] purpose, as initially targeted by this study [125]. By providing consumption information in different levels, including aggregated consumption data in a community place, it differs from most of proposals found in literature, which are restricted to the



(a) (b)

Figure 6.4: Approach to design associating the health of a tree with individual consumption; and a forest represented by the set of individual trees

domestic environment contextualised in a "developed" scenario [130].

Investments on digital inclusion in Brazil make feasible the idea of counting on a public Internet connection to provide consumption data for the social eco-feedback solution. As illustrated in Figure 6.5, a collective public display may show information about groups saving energy challenges and achievements by creating a connection between energy consumption and the environment. At home, a user would rely on TV, a familiar device, as a household consumption monitor. Complementary, private information could be sent to the user via mobile phone, ensuring the privacy of personal data.

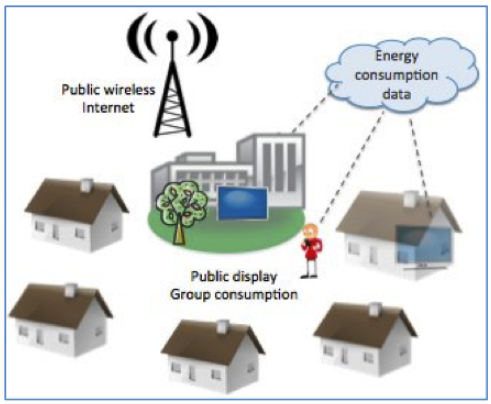


Figure 6.5: Global architecture of a social EFT

Future work encompasses developing this architecture built upon validated user interfaces, properly designed for the social usage in this research context. Beyond technical

aspects, an experimental set must provide ways to engage people to the challenge of promoting the conscious consumptions by means of a collective and social tool.

6.6 Conclusion

This paper analysed sociocultural aspects acquired in a quantitative survey according to the steps of a semiotic ladder. This analysis informed a preliminary proposal for a social energy feedback technology design, which aims at promoting the conscious consumption of energy for our research scenario. Considering each step of the ladder, the analysis made it possible to guarantee that all aspects of the communication between the user and the artefact were taken into account, establishing basis to start the user interface prototyping and also the validation of an experimental architecture.

Chapter 7

Designing to Promote a New Social Affordance for Energy Consumption[1]

7.1 Introduction

The smart grid wave [158] is a manifestation of the need to rethink the way energy has been generated, distributed, and used around the world, especially considering that the natural resources of the planet have already been over-consumed, although not equally distributed among the whole population [168]. Energy companies throughout the world have specific interests in deploying smart grid technologies [31] capable of lowering costs of energy distribution, reducing demand during peak time, etc. Mainly in developed countries, providing more detailed information about how energy has been consumed, a possible feature that might be related to the smart grid technology, has been considered a crucial step for consumption reduction as a response to the pressure for restraining the climate change [31].

In the Human-Computer Interaction (HCI) domain, energy consumption is emerging as an important topic of interest [132] and many different approaches have been adopted to design consumption displays intending to promote a more sustainable individual behaviour. According to the review of energy related-work by Pierce and Paulos [130], other studies that focus on the design and evaluation of energy consumption feedback are situated in domestic upper-middle class population of "developed" contexts.

Some particularities of Brazil have framed energy-related research in the country in the last years, in such way that the importance of the connection between consumption

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and the natural environment by individuals has been underestimated.

Comparing it to other countries, especially to the United States and Europe, the energy is mostly generated by hydro plants, which are less polluting than thermoelectric power, commonly used worldwide [46]; the energy consumption per capita in Brazil is below the world average – in 2009 the Brazilian average reached 2.206 kWh, while the world average was 2.806 kWh; in the United States it was 12.900 kWh and in Europe 6.063 kWh [10].

Nevertheless, Brazil was set in the last position in a 17 countries ranking of a survey that inquired people about the correlation between environmental impact and energy consumption. Asked about factors with a negative impact on the environment, only 27% of Brazilians respondents mentioned individual energy consumption [3]. Results from a survey situated in this research scenario reinforce this panorama. Participants were asked "how do you believe that saving energy might contribute to the environment?" In low-income areas, 85% of respondents said to not know the answer, while only 7% correlated energy usage with new dams or power plant building. These results are related to socioeconomic level of the population, but the "I do not know" answer was in general predominant [127]. The survey, part of two smart grid programs also pointed out the consensual interest (95%) in receiving more information about conscious consumption, as well as the lack of awareness of people's own consumption: in one of the areas, 90% declared not to know the average of their consumption in kWh.

While these numbers provide an overview about how people perceive individual energy consumption and connect it to environmental impacts, 71 new hydro plants have been planned and built from 2008 to 2017 according to the official national plan of energy generation [18], in addition to the 140 already in operation, in order to supply the increasing demand resulting from the economic development and the forecasted population growth.

Coping with this scenario, this study aims at promoting a new social affordance [151][90] regarding energy consumption, which means favoring a new way of perceiving and relating to energy and the natural environment, leading to different patterns of behaviour. In line with [31] and [130], this study intends to take advantage of an experimental deployment of smart grid in Brazil to establish this new relation by means of a technology introduction that has been designed with this purpose. To situate this investigation in the Brazilian context considering socio and cultural aspects in the design, the Organisational Semiotics (OS) [151][90] approach has been the theoretical basis.

In the next session, an overview eco-feedback technology is presented highlighting the need to consider the social context of its usage. Then, we propose the Social Energy Eco-Feedback Technology concept, by mapping the reality into an ontology chart. We also propose a new approach to use this artefact for representing intended behaviour with the new technology design. Further session describes norms that guide the technical device

development, followed by a discussion regarding OS methods and results. The last session concludes and points out future works.

7.2 The role of Eco-feedback Technology

In the energy consumption domain, *feedback* has been defined by Spagnolli [147] as "information about the consequences of household actions that involve electricity consumption", and *awareness* as a condition for conservation, since it represents the "knowledge users acquire about how and why to reduce waste by operating devices more efficiently, including hints that show a larger environmental impact".

Ambient displays, mobile devices, and online visualisations are possible types of Eco-feedback Technology (EFT) designed to incite the transformation of individual's behaviour regarding the environment [52]. The presence of an EFT was found to lead to a consumption reduction between 5 and 20% [31][132].

Froehlich et al [54] [52] evaluated design aspects and motivational techniques for EFT such as goal-setting, comparison, incentive, etc., pointing out some open issues in the HCI area, especially when considering the social domain of the EFT usage, such as the effectiveness of competition as a motivational strategy. In [130], the authors identified works that have raised some criticism regarding the approach that deals only with individual's behaviours, disregarding the social dynamics. Dourish [42] argues that this dominant approach into environmental topics in HCI is self-limiting. Besides addressing cultural and political aspects in the design, he suggests to "connect people through their actions and their consequences", persuading people by the empowerment of collective actions, instead of individually connecting actions to their consequences.

Other studies are also based on social strategies: [76] evaluated the effectiveness of competition, which yielded controversial results regarding this strategy; [37] proposed motivating social environments as one of the mechanisms to involve consumers with the feedback technology. This strategy relies on Social Norms and social proofs, which consider that people act in a certain way to be in line with action of others in similar context [59].

Hall [61] argues that a technical device is the best way to trigger changes in peoples' behaviour. Rokeach [136], and Sanders and Atwood [139] present different experiments where computer and mass media are used to let people become aware of their values. They assert that when individuals become aware of the contradictions between their conceptions of self and their values, attitudes, or behaviour, they will reorganize their values and attitudes, and thus, their behaviour, in order to make them more consistent with their conceptions of self.

In the next session, a social eco-feedback technology is presented, starting from the

concept of affordance, which supports the proposal of a technical solution.

7.2.1 Social affordances and eco-feedback technology

Affordance is a concept associated to how people relate to the environment and to the things that are part of it. Gibson [11] defined affordance in the ecological context as a result of the relationship between physical properties of the environment and the experience of the perceiving actor, which is subjective. Norman applied this concept to design [20] proposing later [18] a distinction between *real affordances* — related to the physical properties of the world — and *perceived affordances*, which instead of that are subjective representations in the mind. Those properties determine how the thing could possibly be used. Taking advantage of it, no labels or instructions would be needed. More recently [19], Norman reviewed the concept centering it in the social domain. *Signifier* is the term Norman proposes to replace affordance, meaning what people need, and what design must provide. *Social signifier* is the most important class of signifier because most actions people do are social. For him, social signifiers are broader and richer than affordances. They include culture and experiences, similarly to Stamper's social affordance idea [90].

Stamper [57] extends Gibson's concept of affordances of the ecological environment to the social environment, arguing that people as agents acting in the social environment are dependent on the knowledge that has been built up and handed down from generation to generation in a society, subsidising the idea of Social affordances as repertories of behaviour tuned to the social environment.

Darby [31] applied Gibson's concept of affordance to understand how householders have perceived and used different types of consumption feedback considering the energy bills and meters, the in-home displays, and on-line visualisations. According to Darby, introducing affordances in the study of the new technology centred the smart metering technology development on the users and in their relation to energy and the new devices.

The concept of social affordance and its nuances in terms of how people relate to the environment and socially interact with it influences the proposal of a technical artefact that aims at changing the way people perceive and relate energy and the natural environment to their actions.

7.3 A Social Energy Eco-Feedback Technology

Differently from most ETF proposals, which are contextualised in the domestic domain [130], this study proposes an EFT that aims at tackling energy consumption collectively, within a social group. The Social Energy Eco-feedback Technology (SEET), or SEETree, due to the metaphor of a tree applied as a signal to connect energy and the natural

environment, consists on a public display and a physical installation located in gathering areas to configure and represent results of energy-saving collective actions. The way the tree is lightened represents achievements of a collective saving action. The SEETree design concept is grounded in the Organisational Semiotics approach as follows.

Organisational Semiotics (OS) is a discipline that studies information and its functions in organised domains, such as a company, a digital system, or the introduction of a new technology in society, as is the focus of this study. SO provides methods and techniques for understanding and modelling information systems, considering social and human activities as part of this system [90][154].

A set of OS methods named MEASUR – Methods for Eliciting, Analysing and Specifying User Requirements [152][153] – supports requirements analysis by considering that an organisation is a system of norms that the members share through signs (information). A norm then is a field of force that influences the members of the community with respect to how they behave or think [149] and can be understood as 'pattern' or 'standard', governing meanings, intentions, knowledge, responsibilities and influence exerted.

In order to propose an information system that intends to promote individual and collective awareness of electricity usage, this study relies on two methods of MEASUR: (i) Semantic Analysis Method – SAM [83]: proposes semantic models of patterns of behaviours (shared meanings) based on agents and affordances, to map ontological dependencies among them; (ii) Norm Analysis Methodology – NAM [153][154][90]: models the social rules identified and specified as the conditions and constraints for realisations of the affordances, considering typical behaviour of research scenario gathered by surveys [127].

7.3.1 SAM and Social Affordances

We subscribe to the notion that the world is socially and subjectively constructed [151]. Considering this, Stamper proposed that Gibson's theory of affordance can be naturally extended to the social world for studying social behaviour, and introduced the concept of social affordance, which has been applied in the OS domain as "a pattern of behaviour that is shared in a social community", has a start and finish time, and a starting and finishing authority [57][90].

In this sense, before promoting a change in the way people relate to energy, it is important to understand current patterns of behaviour, which are, according to literature, mostly unconscious and guided by the environment [74][131]; and according to data gathered in local surveys, they are not directly related to the natural environment people live in [127]. This way, it could be possible to establish target norms, or behaviours that the new technology intends to promote.

The ontology model[2], part of the SAM, maps the vocabulary of the problem domain and graphically represents the nature of reality by ontological (and temporal) dependencies between affordances and agents [151][57]. Agents (graphically represented by ellipses) are affordances that can take responsibility for their actions and actions of others [137]. Both agents and affordances can have attributes called determiners. Figure 7.1 illustrates the ontology model of this study considering firstly the current state (in grey), then the possible future reality by means of a new technology (in white).

In the current reality, a particular Society is the root agent of the model, which means it affords, i.e. determines how we conceptualise and perceive the "natural environment" and the natural resources that the agent Energy generator uses in the generation process, such as water from dams. This energy is then distributed to existing buildings by the Energy distributor, which means that the energy distribution ontologically depends on the natural resources and energy produced by the Energy generator agent. The affordance energy consumption, which is represented in kWh, depends on the distribution and on the agent person (who consumes it) to exist. The Energy metering affordance depends on the consumption and distribution to measure and to show the consumption through its display. Reading this display to generate the bill is an Energy distributor responsibility, while the bill payment is a householder's responsibility. The energy consumption impacts the natural environment via energy generation. However, the person who consumes energy in households, schools, etc., is not aware of this connection.

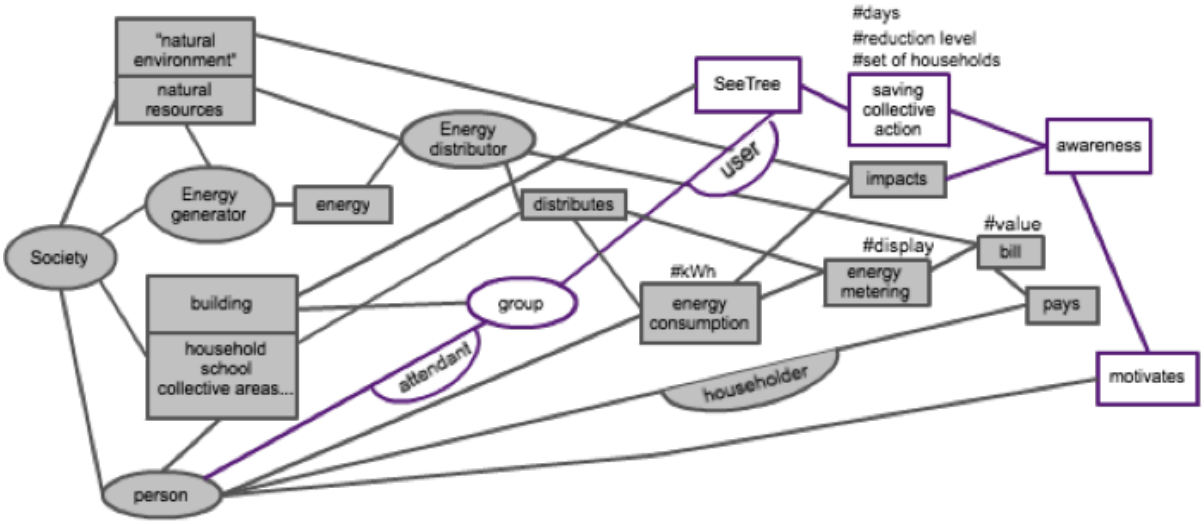

Figure 7.1: The Ontology Chart[2] of the relation with energy and the Social EFT proposal

[2]**Thesis edition note:** More information on the ontology model notation is provided in Appendix C

In the new scenario, represented in white, a public display (the SEETree) appears as an affordance of buildings. It consists on a public installation located in a building that is attended by groups of people. By means of the public display, people may establish an agreement and configure collective saving actions by setting the level of consumption reduction, the number of days to achieve this challenge, and identifying those buildings with smart metering that will join the challenge. The collective action is intended to create an awareness of the impact of the energy consumption in the natural environment, possibly motivating people to more conscious energy consumption; the target people are both: who are part of groups, and those motivated by them.

The ontology chart (OC) in Figure 7.1 differs in some epistemological aspects from a conventional OC [57] [90] or "Stamper's OC" [153]. We thus call the type of OC presented in Figure 7.1 OC for Intended Reality (OC4IR). Table 7.1 lists the main differences between the two types. In short, an OC4IR extends an OC with a part that models a possible future reality that is intended by the designers and possibly other existing or new stakeholders. Since it might introduce new affordances, agents, and ontological dependencies, it is conceivable that there are additional stakeholders in this future reality. The OC4IR is an intermediary document: once the innovation is being designed and disseminated, the OC4IR serves as the blueprint for the next OC that then represents the "new" actual reality. Consequently, it can be expected that the "new" OC deviates in some aspects from the OC4IR, as new stakeholders create a shared understanding of the new reality. For instance, if, for different reasons, awareness of the impact of energy consumption is still not afforded as expected, this will be reflected in the new OC. Furthermore, even parts of the "old" OC might change, e.g., if new stakeholders with new insights are introduced that result in a different shared understanding. The most notable difference between an OC and an OC4IR lies in the "affordances" of the intended future reality.

Table 7.1: Comparing Stamper's OC with the OC for Intended Reality

	Stamper's OC	**OC4IR**
What is modelled?	An ontology in the philosophical sense, i.e. a shared representation of actual reality.	Apart from actual reality, a possible future reality as intended by designers.
Who subscribes the model?	All involved stakeholders.	All stakeholders subscribe to the part that models actual reality, at least designers subscribe to the possible future reality.

	Stamper's OC	OC4IR
Purpose of the model?	To document a shared model of actual reality (the Information System) and to eventually create a computational representation of the technical Information System	- Document the designers' (and possibly other stakeholders') understanding of the innovation task. - Inform design: define new stakeholders, affordances, norms, and assumptions about the future, leading to requirements.
Agent	As defined in [57][151]	As defined in [57][151]; new agents become stakeholders.
Affordance	As defined in [57][151]	Affordances of actual reality (A_{act}) as defined in [57][151]; "affordances" of possible reality (A_{pos}) still need to be established and made perceivable → core challenge of design intention.
Ontological dependency	As defined in [57][151]	As defined in [57][151]
Norm	As defined in [57][151]; prevalence of behavioural norms, expressed in deontic logic.	Additionally: other types / categories of norms regarding intentions, expectations or motivations.

7.4 Norms

An organisation can be seen as a system of social norms, which have the function of determining patterns of behaviour, and whether they are legal or acceptable within the social context, defining a culture. Norms are developed as collective affordances through practical experiences of people (agents) in the society, influencing how people perceive the world, make judgments and possibly guiding their behaviour according to a subjective evaluation of a situation. Norms can be manipulated, applied and disregarded accordingly [149]. Behavioural norms, for example, are described according to the structure of an explicit rule

for a certain community and a certain purpose,
if x then A is (obliged/permitted/forbidden) to do y

where x is some perception of the situation, A is a responsible agent (a person or group of people) and y is the action. The agent A can only act in accordance with the norms of the community for the given purpose if he/she/it has the information necessary for perceiving the situation and the power to communicate other information where the action calls for it [150].

Table 7.2 summarizes norms classification found in OS literature [90][153]:

Table 7.2: Types of norms

Criteria	Types of norms	Description
Formality	Informal	Norms that are known by people who can live according to them without their being able to express them in writing.
	Formal	Norms that can be performed by people following explicit written norms or *rules* which they can be trained to perform in a rather mechanical way .
	Technical	Norms that are handled in this way or are so exactly specified as to be capable of automation.
Aspects of the behaviour they govern	Perceptual	How people receive signals from the environment via their senses through media such as light, sound and taste.
	Cognitive	Enable one to incorporate the beliefs and knowledge of a culture, to interpret what is perceived, and to gain an understanding based on existing knowledge.
	Evaluative	Help explain why people have certain beliefs, values, and objectives. Vary between cultures.
	Behavioural	Govern people within regular pattern.
	Denotative	Direct the choices of signs for signifying; such choices are culture-dependent, such as certain colours to signify happiness.
The effects of their execution	Standing orders	Result in a change in the physical world, because they are commands to perform actions, expressed as one may, may not, must or must not do something.
	Status	Define social structure and legal relations, designating liability, right or no-right over certain events or actions.
	Powers of intervention	Invoke or inhibit the use of existing standing orders.
	Legislative powers	Change other norms.
Types of objects that they are applied to	Substantive	Core business function and operation.
	Communication	Patterns, structures and procedures of communication within an organisation.
	Control	Introduce sanctions and rewards, acting as a mechanism to reinforce that everyone does what he or she is supposed to do, as prescribed by other two types of norms.

According to the Semantic Analysis and the OC4IR, in the next session norms from the actual reality and intended reality are described.

7.4.1 Identified norms and behaviour

In preliminary work [125], a set of norms was identified based on interviews with energy company employees, most of them regarding commercial relationship between customers and the energy company, i.e., how people prioritise energy bill payment among other monthly bills, or reasons to adopt an illegal connection instead of paying for the energy regularly. Part of this set of norms is considered here because they express values and,

consequently, how people relate to energy.

Beyond this qualitative analysis, two surveys done as part of Smart Grid deployment projects also subsidise norms identification. A total of 280 householders members of the projects answered a questionnaire of about 140 questions in the Brazilian state of Minas Gerais, which is partially urban and mostly rural; other 165 householders participated of the survey in the city of Rio de Janeiro, most of them from low-income areas. Interviews were conducted face-to-face by a research institute in 2011 in Minas Gerais and in 2012 in Rio de Janeiro. Results of the survey previously analysed [127] and related to social life, environmental concerns, motivation, and how they relate to energy and to each other in daily life were selected to set norms.

Table 7.3 describes the norms and presents their classification from the Table 7.1, firstly in terms of formality informal, formal and technical levels, then according to the other types of norms. Entities represented in the first part are related to the traditional OC (actual reality), followed by those related to the OC4IR.

Table 7.3: Norms description according to the actual reality and intended reality

Entity	Norm description	I/F/T	Type of norm
Actual reality norms (OC)			
Energy generator	ALWAYS when the energy consumption increases, THEN energy generator MUST produce more energy to supply the demand	T	Standing order, Substantive
	ALWAYS when the energy consumption is predicted to reach the limit, THEN the government HAVE TO plan new power plants construction to generate more energy	T F	Power of intervention
	SOMETIMES, when the demand for energy is close to reach the limit, THEN the Energy generator MUST activate thermoelectric power plants	F	Standing order, Power of intervention
Energy distributor	ALWAYS when a person wants to have energy in a building, THEN the Energy distributor MUST install an energy metering	T F	Status
	WHENEVER when the month is about to end, THEN the Energy distributor HAVE TO read the consumption registered by the meter	F	Substantive
Impact	MOST OF TIMES, when new power plants must be built, THEN new green areas HAVE TO be flooded to create new dams	T	Status

Entity	Norm description	I/F/T	Type of norm
Actual reality norms (OC)			
Householder	MONTHLY, when the Energy distributor sends the bill, THEN the householder HAVE TO pay for the energy consumed	F	Status
	MOST OF TIMES, when the householder pays the bill, THEN he/she SHOULD be aware of the amount of energy they have consumed (they are not[125])	I	Cognitive
Person	MOST OF TIMES, when in contact with people who do not pay for energy THEN consumers MAY believe that they should not pay for energy too[125]	I	Denotative
	MOST OF TIMES, when having incomplete education level THEN a person may not make sense of concepts associated with the energy consumption and its bill (kWh), %, charts[125]	I	Cognitive
	FREQUENTLY, when having a household budget increase THEN low-privileged consumers CAN buy more new domestic electronic devices [125]	F	Evaluative

Entity	Norm description	I/F/T	Type of norm
Intended reality norms (OC)			
Public display	ALWAYS, when motivated to consume energy consciously THEN users MUST receive objective information from the public display about individual consumption that helps them to act accordingly	F	Behavioural, Communication
	ALWAYS, when participating of a saving collective action THEN groups MUST see partial results of the action in a motivating way considering participants household measures	T	Control, Perceptual
Saving collective action	ALWAYS when involved with a collective saving energy challenge THEN users MUST understand the importance of individual contribution to collective achievements	I	Cognitive
	ALWAYS when establishing a collective action THEN users MUST discuss and agree about each user and his/her family commitment	I	Evaluative, Standing order

Saving collective action	ALWAYS when establishing a collective challenge THEN group MUST determine a period to achieve it	T	Behavioural, Standing order
Awareness	MOST OF TIMES when using electricity in the household THEN users MAY think about natural resources consumptions	I	Evaluative, Cognitive
	FREQUENTLY when using electricity in the households THEN users SHOULD discuss about energy consumption and the natural environment	I	Cognitive, Communication
	MOST OF TIMES when interested in preserving the natural environment THEN person SHOULD consider other natural resources, not restricting it to recycling/trash disposal[125]	I	Denotative
	MOST OF TIMES when wasting energy THEN individuals SHOULD relate it to environmental consequences	I	Evaluative, Perceptual
	FREQUENTLY when interested in consciously consuming energy THEN families SHOULD check and discuss about the current consumption[125]	I	Behavioural, Communication
Motivates	ALWAYS when involved with a collective saving collective action THEN users MAY motivate other people in the society to consume more consciously[125]	I	Evaluative
	ALWAYS when involved with a collective saving energy challenge THEN users SHOULD engage their family in the commitment[125]	I	Behavioural
	FREQUENTLY when involved with a saving commitment THEN users MAY want to share their achievements with people they know[125]	I	Evaluative, Communication

7.4.2 Discussion

From the collection of norms, we observe that the actual scenario is mostly constituted by formal and technical norms, while the possible future reality is dominated by informal norms, especially those related to the social psychological view. This is aligned to the intended aim of the new technology design of promoting behaviour change. As for the aspects of behaviour they govern, we notice more evaluative norms in the new set, suggesting more involvement of people in the joint action and collective achievement. Regarding the types of objects that the new set of norms are applied to, there is predominance of communication over control or substantive norms, as the whole scenario inherits the substantive norms of the OC. The norms description also indicates some elements to drive the design (underlined), such as green area, flooding, natural environment, trash disposal, etc.

7.5 Conclusion

The relation between energy consumption and its environmental impact is weak or even almost inexistent in some sociocultural scenarios. This paper presented the concept of Social Eco-feedback Technology, drawing on the social affordance notion and on the analysis of data regarding the connection of energy consumption and the natural environment in Brazil. This approach to energy feedback differs from those in the state of the art firstly by dealing with low-income areas in a developing scenario, and then by proposing a collective interactive solution for a public area.

The analysis and design process have been based on Organisational Semiotics artefacts, which helps to analyse information systems and the introduction of a technology within a social dimension. To consider the possible future influences by this technology, an adaptation of traditional artefacts of Organisational Semiotics was made. Further work involves designing a system that enables the informal and formal norms regarding collective saving interaction and then evaluating the technical solution proposal with regard to its potential for promoting the intended social behaviour change.

Chapter 8

A Socially-inspired Energy Feedback Technology: Challenges in a Developing Scenario[1]

8.1 Introduction

Making people aware of the planet's natural resources limits has been a concern of contemporary society worldwide. This challenge encompasses knowing the way energy has been perceived and consumed, evidencing and sometimes establishing the connection between daily activities and habits to eventual consequences to the natural environment.

Investigations related to the potential of feedback technologies to mediate this awareness process have emerged recently in the Human-Computer Interaction (HCI) domain, as for example, introducing concepts of Psychology to motivate people [117] and to promote changes in behaviour [66]. But beyond personal values and willingness, culture and socioeconomic aspects are external forces that also influence perception and consumption of energy [125][41]. Moreover, literature review presented by Pierce and Paulos [130] shows that the current scenarios of the investigations have not represented social diversity, being mostly situated in domestic environments of developed areas [41][130]. This study aims at contributing to tackle this issue by proposing and evaluating a technology designed to raise energy awareness collectively, targeting a social group of a low-income area in the Brazilian city of Sete Lagoas, where smart-grid technology has been recently deployed.

Brazil has been considered a good example of clean energy generation to the world. However, the developing scenario that increases the purchase power of the mass seems to increase consumption instead of saving it [122]; people may feel motivated to buy new

[1] **Article submitted to an international journal.**

electric domestic appliances, requiring additional strategies to supply the demand for more energy in certain areas. An official recent modification in the energy bill for informing the energy generation condition and resulting variation in monthly prices makes visible this issue [9]. Thermoelectric generation beyond the regular predominant hydro plant production increases the energy price [9], and pollutes the air. Yet, a considerable part of the population may not even realise that this new reality is harmful not only monetarily but also to the natural environment. As evidenced by quantitative surveys in [127] and [3], the association between energy consumption and environmental impact is unclear or totally unknown by most people.

Coping with this scenario, a *Socially-inspired Energy Eco-Feedback Technology (SEET)*, which is composed by an interactive system and a tangible device, has been conceived and designed taking into account both motivational and sociocultural aspects. The Self-Determination Theory (SDT) [35], a motivational theory that considers intrinsic sources of motivation as well as the external forces, has been considered to inform the design. The Organisational Semiotics [90], an approach for understating information in a social context, has shaped the analysis of sociocultural elements.

This paper focuses on the evaluation of the SEET, how it has been perceived and its potential impact to promote social awareness towards energy usage. The SEET evaluation was carried out during a week in a public elementary school involving directly 24 students, and intended to impact aspects of daily life of participants and their social groups, surpassing a controlled research environment.

As also noticed by [41] when studying energy consumption in a low-income area in the US, real-world issues like safety or the community organisation influence participants' perception, motivation, and actions. Such context requires from researchers to deal with issues that go beyond the technical ones shedding light on the social aspects of the evaluation.

This paper is organised as follows: the next section summarises studies of technologies to raise energy awareness mainly in social groups. The design process of the SEET is then briefly described to contextualise the planning of the evaluation scenario in the following section. In the sequence, we present and discuss the results, to finally make our conclusions.

8.2 Related work

Energy-related HCI studies, such as [117], [66] and [79] have mostly focused on aspects of providing feedback in the home environment [130]. As part of a study related to energy management system design, the authors in [14] also recognise the smart grid deployment as an opportunity to raise awareness of energy consumption by overcoming the current need

to uniquely rely on the monthly bill to monitor consumption, considering the difficulties associated to reading the traditional meters, which are not always physically accessible and subject to misinterpretation.

Studies addressing individual consumption have been grounded on theories from Psychology, such as [66] that considers stages of behaviour change, and [117], which relies on personal values towards the environment to guide user interface personalisation. Design and evaluation of artefacts for raising energy awareness of groups have been found in literature for joining employees in workplaces [77][68], promoting collaboration among neighbours [15], and involving students [159][19] in energy saving initiatives.

Watt-Lite [77] used three oversized torches to project real-time energy consumption statistics on the floor of a factory. The evaluation indicated the importance of placing the installation in sociable areas, such as those close to a coffee machine, and suggested that the situated engagement is not a guarantee of further online engagement with the subject. Also in the workplace, [68] proposed an animated public display using the metaphor of a tree as a symbol of carbon sink, representing the building footprint. A sequence of images with trees varying between green and grey meant the amount of water, energy, and the equivalent CO_2 emitted according to the building automation system. The impact of the installation was not discussed.

Motivating savings by the action of neighbours and consequently reducing the demand for energy generation is the aim of [15], which evaluated different design alternatives, such as displaying daily gathered consumption data on the street. During the month of the study, the consumption was reduced in 15%. Other study [84] evaluated water consumption displays integrated with sensors to encourage savings both in public faucets and private showers. The display promoted 30% of decrease in average shower times, but it increased consumption in public faucets due to the interest of people for the technology in use.

Both investigations involving students relied on competition to engage participants. In [159], 50 schools competed for reducing their buildings consumption. The schools ranking is presented in a website that also supports saving energy by teachers and students with recommendations. In [19] and [76], the impact of competition on energy savings was evaluated in a students' residence in Hawaii. The strategy promoted savings, but also has led to unsustainable behaviour due to the strong will of winning the competition [76].

Studies for understanding how people relate do energy in developing scenarios were found in low-income areas in the US [41], and in India [164], the latest focusing on sustainable domestic practices. Studies of domestic consumption situated in Brazil were found, such as [28], but not applying technology to raise energy awareness.

By aggregating findings from literature, this research investigates a technology composed by an interactive system and a tangible device to promote energy awareness collec-

tively. The impact of this technology on the engagement of Brazilian children with both the interactive system with ludic aspects and a tangible feedback artefact is evaluated.

8.3 The design of the Eco-Feedback Technology

In line with the Socially Aware Computing approach [11], the *Socially-inspired Energy Eco-Feedback Technology (SEET)* was designed for and evaluated by users in a social group in the city of Sete Lagoas, where a smart-grid deployment project was taking place. A combination of perspectives involving motivational and sociocultural aspects has been applied to inform the design process, synthesized in the following steps:

1. After analysis on Residential Eco-Feedback design found in literature, the Brazilian scenario with external factors that might influence the perception of energy, as well as the willingness to monitor and reduce consumption [125] was considered in a requirements study;

2. The set of preliminary requirements was then reviewed with the motivational lenses of the SDT [124], suggesting aspects that should be strengthened to promote Autonomy, Competence and Relatedness, the main concepts associated to motivation according to that theory;

3. The metaphor of a tree connecting energy and the environment and other design elements resulted from a workshop on the subject, conducted with HCI students in the role of designers [126];

4. The analysis of the Brazilian scenario according to the 10 areas of culture by Hall [61][122] resulted in implications to design, such as highlighting the importance of personalisation and contextualised elements to empower users to protect the environment;

5. An analysis of a quantitative survey that inquired how people in the area of Sete Lagoas about the way they relate to energy, typical appliances they have, their motivations for saving energy, among other questions was conducted. The analysis was based on the Semiotic Ladder [127], an Organisational Semiotics artefact [90], leading to a social and collaborative architecture, and to design guidelines such as "promoting collective instead of individual actions", "informing about the need to build new dams and power plants to supply energy demand", and "making energy tangible".

6. Analysis of behavioural norms from the Organisational Semiotics perspective, and identification of intended behaviour promoted by the technology, resulted in the concept of the SEET [121]. Some examples of intended behaviour norms description defined in [121] are:

"ALWAYS, when participating of a saving collective action THEN groups MUST see partial results of the action in a motivating way, considering participants household measures."

"ALWAYS, when establishing a collective action THEN users MUST discuss and agree about each user and his/her family commitment."

"ALWAYS, when establishing a collective goal THEN the group MUST determine a period to achieve it."

Figure 8.1 illustrates the steps of the SEET design process. The requirements in step 1 were refined in the step 2. Together with the steps 3 to 6, they informed the design of the SEET.

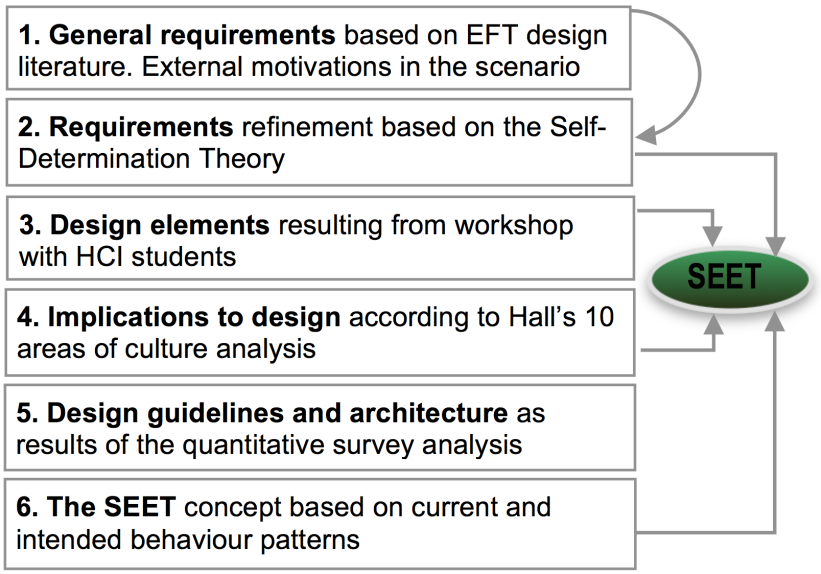

Figure 8.1: Steps of the SEET design

8.3.1 The Energy Tree

The Energy Tree was then created to tangibly represent energy savings. The seven branches of the led-lights tree, which is solar powered, are lightened on progressively, representing accumulated results of collective energy savings.

The tree was handcrafted. Typical Brazilian pastry cups compose the flowers. The controller is based on the Microsoft Gadgteer Fez Spider Kit (Figure 8.2). This device was then joined to a public interactive system designed for gathering areas constituting the SEET.

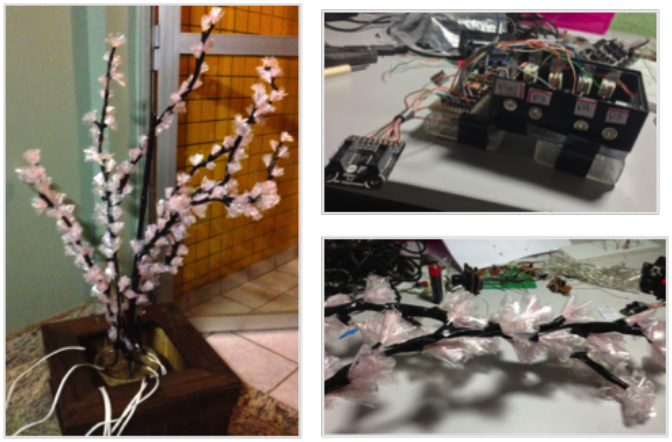

Figure 8.2: The handcraft tree

Through a game style interactive system, groups of users establish the level and the number of days of an energy saving challenge. On a daily basis, they can check their achievements represented both by the number of branches lighted on and by the number of flowered branches in a virtual tree.

The most important psychological needs to trigger motivation in the SDT perspective – *Relatedness, Autonomy, and Competence* – were considered in the user interface (UI) design as described in what follows.

Relatedness

Relatedness refers mainly to strengthening the sense of group to promote collective awareness. Figure 8.3 is the UI for groups of users establishing a saving challenge by determining the quantity of participant households (from 5 to 10), the number of days for the challenge (from 3 to 10), and the level of savings hopefully to be achieved. Users are guided by a description that mentions typical appliances and how they are used. It is expected that the participants discuss their perception of their household consumption to define the parameters consensually.

Figure 8.3: Challenge creation UI (in Portuguese)

Autonomy

Autonomy refers to acting in line with values and beliefs. Establishing a stronger connection between technology and users, and empowering them are strategies applied to promote autonomy.

Connecting technology to the users environment. Users name the group and choose a tree among popular species in the region to represent them. The tree status can be checked online and also via webcam, as illustrated in Figure 8.4. Users can also publish their savings results on the project Facebook page.

Figure 8.4: Webcam visualization UI (in Portuguese)

Empowering users. Figure 8.5 shows the current status of three groups randomly selected. The water level in the forest representing "the new dam" means savings results

of all the groups, promoting the idea that everybody needs to contribute to effectively protect the environment.

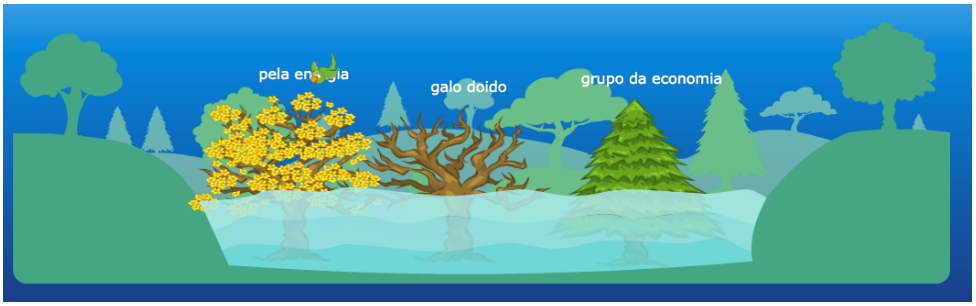

Figure 8.5: The forest UI, with results of 3 groups

Competence

Competence means to propose activities compatible to users skills, interests, and opportunities. Some aspects considered aiming to promote competence:

Making it feasible. Simulations considering the typical consumption in the region and concrete possibilities of reduction were taken into account to determine possible levels of savings to be chosen by users. Too ambitious target may lead users to give up, and too easy might not incite critical thoughts.

Different interest levels. By clicking on the bulb, an always-on link (Figure 8.3), the more interested users access hints and extra information, i.e. about the smart meters functioning, estimated number of trees needed to compensate the CO_2 emitted monthly to light the city, etc.

Avoiding failures. The system is prepared to overcome eventual missing energy readings. As a matter of exception, by inputting a sequence of zeros, the daily consumption is considered the daily baseline reduced by 1%, a symbolic saving. The manual input of readings is also available for those participants without the smart meters installed.

8.4 Experimental setting

The experiment aimed to evaluate: 1) How the children make sense of the SEET; 2) Whether the SEET was effective to promote a new perception of energy consumption and conservation within their social group.

8.4.1 The scenario and participants

The study took place in a public elementary school centrally located in a smart-grid project's geographic area. Most of the students live in the surroundings, sharing the same socioeconomic background and potentially having new smart meters installed at home.

Around 40 students from 8 to 11 years old were invited to participate. A total of 24 children returned a signed authorisation by the parents or guardians, also stating their last month consumption as the baseline. Parents were explicitly informed that their home consumption would not be published and that the children should count with the family collaboration during the week of activity.

8.4.2 Schedule

The SEET was installed in the school's library (Figure 8.6) for the whole week. A TV was used as a big monitor for the interactive system. Besides interacting with the system, the students participated of group activities and system evaluations in an informal and enjoyable way.

Figure 8.6: The tree in the school library

From Monday to Friday, the activities followed the following script:

- Day 1: A focus group discussed the need of energy for performing daily activities, current behaviour towards savings within the family, and identification of waste. They were also asked to discuss about the functioning of the hydro plant, thermoelectric generation and how they impact the environment. The teacher formed groups of 4 or 5 people randomly chosen to set the saving challenges. The students received 3 tangible artefacts: (1) a list of actions that consume an average of 1 kWh, e.g.. having a 17 min shower, 10 hours of TV, 45 min of hair dryer; (2) a form for checking the actions they were committed to perform; (3) a form for writing down daily readings from the meter for those who did not have the smart ones.

- Day 2: The saving challenges creation. The interaction with the SEET was observed by the researcher and evaluated with participants in terms of design elements.

- Day 3: Participants checked their tree status and input the daily readings. The groups discussed their motivations to participate by answering together a questionnaire [60] about their internal and external reasons to be part of the study.

- Day 4: After entering new readings and checking the tree status, participants in groups evaluated the affective quality of the interaction with the SEET [17], and individually responded to the Intrinsic Motivation Inventory [143]. A sample of parents/guardians was interviewed regarding the influence of the activity in the students' family behaviour.

- Day 5: After entering the last reading, the groups checked their final performance in the challenge. Then, they answered a short questionnaire about their perceptions of the activity as a whole. A new focus group discussed consequent changes in the family behaviour during the week, with some testimonials of participants. The school pedagogical coordinator and a teacher were then interviewed evaluating the study setup from the learning perspective.

8.4.3 Savings – low levels

The preliminary quantitative survey [127] was made with households in the area, providing statistics, sociocultural data and energy consumption patterns, essential information to setup the experiment.

The average monthly consumption in the area is 150 kWh, (~5 kWh per day), while the average monthly in the US is 1000 kWh and in the UK 500 kWh [10]. This fact, in addition to the short-time nature of this experiment, suggested that it would be impossible to be precise in terms of savings calculation. Just a symbolic level of savings could then be expected. Thus, raising awareness was the main target instead of assessing savings,

and this was not considered a critical constraint, as in general, people usually think in their consumption at a higher level [104].

Following the consumption simulation results, three levels of savings considered feasible were proposed: Basic level - 3% of reduction, Medium level - 4%, and Radical level - 6%. In an average house example (150 kWh/monthly), the radical level means 1.2 kWh less in the four days of the challenge.

8.5 Execution - dealing with the wild

8.5.1 Students participation

The simple invitation to be part of the experiment brought sensible issues into discussion at school, such as the illegal connections for stealing energy, the reason given by some parents who did not agree with the students' participation. This region is also considered at social risk due to drugs traffic, which interferes in the community life. Teachers had to carefully touch these sensitive topics in terms of values in order to deal with any potential of embarrassment.

Even being centrally located in the smart grid area, a great part of the students belong to a less privileged social group, which was not prioritised to get the smart meters. This required these participants to visit the meter every morning for taking notes of the readings.

8.5.2 Initial perceptions – connecting energy to water

In line with results of the quantitative survey [127], the initial focus group evidenced that children in this scenario relate energy to water, but the way this connection happens is unclear to them: "it is going to have more remaining clean water if we save energy". Participants did not know how to explain the energy generation process and argued that by saving energy they save water. The dams, traditionally part of hydro plants in Brazil, were not mentioned for the hydro plant generation, and the image of a thermoelectric power plant was not recognised by them as a generation process.

Participants did not identify high levels of energy waste at home. Keeping the TV on when leaving the room and constantly opening the fridge are examples of mentioned waste. The electric shower, the typical villain in the energy bill, was not cited in the focus group.

8.5.3 Evaluating the interaction

The collaborative approach

All groups started the negotiation to set the challenge by arguing pro the *Radical level* of savings. All but one group changed to the medium level when they realised that the impact would be in their house, which requires the family collaboration. *"But we consume few"*, argued a participant reading the guidelines from the UI. Another topic of discussion for all the groups was the type of the tree. All of them changed the original, and the criterion for the groups was to find different ones. They wanted to create their identity.

The fact of being a public system setting required from them some negotiation about who would be in control of the interaction. They spontaneously shared the control between two people in each group; one controlled the mouse and other the keyboard, and most of them passed the keyboard to the person at the moment to type their own name and their energy readings. However, this aspect was the only suggestion of improvement in the study when the activity finished: *"I think everybody should use the computer the next time"*.

The bulb with short hints linking to more information was not accessed spontaneously. When invited to explore the link, a typical reaction was that one participant read the content loudly to the others.

The image of a flooded forest represented the need of everyone's contribution for protecting the environment effectively (Figure 8.5). As the process of hydro plant generation was not familiar to the students, initially they were intrigued by the representation, but when explained they quickly made sense of the collaborative meaning.

The tree as a tangible device

The tree became the absolute symbol of the study, which was constantly referred by the teacher and students as "the tree activity". The novelty aspect of the technology called children's attention and also instigated their curiosity to understand the functioning. *"How does the tree know how much we consume?"* was an example of questioning from kids to the researcher.

Some participants came to the physical tree to check whether the number of branches was matching the virtual tree results. However, in the last two days of the activity, they needed to be reminded of the presence of the physical tree. The interactive system and the social aspect of the activity (collaboration and competition) became certainly more important to them than the tangible device itself.

Experienced emotion

Participants' emotions related to the interaction were assessed by applying a pictographic questionnaire based on the Self Assessment Manikin – SAM [17], which evaluates three dimensions of emotions: valence, representing a positive or negative feeling caused by the experience; arousal that means the level of excitement or boredom; and dominance, the feeling of being in control of the situation. Figure 8.7 presents the result of the assessment, in which 1 represents the most negative answer and 5 the most positive. Results were highly positive, excepted by the arousal, which received lower values possibly due to the interaction in groups of 4-5 people, limiting the possibility of everyone to be in the command of interaction.

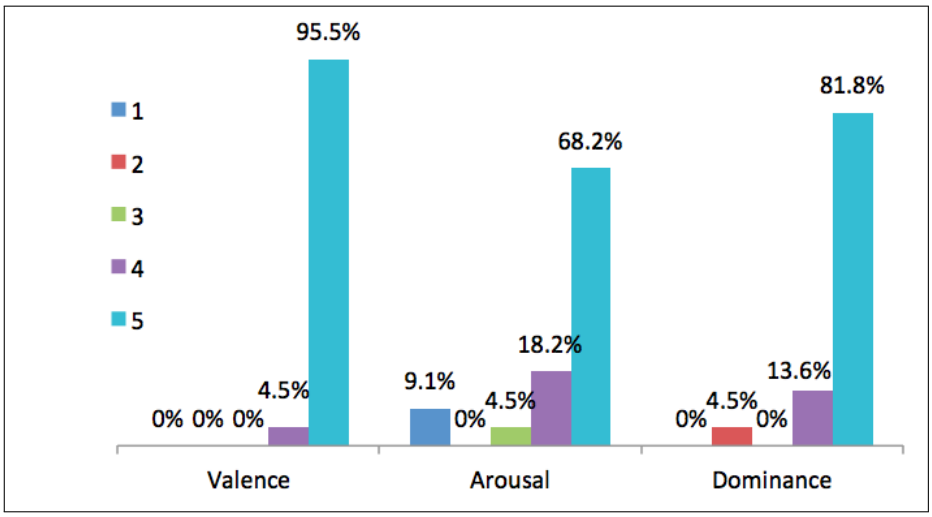

Figure 8.7: Results of the SAM evaluation

A similar assessment approach was applied for the design elements (Figure 8.8), confirming the positive feelings towards the system by the evaluation of the full home page, as illustrated in Figure 8.9. Different types of trees, including the physical one, were also evaluated. As expected, the "empty" tree, with no flowers, received a negative response, but the physical tree was no better evaluated than the virtual ones, suggesting that users considered the setting as a whole.

8.5.4 Motivation

Two validated questionnaires of SDT [35], our main reference regarding motivation, were applied for assessing individual and group motivation. These questionnaires were translated to Portuguese, although not being validated according to the psychometric approach, as the sample size was not enough to provide findings to the Psychology field. Instead, the

Figure 8.8: Example of evaluation of design elements

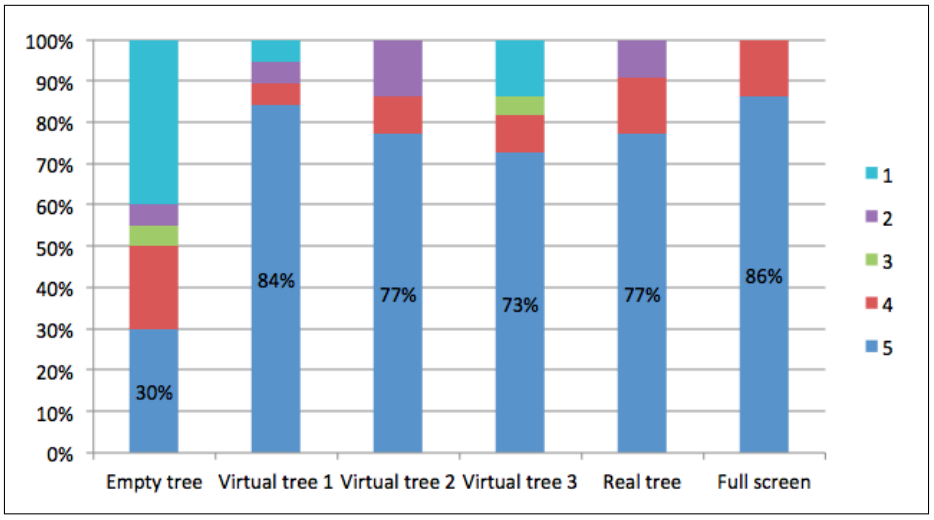

Figure 8.9: Results of design elements evaluation

objective was to evaluate whether the participants were behaving intrinsically motivated or not, and how it could impact their perception and participation. Understanding how these motivational assessments contribute to design was also an indirect goal of the study.

Different sources of motivation

The Elementary School Motivation Scale (EMS) [60] was proposed to assess different types of motivations in young elementary school children from 8-11 years old, checking whether they are acting: a) intrinsically motivated (congruent with values and needs); b) identified regulated, when they identify externally the reasons for performing behaviour, such as the importance of learning; and c) controlled regulated, as a response to internal pressures such as obligation or guilt. The groups had to choose among (1) *always no*, (2) *sometimes no*, (3) *I don't know*, (4) *sometimes yes*, and (5) *always yes*, in a two-part response. First they say yes or no, then indicating if always or sometimes. *"I don't know"* was the last option if the group does not provide any answer, which did not happen. Table 8.1 provides the overview of this evaluation, with the general average score for

each statement and the standard deviation. Results confirmed the high scored intrinsic motivation (4.6 of 5), also the high level of identified regulation (external value) (4.7 of 5), and a lower controlled regulation (3.7 of 5) on using the SEET.

Table 8.1: EMS application results

	Mean	**SD**
Intrinsic Motivation	4.6	1.02
I like using the Energy tree	4.6	0.49
Using the Energy tree interests me a lot	5.0	0.00
I want to use it even when I don't have to	4.2	1.60
Identified regulation	4.7	0.44
I can learn many things using the Energy tree	5.0	0.00
I choose using the Energy tree to learn many things	4.8	0.40
In life, it's important to learn how to use technology	4.4	0.49
Controlled regulation	3.7	1.53
I use the Energy tree to get a nice reward	3.8	0.98
I use the Energy tree to please my parents or my teacher	3.2	1.83
I use the Energy tree to show how good I am	4.0	1.55

Individual Motivation Inventory (IMI)

The IMI applied was adapted from the 9-item version with three subescales: interest/enjoyment, perceived competence, and pressure/tension [143]. Interest/enjoyment is a self-report measure of intrinsic motivation; perceived competence is also a positive predictor of intrinsic motivation related to how adequate the interaction was to participants' skill; and pressure/tension a negative predictor of intrinsic motivation related to external factors. Although the results are limited in statistical terms (high standard deviation) due to the small sample of the study, Table 8.2 presents the general analysis of the IMI application considering the average score, median, mode and standard deviation. Once again, results suggest that the participants had, in average, highly intrinsic motivated behaviour (6.48 of 7), considered the activity suitable and challenging in a reasonable balance (6.09 of 7), and felt low external pressure (2.98 of 7).

8.5.5 Engagement

Unexpectedly, only two participants had smart meters at home, requiring from the majority to manually enter the energy readings during the challenge. Half of the students made all the readings, while only 4 skipped all of them. Among these four, one reported having

Table 8.2: Results of the IMI

	Mean	Media	Mod	SD
Interest / Enjoyment	6.48	7.00	7	1.54
Perceived Competence	6.09	7.00	7	1.84
Pressure / Tension	2.98	1.00	1	2.54

an illegal connection and the other had the energy connection blocked by the utility due to non-payment.

Those who visited the meter for the readings not always took to the school consistent annotations. The main reason of the misreading was an unexpected diversity of meters equipment with different number of decimal places. The paper form and the UI were designed to fit a digital meter with 3 decimal places, informed by the utility as the only one existing in that region. Figure 8.10 illustrates an example of inconsistent daily note. The numbers were supposed to be incremented in few kWh day-by-day due to the cumulative aspect of the meter.

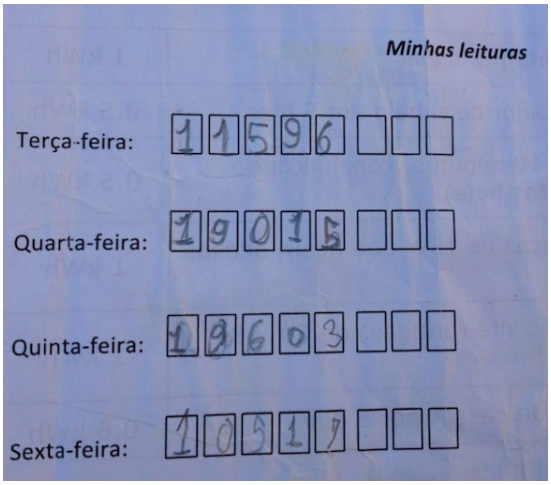

Figure 8.10: Example of inconsistent reading note

Competition (and cheating) and comparison

The children expressed extreme disappointment (one even cried!) when informed that their readings were eventually wrong. When the alternative input (the sequence of zeros) needed to be typed to overcome it, participants felt like failing. It was not the only reason

why children started cheating. Some pretended they memorised the readings and created false numbers to not be blamed by others as the one that caused the group to fail. Some participants wrote down lower numbers than previously and also tried to enter wrong numbers on behalf of other groups.

Known as a controversial motivational strategy from literature [19][76], the competition among groups was not promoted in any circumstance, but it was clearly a motivation for them to feel engaged. Not only winning the competition was valued as important, but having a prize or reward too. Frequently, participants asked: *"Will those who completed the tree earn something?"*. The teacher also suggested providing some symbolic award to fit their expectation. A real seedling of flower was then offered to the groups that completed the tree, and all participants received a thank-you note with a small gift.

As stated by [52], the social comparison was noticed as an important strategy to evaluate individual performance. Participants constantly compared their numbers among the group during interaction and regularly navigated through the system to check the tree of other groups.

When the group that completed the tree noticed that, they brought all the students to the library to show their achievement.

8.5.6 Engagement – a mobile target

The socioeconomic reality of the considered scenario had announced the possibility of low level of savings during the study. Indeed, the few appliances and controlled use they make of them in most of the houses made it unfeasible to precisely assessing reductions in that period. Some students reported changes like *"I'm now disconnecting the mobile phone from the recharger as soon as it is recharged"*, an important collective action but not enough to be measured individually. Short-term experiments are also vulnerable to external factors, such as a blackout in some areas of the city, as happened during the activity, possibly lowering most of the consumptions.

These facts, in addition to the unreliable reading data participants brought, have led to a change in the criteria adopted to turn on the branches of the tree. Participants could see the tree as a feedback of savings until the 3rdday of the challenge. Then, their "engagement" with the activity was considered to calculate their final performance instead. Engagement here is understood as their participation beyond interacting with the system, but bringing their daily readings and participating on the debate in and out of the school. The group that most contributed with the readings was the reference to light on all the tree branches and to calculate proportional results for the other groups.

Results by group

Table 8.3 associates groups' engagement with the mean of their motivational assessment as an attempt to correlate these factors. G2 and G5 were the groups that completed the challenge with the whole tree lighted on, and G3 was the group with lower participation. Despite being applied for groups, differently from its conception, the EMS seemed to better represented engagement compared to the IMI. A possible explanation is that individual responses are more variable, and the sample is not representative enough to express a collective perception.

Table 8.3: Synthesis of motivation evaluation by groups

		G1	**G2***	**G3**	**G4**	**G5**
Participation		67%	**80%**	33%	60%	73%
IMI (1-7)	**Mean of Interest**	7.0	6.4	6.3	6.6	6.3
	Mean of Competence	6.0	5.8	5.4	5.0	5.4
	Mean of Pressure	2.9	3.0	3.3	4.1	4.6
EMS (1-5)	**Intrinsic motivation**	5.0	4.7	3.3	5.0	5.0
	Identified regulation	4.7	5.0	4.3	4.7	5.0
	Controlled regulation	4.0	**5.0**	2.0	3.0	4.3
SAM (1-5)	**Valence**	5.0	5.0	5.0	5.0	4.75
	Arousal	4.6	4.0	4.8	4.75	**3.5**
	Dominance	5.0	5.0	**4.2**	4.5	5.0

The high level of controlled regulation of G2 suggests the importance of rewards expressed by the participants, evidencing that intrinsic motivation is definitely important. Nevertheless, external forces also play a significant role to engage students in such initiative that requires effort beyond the classroom.

Results of SAM represent the overall experience of each participant. It reinforces the positive view of the technical artefacts by the high levels of valence and dominance, which in line with Competence of IMI reflects the adequacy of the system to participants' abilities. The low level of arousal of G5 has a possible explanation by their explicit interest to be in control of the interaction. In addition, they also expressed the highest level of pressure that might have had some influence.

8.5.7 Raising energy awareness

Turning off the lights and reducing the time of keeping the TV on were the most mentioned actions towards savings resulting from the activity. A student reported that took the chronometer to the bathroom to measure the showering time, one of the most valuable behaviours towards savings in that scenario.

Another student brought some educational content provided by the utility in the past and asked the teacher to explore it with colleagues in the classroom. This is an evidence of the study impact on raising energy awareness not only among the participants, but also within their social groups.

8.5.8 The social impact – stakeholders involvement

Publishing the challenges creation and achievements on Facebook with pictures of the groups, when authorised by the parents, revealed to be an important tool to engage the family. Some students spontaneously took note of the Facebook address to show to the parents. Attracted by seeing and sharing pictures of the children, some started to follow the online activities. Others called the school asking more details about the tree functioning after seeing it on Facebook. It is worth mentioning that around 77% of Internet users in Brazil have a Facebook account [71].

The families

A sample of 5 parents/guardians was interviewed. All of them mentioned that the child explained about the tree functioning to the family and asked for their help to read the energy meter, except the participant with the smart meter that explained about it to the family instead. The mother of a participant who did not bring the readings admitted that the reason was that the house had been without energy during that time due to the non-payment, creating some embarrassment to the child. All the others reported that the children were aware of their consumption during all the study and were requiring other people's attention for savings: *"every time she sees something turned on, she says "no... my tree needs to be lightened!"*, reported a parent.

However, not all effort by the children was welcome in their homes. One parent said to feel annoyed by the child behaviour: *"she tries to convince us all the time, but nobody listen to her (...) we are tired when we get back home, and we don't want to pay attention to that"*. Another parent told that the child behaviour incited a fight among the family. An uncle, who is the one responsible for paying the energy bill, complained about the children alerts about waste.

At school

The presence of the tree in a gathering area was also an important element that impacted the social group beyond participant students, eliciting the topic among other teachers and raising other students' interest to be part of the activity.

When asked about their perception of the study, a teacher and the educator responsible for the school highlighted the motivational impact of the tree that triggered more than interest but excitement by the students during all the week. *"The interest and responsibility of the kids were impressive!"*, said the teacher. They were also surprised by the families' involvement particularly via Facebook. Both interviewees mentioned the social problem of illegal energy connection that prevented some students to participate and the consequent bad feeling. Despite that, both stated the desire to repeat the experience with other groups.

8.6 Discussion

Motivational aspects: Considering the high level of intrinsic motivation assessed, which according to the SDT [35] is directly associated to Competence and Autonomy, it is possible to assume that the SEET design and the experiment setup were adequate in terms of content and presentation for the participants. Changing the current dynamics in order to involve everyone in the control of the interaction, thus, is an aspect that might be improved to strength individual commitment with the group.

The intended collaborative aspect of the SEET was clearly understood, as observed during the negotiation when creating the challenge and along the interaction. However, the competition aspect emerged spontaneously even not being intentionally promoted. As also reported in literature [76][52], it was an external force to engage users but with side effects. A student reported that he opened the circuit breaker of the house for having significant savings, since his family was not willing to contribute. As similarly reported by [76], it demonstrated interest and engagement but will not necessarily change his energy awareness or his attitude towards conservation. The motivation assessment also confirmed the participants' interest for being rewarded. According to [124], rewards can be an interesting trigger but cannot be considered as a longer-term incentive.

Social aspects: As pointed out in previous study [125], the socioeconomic scenario brought illegal connection and non-payment aspects to light. The stakeholders (teachers, school director, researchers, and parents), though, must be prepared to deal with these facts. The authorisation for participation was sent in advance requiring from parents to write down the official number of the meter, suggesting that a connection with the utility database would be made. So, parents could address the topic in advance at home, but the discussion emerged at school among kids that wanted to be part of the activity in any circumstance; teachers had to deal with the values involved in the question. An association with the utility could be made in order to provide an opportunity for these households to be welcome as legal customers if they desired to [125].

Some children demonstrate a sense of frustration for not being able to fully motivate

the families' engagement. Additional artefacts or tools could also be developed to empower students when spreading the message to the family members in the household. Online games that engage the family are examples of strategy that could motivate people that are indifferent to the subject [125].

The Energy Tree role: Results indicated that the tree itself was not the main reason for the high motivation (according to the design elements evaluation). Instead, it worked as a trigger for the subject under discussion. For [49], triggers are important to persuade people by means of a technology.

For the reasons already discussed related to data inaccuracy, the tree representing engagement instead of savings worked better to the main target of raising energy awareness. As also stated by [76], dealing with imprecise measurements and baselines are critical factors that make the savings calculation unreliable. Ideally, the criteria to calculate the feedback of the tree should consider two dimensions, savings, even being symbolic, and engagement.

The original idea of calculating savings to light on the tree would be still possible in a homogeneous scenario in terms of types of meters, in larger scale and/or longer term, minimising the effect of external events. Areas with higher consumptions more likely to waste energy fit better the original purpose of the tree.

Making it tangible: Differently from the triggering effect of the tree, the paper form for annotating the readings had a crucial role to keep the experiment during the week. It made the activity tangible, reminding students about visiting the meters daily, and made clear the sense of responsibility from them in keeping the paper for many days. They considered the form as a necessary tool for being active in the study. Instead of being a constraint to the experiment, having to read the meter daily was a positive aspect to engage the students and their family, considering children needed help from adults to make the readings.

Overall perception: Children had a very positive perception of the study according to the answers to a final questionnaire. The cloud tag in Figure 8.11 represents the most frequent words in the answers. Cool, Saving, Love it and Liked it are highlighted. The positive affective feedback was reinforced by thank-you cards offered by the students to the researchers, as illustrated in Figure 8.12. In detail, the card on the top-right refers to the value of learning about saving energy and environmental protection (in Portuguese), while the one in the bottom represents the tree 100% completed.

8.6.1 Limitations of the study and their implications

The wild scenario of the study brought some constraints related to data accuracy that limited contributions; nevertheless, the same scenario showed us conditions that could not

Figure 8.11: Cloud tag of participants' feedback

Figure 8.12: Thank-you cards offered by the participants

have been anticipated and are essential to any real action to be effective regarding the subject addressed (the concept of energy, energy saving, energy relation to the technology and the environment).

Comparing interest and engagement between households with the smart meter and those without it might lead to interesting results, but the small number of participants with smart grid at home restricted such analysis that can be part of further investigations.

The main constraint of the study thus was the impossibility to associate consequences of individual consumption to a direct representation in the tree due to the extreme low level and imprecise savings calculations. Despite that limitation, the potential to discuss effects of minor behaviours and the capability to raise energy awareness were preserved, mainly due to the collaborative aspect of the activity.

Although change behaviour effectively can be considered the final target of an Eco-Feedback Technology such as the SEET, this study concentrated the efforts on the first step of this process, which is raising awareness in a social group.

8.7 Conclusion

This paper reported and discussed results of a study on a Socially-inspired Eco-Feedback Technology (SEET), aiming at promoting energy awareness collaboratively by means of an interactive system and a tangible artefact. Motivational aspects from Psychology and local sociocultural data informed the SEET design, which was evaluated with a group of students from an elementary school. The tree (tangible and virtual) as a feedback was an essential element to trigger motivation, but some daily commitments (reminded by the paper to be filled out) kept it going on. The need of collaboration to achieve significant results was a message clearly perceived and promoted by participants. Despite of the families' involvement, students did not feel empowered enough to change the way of thinking of their family. Competition among groups naturally emerged, reinforcing the need to better understand the potential of group dynamics for promoting a social change.

Considering contextual cultural and socioeconomic aspects was crucial to properly setup the technical solution. Even so, the investigation wild scenario shaped the way the study was conducted; for example, required a change in the meaning of the feedback provided by the Energy Tree from savings to engagement, and revealed conditions that could not have been anticipated and that are essential to any real action to be effective regarding the energy relation to the technology and the environment.

The SEET demonstrated to be effective to raise awareness in this research scenario, but the role the technology can play and how it might change within different social groups are aspects to be explored in further studies.

Chapter 9

Motivating Online Engagement and Debates on Energy Consumption[1]

9.1 Introduction

The acknowledged power of social media of gathering people around common societal problems is unarguable. However, not all online initiatives are well succeeded, often due to issues of user's engagement and motivation. Engaging participants is a concern that challenges online community managers, designers and sponsors, especially those who aim to exploit the full potential of online tools to promote social change, such as governments, NGOs, and policy makers.

The term engagement can be understood from different but complementary perspectives. Yates and Lalmas [169] define *user engagement* as "the phenomena associated with wanting to use that application longer and frequently", as a result of "the quality of the user experience that emphasises the positive aspects of the interaction with a web application". Malliaros and Vazirgiannis [93] adopted the definition of "the extent that an individual is encouraged to participate in the activities of a community". When social change is the target, engagement might be also related to the civic engagement defined by [6] as "individual and collective actions designed to identify and address issues of public concern.".

From the Web Science perspective, investigating engagement with online tools requires understanding the forces that drive human behaviour towards technology, be they individual, social or influenced by the environment. Motivation determines the force and direction of behaviour [135], therefore, a crucial aspect towards engagement.

[1] **Article published as "Piccolo, L., Alani, H., De Liddo, A. and Baranauskas, C. (2014) Motivating online engagement and debates on energy consumption, Proceedings of ACM Web Science 2014, Bloomington, US, pp. 109-118"**

Motivation theories from Social Psychology have the purpose of explaining why people show great effort and persistence on doing things, which may comprehend interacting with a system or being active in a community [135]. This paper is grounded on concepts of the Self-Determination Theory (SDT) [35], which considers that motivation emerges intrinsically for satisfying needs, due to emotion or cognition, and extrinsically, i.e. by means of prizes or rewards. Still, individuals and the environment influence each other supporting or undermining motivation. From the individual side, i.e. psychological needs, interests and values can stimulate engagement with activities and with social groups. The environment, on the other hand, plays a role offering challenges and interesting things to do, providing feedback, imposing goals, and offering opportunities to potentiate the individuals' development [135][124].

This work focuses on understanding the role and impact of motivational strategies on promoting engagement in online energy debates. We build on SDT main elements to evaluate the impact of some motivational strategies not only to promote engagement in terms of online participation but also to connect people to a common issue. Namely, we present a user study in which an online argumentation tool has been used for raising energy awareness and fostering social change towards energy conservation in the workplace. By means of the debate tool, users from a computer science lab discussed about current consumption issues and possibilities to change behaviour, building the knowledge collectively and collaboratively.

As expected, the voluntary adoption of this tool by employees required a certain level of motivation, since it was competing in terms of time allocation with other daily obligations. Moreover, the "intangible" aspect of the debated issue can also be seen as an additional challenge to attract people for debating online. This is due to the fact that energy consumption is perceived influenced by habits and environment more than by individual decisions [131][74] and, therefore, people may fail to understand how this issue can relate to individual behaviour.

Finding ways to engage people with energy consumption towards conservation has been a concern also for governments and police makers, requiring from them the understanding of the behaviour change dynamics and motivational strategies to promote it [47][69][32]. Individually, we see engagement as a precursor of behaviour change. Collectively, it is the first necessary component leading to a social change.

We hypothesise that engagement with "intangible" issues, such as energy consumption, may benefit from "tangible" feedback to improve users understanding and appropriation of the problem. To test this hypothesis we built the Energy Tree, a public tangible artefact with visual feedback of contributions to the online tool. We added to this analysis the influence of social dynamics of collaborative work and competition on engagement with the online debate.

Composing this exploratory study we:

- Assessed to what extent the presence of the Energy Tree promoted engagement with the energy debate by comparing online engagement during two identical workshops, the first without the tree and the second with it;
- Associated the tangible feedback with social comparison (and the consequent competition) to promote online participation after the workshops, and evaluated qualitatively how they impacted engagement.
- With the lenses of the SDT, analysed the interplay of intrinsic and extrinsic motivational forces that have led to the engagement in this research scenario.

In the next session we present related works with regard to motivation, online participation and energy awareness/savings. The following session describes the overall methodology, which includes the description of the debate tool and the Energy Tree in terms of features to support the experiment. Then, we describe the experimental setting, which is followed by the results related to online participation and self-assessments. Combining the collected data, we analyse our findings, and subsequently discuss the limitations of the study. We then conclude the paper.

9.2 Related work

From the Human-Computer Interaction perspective, Shneiderman [146] sheds light to the current need of better understanding people's behaviour, collaborative strategies, engagement, and cooperation to improve social media potential. He illustrates this challenge by underlining the subjectivity and ephemeral aspect of related concepts, such as motivation, an ancient notion that was brought to technology design only recently, according to him.

In [86], Lee et al. evaluated individual achievements, social achievements and gamification strategies in the design of an application that aggregates the Tweets of the employees in a company. Their analysis pointed out that over using motivational strategies (including gamification) may lead the user to lose their intrinsic motivation.

According to Vassileva [160], theories from psychology have been applied in literature to motivate specific behaviours or behaviours change, but not explicitly to motivate a person to contribute to a community. The author analysed different approaches to motivate participation and found out that money or status rewards may jeopardise the quality of contributions, since people may act for results and not inline with their intrinsic motivations. She also highlights the importance of visualisations and states the need to consider both the user (micro level) and the community model (macro level) for providing

incentives. Involving users' real communities beyond the online one is also an important motivational strategy for her.

9.2.1 Acting socially to promote energy awareness

Working socially to foster energy savings has been a recent approach. According to Pierce and Paulos' literature review in 2012 [130], the vast majority of studies related to energy conservation had been focused on the individual behaviour disregarding social changes dynamics. Most of the studies had been evaluated in terms of consumption reduction as a consequence of information provision, either as consumption feedback or by providing hints for saving. A number of initiatives launched by governments and NGO's are found in the literature since the 70's leading to marginal effects on savings [1][54].

Instead of connecting individual's actions to their consequences, as the usual approach, Dourish [42] suggests the need to "connect people through their actions and their consequences", persuading people by the empowerment of collective actions. According to the Climate Change Communication advisory group [26], "there are few influences more powerful than an individual's social network" to promote pro-environmental behaviour. People tend to act in a certain way to be in line with others in similar context, following social norms [59]. But just adopting social norms to avoid guilty, or the fear of not 'fitting in' usually produces low level of motivation. When combined with intrinsic motivations, the social norms can be more effective and persistent [26].

Then, studies that associate motivational strategies (social comparison, competition) to engage people via online social networks started to emerge leading to a higher level of savings, such as [51] and [118]. However, factors that contribute to their success are most of the times unclear [39]. Petkov [118] affirmed that users prefer to compare their data against users they know (even if the households present significant differences), suggesting that in the context of real community, such as a working place, this strategy may be even more effective. Welectricity [167] and Opower [112] are examples of online tools that allow users to compare their energy consumption with similar houses.

Competition is a controversial motivational strategy, with some positive results, but yet not so positive effects [54][76] especially when targeting behaviour change. In fact, it is found that competition might even encourage the development of unsustainable energy consumption practices [19]. Competition can be associated to rewards, e.g. money or prizes, such as the San Diego Energy Challenge [138]. Although, some authors argue that extrinsic rewards may even undermine intrinsic motivation in some situations [81].

Competition and collaboration can be applied together in different levels, such as teams collaborating internally and competing against each other. A collaborative approach was found in [15], relying on collective savings to reduce the need of energy generation.

Projecting consumption data in the street for engaging neighbours to work together is a design alternative evaluated by the authors. Watt-Lite [77] publicly represented statistical data of energy consumption projected on the floor of a factory. It was successful to engage people in the topic when they were close to the installation but not enough visiting the project website afterwards.

Differently from the above-mentioned, evaluating savings or assessing behaviour change is out of the scope of this study. We consider engagement as the fundamental step leading to behaviour change, and then analyse how engagement in the debate of energy saving issues can be promoted by comparison, competition and public feedback in the context of a working place.

9.3 Methodology

In line with [26] and [29], this work relies on the potential of peer-to-peer learning, dialogue and argumentation of different viewpoints to build contextualised knowledge about energy usage. Engaging participants in this collaborative knowledge building process is the first step towards fostering longer-term changes.

For promoting engagement, we designed the Energy Tree, a public tangible artefact with visual feedback of contributions to the online tool. We combined face-to-face group activities with online participation to explore the impact of the Energy Tree on participants' engagement with the online debate on energy conservation. The methodology comprehended qualitative analysis applied to:

1. **The assessment of the impact of tangible and public feedback on engagement.** Two identical workshops promoting the online debate, one with and the other without the Energy Tree were conducted. Resulting contributions to the online debate associated to self-assessment questionnaires provided data for the analysis of the role of the tangible feedback on engagement.

2. **Evaluation of the tangible feedback associated to social comparison dynamics.** After the workshop, the Energy Tree was placed in a public area providing feedback of new contributions for both workshop groups, alternately, for 10 days. The impact of comparing group performances by means of the tree was evaluated supported by a sample interview with the top contributors and people who completely stopped contributing after the workshop.

3. **Analysis of motivational forces considering intrinsic and extrinsic sources.** Participants of the first workshop, the one without the tree, were told about a prize (no money related) that would be offered to the top contributor, adding an

extrinsic motivation element to the study. The analysis of the motivational forces, intrinsic and extrinsic, on engagement took into account the main elements of the Self-Determination Theory. Qualitative study of contributions to the online debate, self-assessments responses and outcomes of interviews subsidised the analysis.

How this methodology was applied to this experimental setting is further detailed. The experiment relied on the adequacy of the technical artefacts, both the debate tool and the Energy Tree, in providing features that motivate engagement. In the next sessions we describe how these artefacts were conceived and configured to support this study.

9.3.1 The debate tool

Energy saving and behavioural change are complex domains to be discussed, in which there are no right answers, or unique world views. Then, a debate tool must be featured to provide the expected contrast and connections of opinions. The Evidence Hub is a kind of Contested Collective Intelligence Platforms [34] applied to this study, suitable to support the complexity of discussion domain.

As an argumentative knowledge construction tool [33], instead of leading to find the best and quickest answer to a question, the Evidence Hub promotes the development of critical thinking and collective assessment of several solutions in order to support a higher-level reflection on the different aspects of a debate.

Users can create **issues**, and **ideas** that overcome issues. Both issues and ideas can be supported or challenged by **arguments**, promoted by **votes for** and demoted by **votes against**. Users can also add **Facts** or Web **resources** to enrich the debate. Figure 9.1 illustrates a Knowledge Tree connecting an Issue to Ideas, Arguments and Facts.

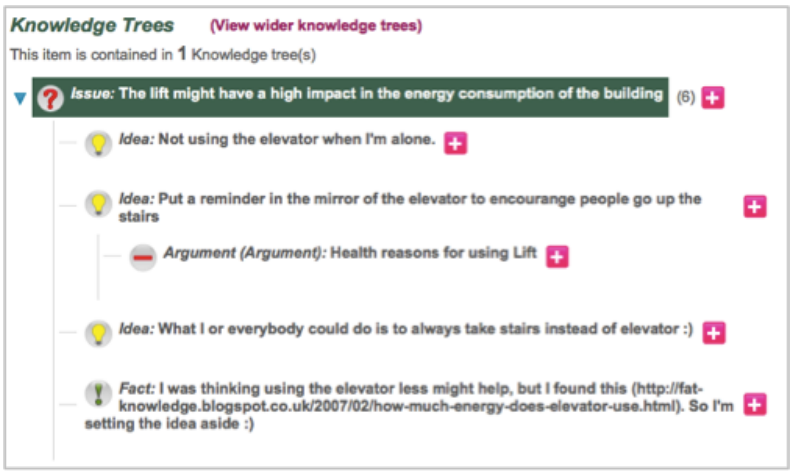

Figure 9.1: Screenshot of a knowledge tree in the Evidence Hub

Based on the nature of the content expected to be generated by participants, the Evidence Hub was set up with six main themes to debate on: 1) Behaviour Change; 2) Consuming Energy, mostly issues about how energy has been used and eventually wasted; 3) Environmental Impact; 4) Good Practices, a theme that emerged for need of sharing the good behaviours that people already had; 5) Institutional Actions, identifying constraints associated to the building or to the institution, therefore out of individual control; and 6) The Tree – a space for ideas of how to apply the tangible device for the experiment.

Besides navigating content by tags, key challenges or type of contribution, users can also explore the map of connected people and ideas. Figure 9.2 illustrates the dynamic social network visualisation. By means of this polarised semantic map, users can identify those who they mostly agreed, disagreed or expressed neutral comments within the conversation. The colours green, red and grey represent these levels of connections

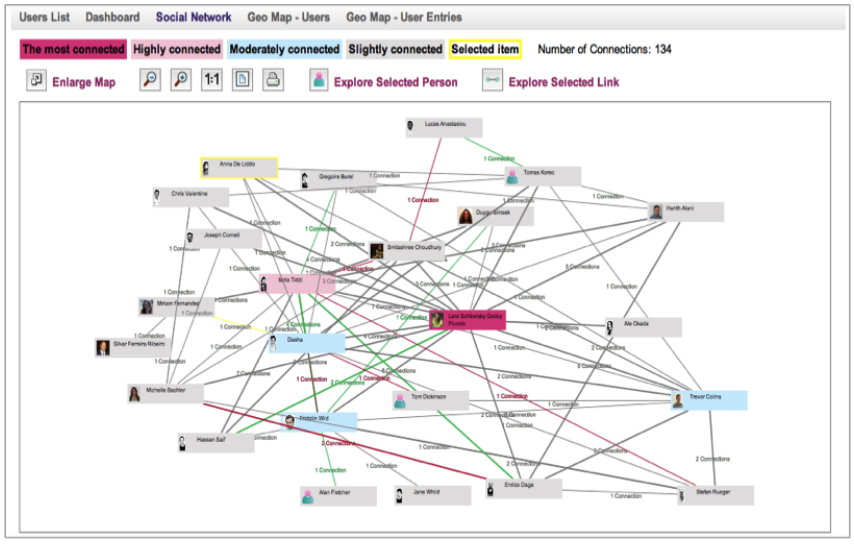

Figure 9.2: Screenshot of the users connection map

The Energy Tree was connected to the Evidence Hub database to provide a visual feedback of the number of contributions to the online debate. In the next section we describe the Energy tree functioning and its expected role to promote engagement.

9.3.2 The expected role of the Tree

Technically, the Energy Tree is a led-lights tree (Figure 9.3) designed to be solar powered, with seven branches that illuminate independently. It was developed upon the Microsoft Gadgteer Fez Spider Kit and connected to the Evidence Hub in such way that every 60 new user-contributions to the tool lighted on a new branch of the tree.

Figure 9.3: The Energy Tree

Conceptually, it is a Socially-inspired Energy-Eco-Feedback Technology [121][120], conceived to promote new patterns of behaviour (social affordances) within a social group [148] by promoting the connection between energy consumption and natural environment impact.

The Energy Tree was conceived to be a motivational artefact. In Table 9.1, we describe how the tree and the debate tool together are featured to promote motivation according to a set of ten design principles for *motivational affordances* [171]. These motivational affordances, which are also based on the SDT main concepts, refer to properties of objects that determine whether and how they can support one's motivation, considering psychological needs, cognition, social needs, and emotion as possible sources of motivation [171].

The Energy Tree was originally conceived as a tangible feedback of group energy savings [121][120], but the need to first promote engagement has lead to a change in the design. How the tree was applied in the experimental setting is described below.

Table 9.1: The Energy Tree and Evidence Hub features related to motivational design principles

Design principles	Features
Psychological needs	-Users of the debate tool have their profile with pictures. -The Energy Tree represents results of a pre-established group of users
1.Support autonomy 2.Promote creation and representation of self-identity	
Cognition	-The target established to light on the tree was previously calculated to be feasible, but not too easy to achieve. -The tree provides instant feedback of new contributions.
3.Design for optimal challenge 4.Provide timely and positive feedback	
Social and Psychological needs	-Being publicly displayed, the tree aims at promoting collaboration among participants towards lightening it on completely. -It has also the intended role to trigger online and real discussions about energy consumption. -The debate tool provides visualisations of people connected by their content (Figure 9.2). -By voting and arguing, users can explicit support or oppose others' idea.
5.Facilitate human-human interaction 6.Represent human social bond 7.Facilitate one's desire to influence others 8.Facilitate one's desire to be influenced by others	
Emotion	-The tree was designed intending to be visually attractive, calling people's attention and reminding them about the current energy awareness initiative. - The novelty aspect of a tangible feedback can be considered as a motivation.
9. Induce intended emotions via initial exposure to ICT 10. Induce intended emotions via intensive interaction with ICT	

9.4 Experimental Setting

The study took place in a research university department in the UK during October-November of 2013. Four phases shaped the experiment that together implemented the methodology. The phases are:

1. **Online survey.** Aimed at collecting initial perceptions about how energy has been consumed in the lab and preliminary ideas for behaviour change. The participation was opened to everyone in the department by means of an online form with three

simple questions. The results of the online survey were then used to pre-seed the Evidence Hub with meaningful content, thus providing a useful starting point for the online debate.

2. **Two workshops (WS1 and WS2)** were organised to promote the online debate by gathering volunteers to use the Evidence Hub. The two workshops had the same dynamic, except by the presence of the Energy Tree in WS2, making it possible to compare results and infer about effects of the Energy Tree on engagement. The Energy Tree was centrally located as a feedback mechanism during WS2 by reflecting the number of new submitted contributions. Each workshop lasted 2 hours and was run in a meeting room. Participants were asked to create, promote or demote Facts, Arguments, Issues, and Ideas online. Some face-to-face discussions enriched the online debate, but most of the time participants interacted individually with the online tool. The content generated in the WS1 was not visible for the participants of the WS2 to avoid influence. For assessing possible effects of extrinsic motivation on engagement, participants of WS1 only were told about a non-monetary prize (indeterminate) that would be offered to the top contributor in the end of the study. After interacting, the attendees completed usability and motivational assessments.

3. **10 days of online debate.** For evaluating motivation and, complementary to the workshop dynamic, "spontaneous" engagement with the debate, Group1 from WS1 and Group 2 from WS2 were asked to continue contributing to the online debate for 10 days, each group contributing to a different website. During that time, participants could optionally make use of energy monitoring devices for learning and sharing knowledge about individual consumption. The Energy Tree was placed in a social area as a feedback of engagement. Every 60 new contributions to the tool (new issues, ideas, arguments, facts, resources or votes) turned on a new branch of the tree. Results of each group were identified by a sign and kept alternating from time to time. The competition between groups was not clearly promoted.

4. **Sample interview.** To understand what motivated participation, perceptions, as well as their overall experience towards this study, a sample of participants that included the top and bottom contributors was interviewed.

9.4.1 Motivation assessments

We applied two self-assessments artefacts to workshop attendees aiming at finding qualitative evidences of potential motivational forces related to engagement:

- The Self-Assessment Manikin – SAM [17] was applied to evaluate the affective quality of the interaction with the debate tool, potentially under influence of the Energy

Tree for Group 2. It consists on a pictographic questionnaire that assesses three dimensions of emotions: valence, the positive or negative feeling caused by the experience; arousal that means the level or excitement or boredom; and dominance, in this case, it means the perception of control interacting with the Evidence Hub.

- Intrinsic Motivation Inventory (IMI) [143]. This questionnaire is part of the SDT framework. We applied the shortest version with 9 items consisting of three subscales: *Interest/enjoyment* that measures the intrinsic motivation directly; *Perceived competence*, a positive predictor of motivation related to how adequate the interaction was to participants' skill; and *Pressure/tension*, a negative predictor of intrinsic motivation related to external factors. Lower values are preferable for this subscale. Usually the IMI is applied to larger samples making it possible to explore correlations statistically. In this limited research scenario, the IMI was applied to point directions of the eventual impact and influence on intrinsic motivation.

9.4.2 Calculating contributions

Voting clearly requires less effort from the Evidence Hub user when comparing to the action of creating a new idea or issue, for example. For this reason, a system of points was established to calculate participation and identify the top contributors. Any new Idea, Issue, Fact or Web Resource value 3 points; Arguments value 2 points and votes 1 point each.

9.5 Results

Numbers related to participation and self-assessments are presented here, supporting the qualitative analysis and discussion in the next session.

9.5.1 Participation

The four phases of the study involved a total of 33 participants, most of them researchers and some PhD students of the computer science lab. The workshops gathered 24 voluntary participants (12 people per workshop), including 10 of the 19 respondents of the online survey.

The total of contributions generated in the debate tool is synthetised in the chart in Figure 9.4. Group 1 generated less contributions in the workshop (348) compared to Group 2 (542), which had the tree. The score inverted when the tree was installed in the public area as a feedback of contributions for both groups alternately (phase 3). Group 1 created 247 new contributions and Group 2 only 78. These numbers suggest that the

Energy Tree had a potential impact on participation when seen as a novelty. This result though must be associated to other assessments and variables to be conclusive.

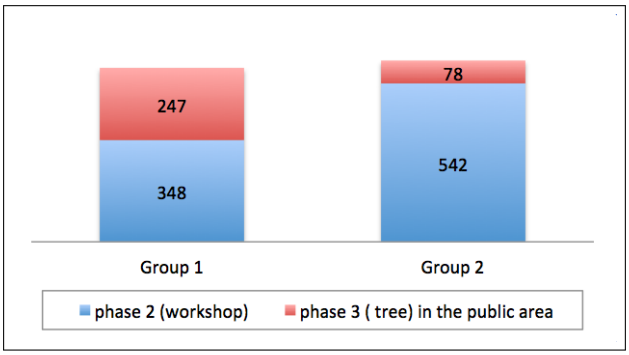

Figure 9.4: Contributions to the debate tool per group

In terms of type of contributions among votes, ideas, issues, arguments, facts and resources, both groups had comparable distribution as represented by the chart in Figure 9.5. These distributions can be considered adequate for the debate balance, such as the higher number of ideas than issues, as well as the expected high number of votes, which reflects that users accessed other people's contribution and expressed their opinion.

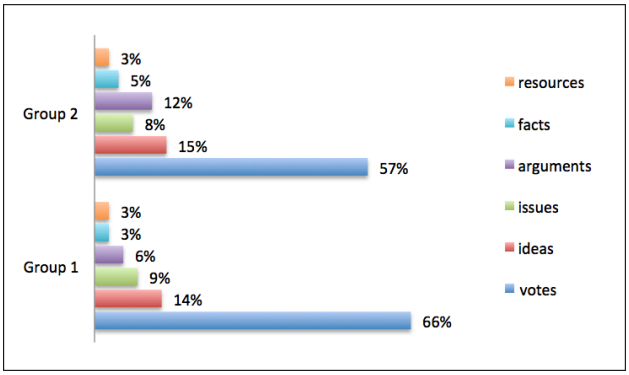

Figure 9.5: Distribution of types of content in the debate

The most significant distinction between the groups is the number of arguments created by Group 2, twice as many posted by Group 1, possibly reflecting a characteristic of the group.

The main challenge of promoting engagement was keeping people motivated to access the debate tool during the phase 3, after the workshop. The chart in Figure 9.6 illustrates the number of contributions day by day during this phase. The number remained stable between D3 (Friday) and D7 (Tuesday), when an external intervention occurred: an email ranking results of both groups was launched. Just after that, the number of Group

1 contributions increased 37% (59 new posts) and 201% (31 new posts) for Group 2. The score was published again on D8 and D10 also reminding participants about the last day of the study. The last increased the participation once again in 9% for Group 1 and 70% for Group 2.

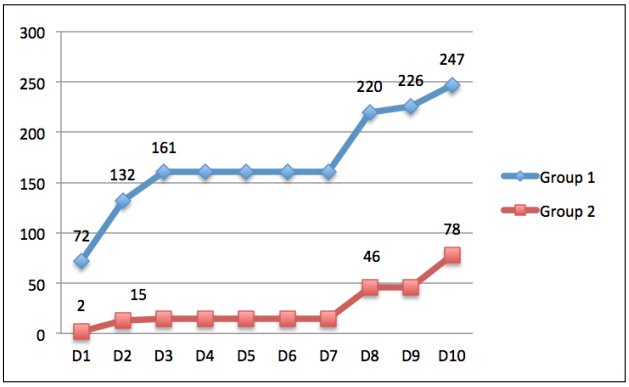

Figure 9.6: Contributions generated per day

9.5.2 Assessments and sample interview

Figure 9.7 presents comparative results of the affective quality assessment [17] regarding to valence, motivation, and dominance. These aspects were scored from 1 to 5, in which 5 is the most positive answer. Participants of WS1 demonstrated slightly more positive perception (valence). The average was 4.26 for Group 1 and 3.83 for Group 2. Despite of being differently distributed, the mean of motivation was identical, 4 for both groups. Dominance was the aspect worst scored with 2.6 of average for Group 1 and 3.0 for Group 2, suggesting that people from both workshops felt a bit too challenged when interacting to the debate tool.

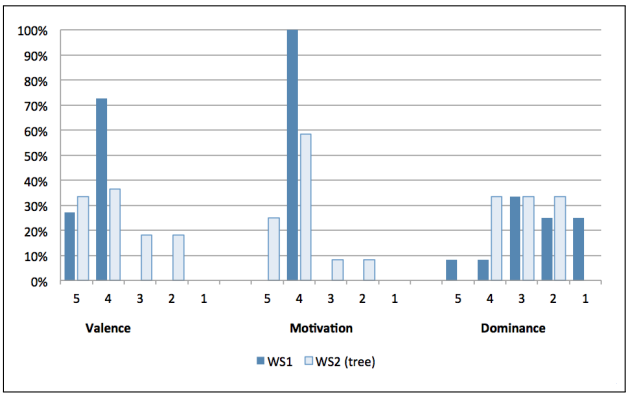

Figure 9.7: Results of the SAM

The concepts related to motivation were scored from 1 to 7 in the IMI [143]. The results presented in Table 9.2 are statistically limited (high standard deviation) due to the small sample of this study, but it suggests higher motivation by participants of WS1 than WS2, which had the tree. The competence subscale results are proportionally comparable to the dominance assessment by the SAM [17]. Both groups expressed having an autonomous behaviour at a certain degree by the low score of Pressure/Tension.

Table 9.2: Results of the IMI

		Mean	**Median**	**Mode**	**SD**
Interest / Enjoyment	G1	**5.22**	5.00	6.00	1.20
	G2	4.60	5.00	5.00	1.42
Perceived competence	G1	**4.67**	5.00	6.00	1.78
	G2	4.13	4.00	4.00	1.62
Pressure / Tension	G1	2.25	2.00	1.00	1.72
	G2	2.25	2.00	1.00	1.36

Details of the usability evaluation of the Evidence Hub are out of the scope of this paper. However, how participants perceived the online tool might influence engagement and motivation. The Table 9.3, thus, summarises the average score (from 1-5) of positive and negative usability aspects by both groups, pointing out that Group 1 had a better perception in terms of the ease of leaning and use, complexity, etc. The complexity was the main issue pointed out by participants.

Table 9.3: Summary of usability evaluation

Usability aspects	**Group 1**	**Group 2**
Positive	3.40	2.96
Negative	2.15	2.42

As part of the usability assessment, when asked about the effectiveness of the Evidence Hub to raise energy awareness, workshop participants highlighted mostly aspects related to debate, as enumerated in Table 9.4.

Nevertheless, one participant pointed out his/her dissatisfaction by saying: *"I would prefer to search Google/newspaper for facts and reports rather than view other people's claim / notes"*. This particular participant also reported the lowest level of intrinsic motivation (2.8) for using the debate tool.

The interview with a sample of participants revealed aspects related to their overall experience towards the study. Regarding reasons to participate, respondents were asked to choose up to tree reasons to be engaged in this study. The results are quantified in the

Table 9.4: Mentioned aspects of the debate tool that contribute to energy awareness and % of answers that refers to it

The informative aspect, new ideas, knowledge sharing	44%
The debate elements (contrast,opinion, arguments)	31%
It made me think	6%
Potential to organise a community around a problem	6%
Connecting ideas	3%
Funny	3%
The tree as motivational aspect	3%
Goes from discussing issues, until finding solutions	3%

chart (Figure 9.8), evidencing that the tree was the second main reason for participating, more than all other technical artefacts or the social aspect of the activities.

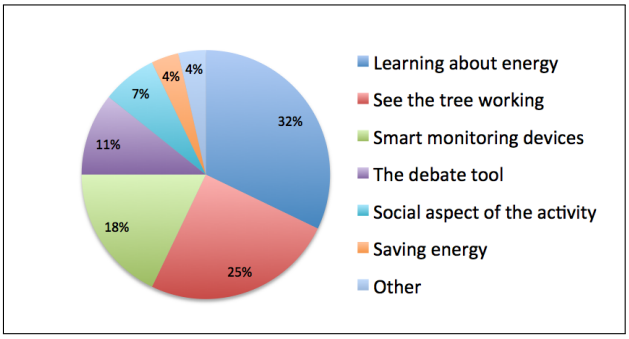

Figure 9.8: Reasons to be part of the study (chosen among a set)

Interviewees also scored (1 to 5) the level of attention they spent to the tree during the WS2 and during the time it was installed in the public area. The average score of attention in the workshop by Group 2 was 3.5, while in the public space was higher, 3.9. Figure 9.9 represents the score distribution.

Table 9.5 relates a sample participants' data, including the top 2 contributors of each group, plus one person of each that did not contribute at all after the workshop. Data from different sources were associated: the user's participation in points, as described in the section 9.4.2, the Interest/enjoyment subscale of IMI score, the stated main reason for being part of the activity, and the meaning of the tree for them when they used to see it in the public space.

From this group of interviewees, only the G1 participant that did not contribute admitted to not have changed any behaviour as a consequence of the study. All the others mentioned examples of changes both at the workplace and at home, suggesting

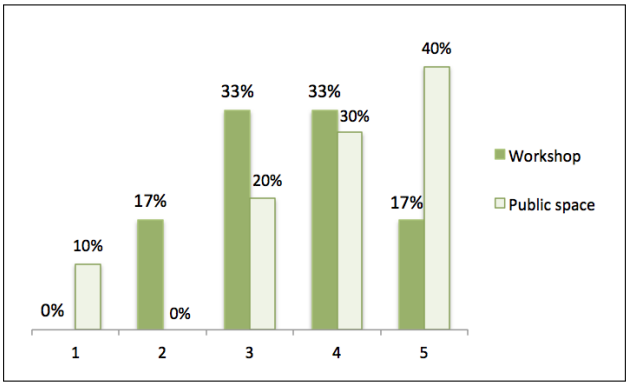

Figure 9.9: Score of the level of attention to the tree

Table 9.5: Cross data of a sample of participants

		Points	**Interest / Enjoyment**	**Main reason for contributing**	**The tree meaning**
Top 1	**G1**	244	6.20	Learning	The progress, competition
	G2	99	5.40	Environmental	Competition
Top 2	**G1**	99	4.60	Learning	Competition
	G2	58	4.80	Learning	Guilty
No participation	**G1**	34	5.20	Social aspect of the activity	Someone is doing
	G2	12	4.80	Learning	Guilty

the positive effect of the study in raising awareness, i.e., referring to longer-term changes in behaviour: *"I am more attentive to energy consumption in general and whenever I have the chance in the future, energy consumption of devices I purchase will play a more important role"*. And *"I recently got a table lamp and use it instead of the main lights when I am alone in the open space)"*, referring to changes in the workspace.

9.6 Analysis

By connecting results from the Evidence Hub, self-assessments and the sample interview, we analyse and discuss the impact of the tangible device, as well as the effect of social comparison and competition on engagement. Then, we analyse results taking into account the main SDT concepts.

9.6.1 The tangible device effect

Results of self-assessment pointed out higher level of motivation (9.2) and a better perception of the tool by participants of Group 1 (9.3). However, Group 2 produced 56% more during the workshop, as illustrated by the chart in Figure 9.4, evidencing the impact of the tangible device on participation. The Energy Tree was also declared as the second reason for people to be engaged in the study, more than the smart monitoring device and the debate tool (Figure 9.8).

However, the presence of the tree in the public area was not enough to keep Group 2 participants engaged. A possible explanation is that the novelty aspect of the technology, which may increase motivation, was not present anymore for this group that had already lighted on the Energy Tree completely beforehand, during the WS2.

In the workshop, the effect of the tree could be even stronger if there was no pre-established goal to light it on, which was perceived as a limit by workshop attendees. When the tree was completed, and the last branch was lightened, typical reactions from the participants were: *"and now?"*, and *"we don't need to contribute more"*. Similar effect of loosing motivation was observed in on-line communities where users had to achieve a goal to have access to new features [94]. Design alternatives to go beyond the goal - more levels of contributions represented by unexpected lightening effects, for instance, should have overcome this constraint.

Placed in the public area, the visual feedback of the tree was more effective in attracting participants' attention (Figure 9.9). Differently from the workshop, in which people spent most of the time working online, in the public space the tree was considered mainly a reminder that the study was going on, as suggested by our previous analysis with regard to energy awareness.

The expected effect of the artefact leading to new patterns of behaviour was identified as a post to the debate tool: *"It looks like thanks to the tree we started switching off the lights during the day"*, however, this effect could not be identified by the sample interview, in which the tree was said to be perceived mostly as signal of competition or guilty for those who were not collaborating, as further described.

9.6.2 Social comparison and competition

Learning about energy was stated by participants as the main reason to engage with the study (Figure 9.8). We see comparison as central aspect in a collective learning process, for this reason social comparison has not been evaluated in terms of effectiveness in this study.

The debate potentiates the comparison not only in terms of number of posts created, but also by the possibility to contrast opinions. Participants highlighted these aspects

positively when discussing about the effectiveness of the tool to raise awareness in Table 9.4, as well as they made evident the value of arguments and the possibility to see connected people and ideas.

The public feedback by the Energy Tree was also a tangible way to provide social comparison both within the groups and especially between them. A participant from Group 1 declared to think that *"some people are saving energy"* when seeing the tree in a public place, meaning that him/herself was not contributing, although the group result was evident.

Making public results of both groups changed the perceived meaning of the tree for them: the group with better result mostly associated the tree with a feedback of their performance (including competition), while for the Group 2, the tree was a signal of guilty: - *" it's like I am not fulfilling my responsibilities"*, declared a Group 2 interviewee.

Social comparison is actually a predictor of competition, which was reported as an important trigger for the most engaged people in Table 5. The Group 1 second contributor said about his/her thoughts when seeing the tree in the public space: "Shamelessly competitive: *Is my group doing best?"*. Another important aspect to be highlighted is that the both top contributors claimed for a public reward.

Comments during the WS2, such as *"Does the tree refer to everyone?"*, expressing disappointment, and *"We should compete against each other!"* illustrate the preference for the competition approach instead of working collaboratively.

In terms of number of contributions, the curve associated to daily contributions in (Figure 9.6) made clear that the first intervention of publishing the ranking of both groups' contributions on D7 impacted participation. The importance of competition stated by the top contributors suggests that the ranking had a motivational meaning. The same effect of the intervention was not observed in the following day though, suggesting that the frequency of interventions must be carefully planned to be effective.

In terms of quality of contributions, the controversial effects of competition found in the literature, such as cheating and loosing the quality [76], were not confirmed in this research scenario. Group 1 had a higher number of votes. For being the simplest way to interact to the system, it can be considered as a consequence of the individual prize offered for the Group 1. However, voting is also a relevant way to promote the debate, so, in this context, it cannot be seen as cheating or quality loss.

Despite of presenting the highest level of intrinsic motivation towards the debate tool during the workshop, the top contributor also declared the interest by the competition, prize and reward, suggesting that the intrinsic motivation was not the only responsible for the engagement.

9.6.3 Motivation and engagement

Satisfying a need leads to well being, for this reason Autonomy, Competence, and Relatedness are considered the most important needs that lead to intrinsic motivation according to SDT [135][35].

More **Autonomy** means stronger motivation. The behaviour is said to be autonomous (or self-determined) when in line with one's interests, preferences and wants; otherwise, external forces, like pressure, guide it. **Competence** reflects the interest in applying and developing our skill performing a task; to enhance intrinsic motivation, competence must be accompanied by autonomy. **Relatedness** refers to the need to establish close emotional bonds with other people. Relatedness may also be a reason to internalise extrinsically motivated behaviours, since people are willing to have the behaviours valued as significant by others to whom they want to be connected, whether a family, a peer group, or a society [35].

Autonomy

As voluntary participation, contributing to the online debate relies on autonomous behaviour, which in turn is related to intrinsic motivation, interest, and enjoyment. Individually, intrinsic motivation measurements could not be directly associated as an indicator of engagement in this research scenario. People who did not keep contributing after the workshop had similar or even higher level of intrinsic motivation than people among the top contributors (Table 9.5).

However, the novelty aspect of the Energy Tree seemed to promote initial engagement, leading to a higher number of contributions to the debate tool in the first contact of users with the tangible technology.

Competence

In this study context, competence was mainly related to the perception of usability aspects of the tool, declared to be complex by users. The Group 1 participants' higher intrinsic motivation (and perceived competence) seems to be associated to the experienced affective quality (Figure 9.7), also higher in average. They better evaluated the tool in terms of usability than participants of WS2, with the tree.

Low levels of competence may prevent users to adopt a tool after the first contact. Although usability aspects are out of the scope of this paper, the adequacy of the online solution to the user skills and expectation must be ensured to motivate engagement. Results pointed out that the group with higher competence continued contributing, but it is not possible to affirm that it happened due to this correlation, since the presence of the tree, as describe below, had others more evident influence.

Relatedness

By far, relatedness is the strongest motivational aspect in this experimental setting that relies on a collective platform. Elements associated to the debate such as argumentation, contrast of opinions, support or opposition to others' contribution, were mentioned as strengths for promoting energy awareness, as describe in Table 9.4.

Competition and public reward played an important role on engagement of those who most contributed to the online debate, demonstrating the importance of human bonds and social influence. Differently from reported by [120], a study that also evaluated the Energy Tree in the context of an elementary school, competition did not affect the quality of contributions. A possible explanation refers to the social context; in a working environment, people tend be more careful about preserving their image.

The consequent changes in behaviour declared by most of the interviewees suggest the effectiveness of this experimental setting to raise energy awareness. Associated, intrinsic and extrinsic reasons together strengthened motivation and promoted engagement.

9.7 Discussion

Vassileva [160] states that relating motivation and online community engagement requires dealing with the influence of external factors that may lead to unpredictable behaviour by the participants. We argue that the methodology and the experiment design must consider alternatives to overcome possible influences created by the environment. In the context of a workplace, for example, hierarchical pressure for participation or the lack of institutional support could bias results of engagement. In this research scenario, we did not detect unpredicted behaviour, possibly due to the controlled and familiar environment where the experiment took place, its short-term run, and the relatively small number of participants.

These characteristics made it difficult to statistically analyse the impact of our motivational strategies on online engagement. Despite all that, qualitative results pointed out some interesting directions with regards to:

- **The tangible feedback of contributions:** the presence of the Energy Tree promoted engagement in a situated interaction (the workshop), possibly due to the novelty aspect of it. When placed in a public space, the artefact was mostly perceived as a reminder of the study.

- **Social comparison and competition:** even though competition was not strongly promoted, the top contributors in the study declared it as an important motivational force behind their engagement. No negative aspects were reported or found to be associated with competition in this research scenario.

- **Intrinsic and extrinsic motivations:** engagement could not be explained by intrinsic motivation alone. The top contributors requested public rewards as well as declared their interest in the prize, suggesting that intrinsic and extrinsic motivations must be combined to promote engagement.

- **Characteristics of the online debate:** participants evaluated the debate as effective to raise energy awareness due to the possibility of comparing and contrasting their opinions and ideas.

As an exploratory study, we mixed some motivational strategies, such as the presence of the Energy Tree and social comparison/competition, thus making it more difficult to evaluate the potential impact of isolated strategies. However, studying the impact of multiple interplaying strategies is the focus of this work, which is also supported by the literature on behaviour change which argues for using a combination of motivational strategies to engage people more effectively [69].

Vassileva [160] argues that results associated with successful incentives in one community cannot be easily generalised to other communities. The users in our study were all computer science researchers, which limits our ability to generalise our findings to other user groups. Nevertheless, our results can act as pointers to further research directions, and to experiments involving a wider variety of users.

9.8 Conclusion

This exploratory study analysed motivational strategies related to the engagement of users with online debate on energy saving. A public tangible feedback of online participation was proposed as a motivational strategy. The impact of this device on engagement and how the social dynamic of competition and collaboration influenced participation were analysed qualitatively.

In the context of this research scenario, external factors were found as positively impacting engagement. While scores of intrinsic motivation alone could not suggest engagement, competition and public reward were mentioned as crucial for those participants who most contributed.

Possibly due to the novelty aspect associated to the device, which attracted participants' curiosity, the Energy Tree was effective on promoting situated engagement. However, placed in a public area, the presence of the tree promoted competition between groups of users, and worked as a symbol, a reminder of the ongoing energy awareness study.

For promoting Relatedness, one of the most important needs that lead to motivation, participants judged the Evidence Hub as effective to raise awareness and highlighted

debate elements (arguments, contrasting opinion) as the strengths. These elements of collective knowledge building are important to promote engagement not only in terms of online participation, but also to establish and promote new social norms, leading to a desired social change.

In the Web Science perspective, our results contributed to the understanding of the relationship between motivation, a force that drives behaviour, and engagement with an online tool. Even though situated, the findings point directions to further investigations in different research scenarios.

Chapter 10

Conclusions

Aiming at exploring the potential of technology to contribute to societal changes, this PhD study introduced motivational aspects, from Psychology, in design, as a way to conceive digital artefacts that motivate engagement with a social issue. The investigation was instantiated in the problem of raising awareness of energy consumption, coping with the urgent and contemporary need to make more notable to the society the planet natural limits.

How to provide consumption feedback has been the traditional concern in HCI literature in the energy domain, since the lack of the information is still an open issue. Information leads to some level of energy saving according to previous studies, but how technology can motivate engagement with the issue for raising awareness among a social group is an underexplored aspect, which is investigated by this PhD study.

Within both Psychology and HCI literature, motivation has been mostly recognised as a force triggered internally, to satisfy our needs. Zhang [171] for instance, proposed a set of motivational affordances to be applied to interactive systems design, based on the SDT main concepts, to promote intrinsic motivation. This study evidenced, though, that the influence of the social context on promoting (or even demoting) external motivation towards a technology cannot be ignored, especially considering technologies designed with the objective to impact a social group towards developing new worldviews.

This research took into account both intrinsic and extrinsic sources of motivation, the later relying on artefacts of Organisational Semiotics to inform the design with sociocultural aspects. The situated design in the Brazilian scenario has led to the conception of the *Socially-informed Energy Eco-feedback Technology (SEET)*, composed by a tangible and public feedback display and an interactive software for raising energy awareness collectively.

The evaluation of the SEET in the Brazilian context illustrated the variables that come to play applying the socially-aware design approach. Due to socio and technical

constraints related to the access of energy measurements, the meaning of the Energy Tree changed along the field study. Instead of measuring energy savings, we assumed that **engagement** with the energy issue would be more precise as a feedback considering the experiment settings.

As a lesson learned in the Brazilian scenario, the following experiment in the UK also targeted engagement instead of energy saving, assuming that the more people contribute to the online debate more they are raising their energy awareness. This evaluation confirmed the engagement as a valuable objective for technologies that aim at promoting social changes.

Critically analysing the introduction of motivational aspects in design, we recognise that elements of intrinsic motivation, mainly Autonomy, Competence and Relatedness, contributed to the conception of the innovative design of the SEETree. Beyond the public feedback and the interactive system promoting collective and collaborative actions, other features that emerged from this approach were shown to be crucial to engage people, such as: the possibility for users to create their identity (related to autonomy); planning feasible targets for savings (competence); and strengthening the feedback of collective results (relatedness), for instance. However, the benefits get even more evident by predicting external factors that may interfere in the adoption and use of technology, the extrinsic motivations, such as how people in the scenario evaluate sharing, eventual external pressures, and so on.

10.1 Contributions

This study main contributions can be seen from theoretical and practical perspectives. The highlights among the theoretical contributions are:

- Conceptual analysis of affordance and how this concept has been changed in HCI over the years.
- Analysis of motivational concepts suitable to design, considering both intrinsic and extrinsic sources of motivation.
- Sociocultural analysis to elicit extrinsic motivational factors, broadening the notion of motivation informing design.
- Validation of the Organisational Semiotics as an adequate methodological basis to the motivational design approach.
- Adaptation of an Organisational Semiotics artefact, the Ontology Model, to comprehend also intended patterns of behaviour.

Contributions in practical terms:

- 2 evaluations of design solutions, considering also their social impact.
- The Energy Tree(s)
- The Web prototype
- SEETree architecture composed by the Energy Tree, the controller (based on the Microsoft Fez Spider Kit), the Web platform communicating with Facebook, and integration with smart meters readings from Cemig's database.

And more specifically to the Energy Awareness domain:

- Design situated in an economically developing scenario, complementary to the literature review that is mainly focused on middle-upper class households in developed areas.
- Energy Awareness initiatives in 2 real scenarios.
- Evaluation of the impact of technology beyond individual interaction with the system, considering also the social group (from the school/workplace to home).
- The introduction of the concept of engagement to raise awareness collectively.
- The design of a tangible device as a collective feedback of engagement.
- Association of a collective-knowledge building concept and an argumentation tool with an energy awareness initiative.

In the next section, further analysis of both evaluation experiments is presented.

10.2 Analysis on the Evaluation

The collective and collaborative approach of the SEETree emerged from the Brazilian sociocultural context. Although the resulting technology was situated in a particular scenario of consumption and perception of energy, the general architecture composed by the Energy Tree and the interactive system for raising awareness collectively was adequate to the United Kingdom scenario, fitting the link with the online argumentation tool.

Some features or artefacts applied in the Brazilian experiment were not developed for the UK scenario: the remote live visualisation of the physical tree and a list of simple possibilities of saving energy according to typical appliances usage. Interestingly, these

features were suggested by participants in the UK when evaluating the experiment, reinforcing their relevance in the architecture.

Although with differences in the settings, both scenarios had equivalent configuration considering artefacts and dynamics in the technical, formal, and informal levels (an OS perspective):

- The Energy Tree has a role in the *technical level* making the energy awareness initiative tangible, as a reminder to change the social affordance. In the same level are the smart monitors and the in-home displays applied in the UK as learning tools for individual appliances consumption; In Brazil, the paper sheet presenting typical consumption values in kWh for the students had equivalent informative role.

- The *formal level* represents the sense of belonging, of promoting a change collectively. The interactive systems formalised the group work and the place for sharing results and experiences. The physical location of the Energy Tree, in a gathering area, also contributes to formalise and create a sense of community work. Beyond that, it is necessary to extend the sense engagement to the family, to the school members, or to demonstrate the institutional support at work to the participants.

- At the *informal level* is the challenge to promote the energy awareness initiative as something funny, attractive, positive, in order to establish the desired social norm, the "everybody does" and "I also want to be part of it". It has been represented in the case studies by the psychical affordances of the Energy Tree, as well as by features of the interactive system considered as motivating such as sharing on Facebook, creating identities, comparing with other groups, etc.

Table 10.1 summarises the aspects evaluated in each evaluation experiment.

Table 10.1: Aspects evaluated in the experiments

Aspect evaluated	**Brazilian Scenario**	**UK Scenario**
Impact of motivational approach in design	X	X
Socially-aware design approach	X	X
Role of the Energy Tree	X	X
Role of the collective architecture	X	
Impact of social dynamics (collaboration and competition)	X	X
The impact in the social group	X	
Pedagogical interest	X	
Role of the consumption displays		X
Role of an argumentation tool		X

The UK experiment made evident that the lack of information about energy consumption is not a problem restricted to economically developing contexts, it also exists in a developed scenario, even in a context where people are strongly related to new technologies. In-Home Displays are commercially available as well as Smart Grid technology is a reality in many places, but these technical aspects were not enough to change the way people relate to energy. For both contexts, knowing how to effectively change behaviour towards savings requires discussion and an understanding of the context.

The results point out the Energy Tree as an external motive to be part of the initiative for both cases, and as a reminder that some collective activity was going on. The "intangible" aspect of energy has also been evidenced as a global challenge that can be tackled by from different perspectives when technology and people, with all their complexity, are equally considered as part of a solution.

Some differences were found, though, in the role of the social dynamics. In both scenarios, competition emerged as a relevant motivational force even without being strongly promoted. The most intrinsically motivated people in the UK experiment declared the interest in competing and receiving awards. In the Brazilian context, though, competition led to the side effect already mentioned in literature: for some participants, it became more important than the energy issue itself. Probably due the work setting and consequently more formal environment, this consequence was not evidenced in the UK.

As main contributions, the Brazilian experiment validated the SEETree architecture, the importance of sociocultural aspects to conceive and introduce a technology, and the motivational approach to design. The experiment in the UK, in addition, validated the relevance of defining engagement as a mean for social change, and pointed out that intrinsic motivation alone is not enough to motivate engagement. Social factors and dynamics

can contribute to motivation when properly considered in the technology design and application in a situated context.

10.3 Answering the Research Questions

As part of the thesis' objective, a set of research questions was defined in the beginning of this study (and presented in the Introduction Chapter). Based on the knowledge built and in the advances achieved, we then conclude this thesis by providing the answers.

- *How to evoke motivation with device features?*

  In the literature review we identified a set of motivational affordances [171] as general guidelines for promoting intrinsic motivation in design. Guiding the design by the intrinsic motivational elements of SDT, mainly Autonomy, Competence, and Relatedness have led to the conception of features well evaluated by participants of the case studies. But our experience demonstrated that intrinsic motivation is not enough, we also need to consider those external factors that influence motivation, such as how people in a social context act socially, how they evaluate sharing, collaboration, eventual external pressures, particularities in the way they perceive the social issue, and so on.

  Although the SEETree design has been situated, taking into account the sociocultural reality of groups in Brazil, the general architecture proposed could be adapted to a different context. While a ludic application, with some game aspects, was applied for the school context, in the workplace a tool that promoted debate and visual connection of people and ideas was more suitable, preserving the motivational aspects.

- *How to identify motivations of different people to adopt (or not) this new technology? and how to consider different motivations when evaluating the adequacy and the impact of the solution?*

  Different motivations mean that people perceive and adopt technology in different ways, which must be considered both in design and evaluation. Applying the Energy Tree as a feedback of savings, for instance, would have been a mistake for not taking into consideration those people who are in the initial process of awareness and need learning. Measuring engagement with the tool instead was a wider, therefore more suitable, approach to consider different motivations.

  Qualitative data from interviews and observation, as well as quantitative data from a survey were the source of the sociocultural analysis to identify elements that

potentially shape motivation, mainly from the extrinsic perspective. The artefacts provided by the Organisational Semiotics were suitable for analysing such factors and then informing the design.

For assessing level of motivation and the adequacy of the technical solution to the users' skills, both the IMI, questionnaire provided by SDT to assess intrinsic motivation, and the SAM for measuring affective quality are suitable and easy to apply. The IMI consider competence, and the SAM the feeling of dominance in the interaction, very similar concepts.

And to evaluate and analyse the impact of the solution, the perspective provided by the OS considering technical, formal and informal has been shown to be valuable in building a wide understanding.

- *How to propose user interfaces that make sense to as many people as possible, considering cultural differences?*

  The cultural analysis based on the 10 areas of culture by Hall [61] pointed out the importance to locally contextualise the design, and also evidenced that the possibility for people to create their identity are important motivational aspects identified, such as the possibility provided to users in Brazil to choose a typical tree to represent the group.

  As already discussed when comparing the case studies, the general concept of the SEETree was applied in completely different contexts with similar effect, suggesting that it can be adapted to different cultural contexts preserving motivational aspects.

- *How to model and represent aspects of culture reflecting them in the user interface in order to promote a social change?*

  As a methodological basis, the Organisational Semiotics was effective in informing the design with some cultural aspects.

  We extended the ontology model to suit not only current observed social norms, but also those we want to promote by means of the technology.

  Additionally, as already mentioned, we also modelled cultural aspects according to Hall's 10 areas of culture, approach that resulted in guidelines to contextualise the design in terms of individual impact and collective achievements.

- *How to promote a good affective quality in the user's interaction with this new device, aiming at keeping their motivation?*

  The Energy Tree was pointed out as an attraction by the evaluation participants. However, not necessarily it has been the main aspect that led to a good affective

quality, as assessed in the Brazilian experiment. The complete set considering design elements of the interactive system, the social dynamic, the formal support, etc., also influence the perception and the affective quality. The social aspects and social dynamics of the activity, though, for gathering people to discuss the social issue and together envisage solutions seemed to be the most positive characteristic for the participants. Strengthening the sense of Relatedness by establishing bonds, creating features and tools for sharing, collaboration, or eventually certain level of competition, are promising ways to maintain a positive perception of the technology.

- *How to raise awareness of energy consumption by means of the technical device?*

  In line with the previous answer, the experiments made clear that technical devices are not the only element for raising awareness. The Energy Tree, for instance, worked as a reminder, a trigger for a collective action. The smart monitor devices were also considered as learning tools, providing essential information about consumption, but not necessarily motivating people to be engaged with the social issue. The power of raising awareness was noticed, instead, in the social aspect of the activity, gathering people to discuss contextualised strategies for saving energy.

  Generalising these findings, Figure 10.1 summarises in the Semiotic Onion the full set of elements applied in the motivational design.

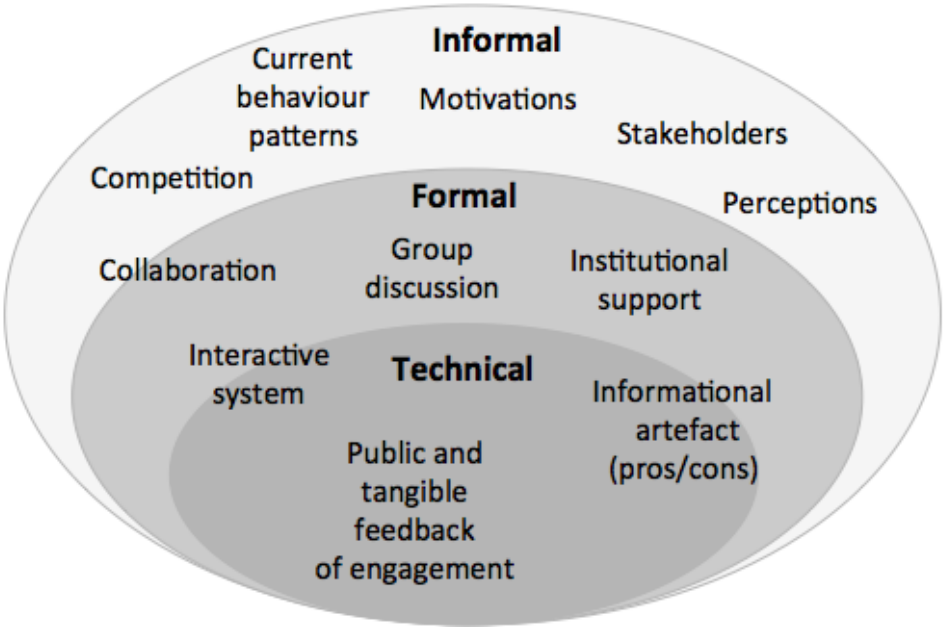

Figure 10.1: Elements applied in the motivational design

The tangible and public feedback of engagement (the trigger) is in the core of the

semiotic onion, at the technical level. An interactive system and an informative artefact with pros and cons of possible solutions are between the technical and the formal level. In the formal level are the group discussion, referring to a negotiation phase among participants towards the desired change, and the institutional support, reinforcing the participants' initiative is not an isolated action. Collaboration is part of the formal level, but with some informal elements. Promoted or not, competition should emerge and the design must prevent some eventual harmful effects of that. In the informal level are the elicitation of current (and intended) patterns of behaviour, the motivations (intrinsic, such as novelty, well-being addressed as Autonomy, Competence and Relatedness; and extrinsic, like mapping eventual social pressures, how people share information, etc). In the informal level are also the stakeholders and their main concerns that may cope or not with the desired scenario, and the participants' perception both in terms of the desired social change and how they use and perceive technology, which influences their engagement.

10.4 Limitations

As mentioned in the Chapters 8 and 9, dedicated to the case studies, the number of participants we had for the experiments were around 24 people each. This configuration prevented us to statistically explore motivational aspects applying the SDT self-assessments artefacts. These questionnaires provided a valuable overview of intrinsic motivation and the eventual existence of pressure, a negative motivation, which was not identified. But bigger samples would make it possible to correlate engagement with metrics of intrinsic motivation, and also to identify other potential triggers of intrinsic motivation related to design elements.

The artefacts provided by SDT however are focused on intrinsic motivation only, not extrinsic, therefore not helpful for measuring the social dynamics impact specifically, such as the effect of competition on motivation, of the collaborative work, and so on. This analysis was made mostly qualitatively, based on sample interviews and observation.

The architecture of the SEETree was appropriate to the study, but some possible improvements were identified, such as new possible lightening effects which could enlarge the possibilities to apply social dynamics of collaboration and competition; and the need to empower participants in their social context: even when feeling motivated to change his/herself behaviour and reduce energy consumption, some people reported to not feel empowered enough to change other people's mind in the household.

The impact of competition, prizes, rewards, etc., is also addressed by researches on gamification. This study, though, did not consider gamification as part of the theoretical referencial.

10.5 Future Work

The main future work would be to evaluate the design solution in different contexts, such as for general pro-environmental behaviour, such as recycling, or in other domainslike promoting citizen participation in government.

In the energy awareness domain, the experiment in the UK pointed out sensors are not always effective assuming individuals' control on energy consumption and savings. Not working properly, they prevented people to assume the control of energy usage and notably were responsible for certain level of waste and sense of frustration by the participants. Understanding the role of automation systems for lightening and temperature control, for instance, in which extent they contribute to savings and/or promote or prevent energy awareness development is another work that could be addressed.

As a step further than raising awareness, we also envisage future works for promoting and assessing behaviour change towards more pro-environmental attitudes. In the context of DecarboNet, stages of behaviour change have been already studied as well as tools and features related to social media that can foster this process. Differently from this study centred on Motivation, from Psychology, the range of theories associated to behaviour change is in mostly the Social Sciences domain.

This set of open questions synthesises the future works:

- How new features on the tangible and public feedback would be perceived by users?
- How to move from awareness to behaviour change?
- How to measure behaviour change?
- How to make behaviour change sustainable?
- What kind of tools could help already engaged people to influence others?
- How sensors impact the affordances and energy awareness?

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Appendix A

Perspectives on the Evaluation of Affective Quality in Social Software[1]

Abstract

Enormous changes in the computing field are being experienced, altering the way we relate ourselves with computational technology. If computers had at first limited function and presence in our lives, they are now being used everywhere, all the time, for a multitude of purposes and interaction means, supporting even our social relations. This shift calls for new ways of evaluating systems, demanding attention not only to usability and accessibility issues but also to the emotional and affective ones. This paper presents a brief review on theory and methods for affective evaluation of computer systems as a preliminary discussion on the suitability of existing methods for social software applications. The discussion is instantiated in the inclusive social software Vila na Rede, a system developed under a participatory design approach with the purpose of building a Web based community among the less favoured segment in the Brazilian society.

Keywords: Human-Computer Interaction; Inclusive Social Networks; Affective Quality; Emotional Design

1. Introduction

Along the countless new challenges that we have been facing with novel computer technologies and ways of interacting with them, several authors agree with the importance

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of keeping human values as the core of Human-Computer Interaction (HCI) (Friedman et al., 2006; Goguen, 2004; Sellen et al., 2009). This means taking into account elements that did not use to be considered when systems were mainly task-oriented. The value-sensitive (Friedman et al., 2006) or value-centred design (Goguen, 2004) is concerned with what human beings – in their interaction with computers, or in their interaction with other human beings through the use of computers – desire and need. Among these new elements that need to be included in the HCI theory and practice are culture and emotions (Bødker, 2006; Harrison et al., 2007). Emotions may be considered both as part of the context or input (ITEA, 2009) and the way emotions are related to social software experience is the focus of this paper.

Our affective system makes judgments and quickly helps determining whether the elements in our environment are dangerous or safe, good or ill (Norman, 2004). The affective functioning model proposed by Ortony et al. (2004) helps to understand how the human cognition is influenced by the affective states and how this influence could be considered in HCI.

The positive judgment in the interaction with a computer system can be referred to as the affective quality of the interface (Chorianopoulos and Spinellis, 2006), a concept that started to be seen in studies in the HCI area in recent years. According to Zhang and Li (2005), those artefacts that awaken a positive affective state work better, are easier to learn, can be more regularly used and are capable of influencing purchase choices. Perceived affective or hedonic quality of an interface has a positive impact on how users perceive the usability of systems (Zhang and Li, 2005; Norman, 2010; Chorianopoulos and Spinellis, 2006). Tractinsky el al. (2000) also evidenced that beautiful user interfaces influenced the user's affective state and worked better.

Ongoing research related to this subject has addressed many issues, such as the relationship between usability of computer learning systems and their affective quality, measurement of body responses and its relation to emotions felt when playing computer games, etc. When we consider a Social Software (SS) that supports a web based community, even more questions rise: How can the affective quality of a SS be determined? Can it be predefined or is it socially constructed and different in each instance? Are the approaches found in literature for games or other contexts suitable for SS? In this context, the objective of this paper is to bring forth a discussion on how to assess the affective quality of SS, considering the human being with its complex and dynamic relationships with others through the SS or with the SS itself.

In order to discuss the assessment of affective quality in SS, we first review the state of the art in the topic of affective and emotional aspects of interaction. We then analyse different possibilities to evaluate these aspects. In order to guide that analysis, we propose a combination of elements of human values (Pereira et al., 2010 and Smith) and different

dimensions of interaction. Then we bring into discussion the evaluation possibilities in a SS perspective, looking closer at some features of Vila na Rede, an inclusive SS or Inclusive Social Network (ISN). We understand SS as the service that allows groups of people to interact online, communicating and sharing ideas, feelings and interests. By associating some human values to system features, it is possible to investigate affective and emotional aspects of SS, which may have a potential impact on determining the success or failure of the SS.

The paper is organized as follows: in the next section we present the main concepts and theory on emotion and affective quality of stimulus; then we show some methods found in literature for measuring emotional responses from users; next we use this theoretical base to discuss the use of these methods in the evaluation of social software affective quality, using Vila na Rede as case study. Finally, we conclude the paper indicating further research directions.

2. Affective quality

Affective quality is a property of stimuli, such as objects, places, and events, capable of changing an individual's affect (Romani and Baranauskas, 2009; Zhang and Li, 2005). The perception of the affective quality of a stimulus is based on how pleasant, unpleasant, exciting, boring, upsetting, or soothing each stimulus is and this evaluation influences a subsequent reaction towards these stimuli (Romani and Baranauskas, 2009).

By conceptualizing the affective system according to the neuroscience and psychology literature, in the next sessions we describe how the affective process occurs in the individual.

2.1 Affect, emotion and cognition

Emotion, affect and feelings do not have a consensual definition in literature (Goleman, 1995). In a neuroscience perspective, emotion is the record of the body for external stimuli, and feeling is the individual experience of living an emotion (Damasio, 1994); primary emotions are innate and involve the limbic brain; secondary emotions are learned from events of the past, and involve also the cerebral cortex, a brain area associated with decisions.

In the psychology domain, Norman (2004) defines affect as a broad term that applies to a system of judgments. Emotion, mood, preferences and feelings are sub-categories of affect. Feelings are readouts of the brain about changes in the body state, such as attention level or muscle tension. Emotions are interpreted feelings, or conscious experiences of affect. Thus, feelings are necessary but not enough for emotion, and emotions, in turn, are subsets of the affective system (Norman, 2004; Ortony et al., 2004).

Even though from different points of views, both authors agree that affect and emotion encompass conscious and unconscious components and bodily changed records for emotion and affect.

Both affect and cognition are information processing systems, and together with motivation and action, build in the four domains of an organism funciotioning (Ortony et al., 2004). While cognition interprets and understands the world, affect allows rapid decision making, sometimes before the cognitive interpretation. A lack of the affective system caused by a brain injury, for example, could prevent a person from making decisions or thinking about his/her future (Damasio, 1994).

The effect of positive affect is demonstrated by experiments which have shown that people who received a candy or watched comedy movies before being exposed to a complex problem had better performance (Norman, 2004; Ortony et al., 2004). Damasio (1994) also illustrates the interference of affect on cognition based on the conclusion of an experiment that required logical thinking: results show that it is more likely that a patient accepts a health care when informed that 90% of patients survived than if informed that 10% died. The feelings linked to the idea of death (negative affect) lead to what he calls an unreasonable inference. When designing technology, generally it is desirable to create strategies to induce a positive affect, since happiness facilitates creative thinking. The vigilant state led by a negative affect, on the other hand, may benefit concentration and attention to details (Norman, 2004). A negative experience is not the expected experience when designing the interaction with a SS.

To be aware and in control of our own emotions is considered part of intelligence according to the concept of Emotional Intelligence (Goleman, 1995). The ability to recognize emotions in others is considered an important point in establishing a social contact as well. Mediated by a technological platform or not, social contacts are important for the constitution of the emotions of the individual and of his entire group. Being considered as an intrinsic part of our social lives, many authors state that emotions are also experienced through interactions (Boehner et al., 2007; Almeida et al., 2010; Benyon et al., 2010; Bødker et al., 2003). In this sense, understanding users' affect related to the interaction with Social Software implies considering both individual's aspect of the interaction and also the relationship with the social group that may (or may not) motivate the interaction.

Building on Norman's (2004) definitions of affect and emotion, the functioning of the affective system is explained in the following session.

2.2 A Functional model of information processing considering the affective system

Ortony et al. (2004) describe the functioning of an organism as a multi-functional

model with three levels of information processing that corresponds to different parts of the neural system. This model reflects the biological origins of the brain; simpler animals are restricted to the reactive level [called visceral in Norman (2010)]; the behavioural [or routine (Norman, 2010)] level is part of mammals, and the reflective level is an exclusive attribute of the human being. Figure 1 illustrates the relationship between the three levels and the world, and is described as follows:

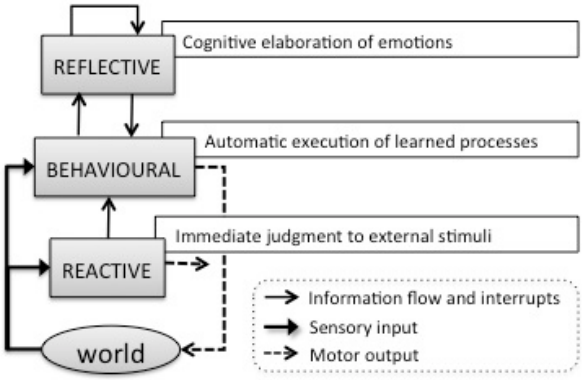

Figure 1 – Multi-functional model of an organism functioning (Ortony et al., 2004; Norman, 2004)

Reactive level: rapidly assigns positive or negative values to external stimuli, being essential to mobilize appropriate responses to environmental requirements. It receives sensory signals, sends signals to the motor system and alerts the higher levels. Its action can be potentiated or inhibited by the higher levels. Approach and avoidance are classes of behaviour and the motivation operates with simple drives, such as appetite and survival. There is no affect, but a proto-affect restricted to the moment without references to the future or to the past. The reactive responses vary with each individual according to parameters such as intensity, speed, accuracy and sensitivity to a variety of functions.

Behavioural level: dedicated to the execution of automatic processes that were learned, such as driving a car. Unlike in the reactive level, skills are acquired. Processes can be triggered by the reflective level (deciding to take or not to take an action), by activities of that level, and by the sensory system that monitors internal and external signals. It also acts as a control system, halting processes when something understood as an anomaly is found. There is no consciousness, only awareness. Cognitive processes include aspects of perception, basic processes of language comprehension, among others.

The affect in this level has some characteristics similar to those of emotion, but it is still not interpreted. These "primitive emotions" are created crossing temporal representations of the behavioural level with positive or negative valence of the reactive level. For example, fear is a negative feeling about a potential bad thing, but it is still a feeling waiting to

be processed on the reflective level. Table 1 describes this characterization according to Ortony et al. (2004).

Reflective level: where the emotions are cognitively elaborated. As shown in Figure 1, it neither receives sensory information directly, nor sends signals to the motor control, but influences the lower levels. The proto-affect of the reactive level and the primitive emotions and feelings of the behavioural level are interpreted by relating cognitive representations with internal and external events that induced the affect. Considering the consequences of reflecting upon fulfilled or violated expectations and fear, elaborated emotions are created and can be labelled as in Table 1. Regarding the reflective level, there are references to past, present, future, and also to hypothetical situations, as well as individual differences in operational parameters regarding focus of attention, working memory, knowledge, culture, self-analysis and even the ability to influence the lower levels.

Table 1 - Characterization of primitive emotions on the behavioural level

Primitive emotion	**Level of valence (reactive level)**	**Temporal relation**
happiness	a positive feeling about a good thing	present
distress	a negative feeling about a bad thing	present
expectation	a positive feeling about a potential good thing	future
fear	a negative feeling about a potential bad thing	future

Processes can be bottom-up (from the reactive to reflective) when driven by perception, and top-down (from the reflective to reactive) when they are driven by thought.

At the reactive level occurs the proto-affect – the association of a value to a stimulus –, which can be interpreted in different ways by higher levels resulting in a vague feeling that something is right or wrong at the behavioural level, or generating a full emotion at the reflective level. Emotions – the highest level of affective state – are interpretations of feelings from lower levels and occur only at the reflective level, influenced by a combination of contributions from behavioural, motivational and cognitive domains. Therefore, affect is something general, built according to psychological conditions related to individual value.

In his Emotional Design, Norman (2010) argues that it is possible to design interactive artefacts in such way they influence the affective state of an individual, highlighting the importance of affect and emotion to design pleasurable interfaces. According to Zhang and Li (2005), these artefacts have the potential to be more regularly used, easier to learn, influence purchase choices, and produce a more harmonious result.

Although considered one of the most comprehensive definition of emotion in HCI (Lim et al., 2008), Palen and Bødker (2008) argue that Norman's approach is concerned with a single-user experience, an add-on to cognition, and ignore important aspects such

as emotions created in interaction among human beings, a crucial phenomenon when addressing social software context. Differently, Boeher et al. (2005) tackle emotion from a social and interactionist perspective. However, for Palen and Bødker (2008), this approach paradoxically undermines the importance of emotion since it considers emotion as the purpose of the interaction instead of a feature that may contribute to the interactive experience.

Aiming at providing a panoramic view of different approaches, in the next section we present some models to the evaluation of the affective quality of user interfaces.

3. Models for evaluation of systems affective quality

Different methods have been proposed as an attempt to model or to evaluate the affective quality of a computational system, identifying users' responses in terms of human factors or the impressions that they have about that system, complementing traditional HCI measures. Boehner et al. (2007) classify these approaches based on two different understandings of affect and emotions: informational and interactional. They call "informational" the perspective in which emotion is seen as a measurable object of study. In this group the authors include all research methods that try to objectively quantify emotional responses of users. In opposite direction, Boehner et al. (2007) named "interactional" the perspective in which affect and emotion are dynamically constructed and interpreted by, with, and in a social (cultural) setting. As examples of the informational methods, are most methods based on the measurement of bio-physiological responses, for example: Joho et al. (2009); Khan et al. (2009); Ravaja et al. (2006); Thayer (1989). These approaches allow formalization and accountability, and are common in the context of games. In general, physiological responses (e.g. heart rate) are taken in order to classify or associate the resultant metrics with emotional states of the user. Another approach that is closer to the informational model is the Affectiva Smile Tracker (Forbes, 2011), where the system, by using a webcam, identifies and accounts for your smiles.

Some examples of approaches closer to the interactional model would be: Almeida et al. (2010); Angesleva et al. (2004); Boehner et al. (2003); and Isbister et al. (2006). The proposal of the interactional models (Boehner et al., 2007) indeed represents a rich and preeminent taxonomy. But one can find in literature studies that might lay in between the interactional and the informational models. Among these studies are those that do respect the variety of meanings and interpretation, are aware of the fact that emotion and affect are cultural and social products, but that still try – to some degree – to quantify, register and/or label emotion and affect.

In this category we can mention the work from Hayashi et al. (2009), based on Lang

et al. (2005). Using a pictographic questionnaire [the Self Assessment Manikin - SAM (Lang et al. (2009)], the method proposed by Hayashi et al. (2009) evaluated the affective quality of a computer system for digital inclusion; the results were later computed and shown as a quantitative result regarding the dimensions of valence, arousal and dominance together with the reactive, behavioural and reflective levels [from Norman's three levels model (2010)]. Figure 2 shows SAM and the software that was evaluated in Hayashi et al. (2009). In the framework proposed by Chorianopoulos and Spinellis (2006) for the evaluation of user interfaces of interactive TV, SAM was suggested as an instrument for the reactive level. In Hayashi et al. (2009), the framework was adapted and SAM was applied for the measurement of users' responses for both the reactive and reflective levels. To fit the reflective level, the authors asked participants of their experiment to fill in the artefact after a group debate about the system. This discussion gave the participants the opportunity of bringing the visceral responses into reflection.

Figure 2 - the Self Assessment Manikin - SAM
being applied at (Hayashi et al., 2009)

Other directions that might be considered as standing in between the interactional and informational models include the thoughts of Norman (2004; 2010). Even though Norman's works indicate his agreement with the rather dynamic and evolutionist construction of emotions (interactive), they also suggest that, once the emotion is expressed in the form of human behaviour, it is no longer as subjective as the sentiment itself. Therefore, there seems to be a place in between the interactional and the informational models where emotions and their manifestations are not only actively created in society but also, to some degree, they are informative and measurable.

Although the followers of more strict interactional views might consider questionnaires as rather biased methods, SAM (Lang et al., 2005) still maintains some subjectivity as it does not label emotions, but considers them in the three dimensions of valence, arousal and tension [or dominance, as some authors (Romani and Baranauskas, 2009) refer to]. The pictographic format makes it of easy access for young children, and especially for the illiterate and the elderly (or others with reading difficulties) – potential users of inclusive SS –, although without adaptation it is not suitable for the blind. SAM has been

successfully used in different contexts. Romani and Baranauskas (2009) applied it in an inclusive context for the evaluation of a GWIDO game. In Leung and Underwood (2007), only the first two of SAM's three scales (valence and arousal) were used to collect users' responses for the evaluation of promotional websites. Other instruments mix pictures and texts in the attempt of providing more ways of assessing emotional responses, in different types of applications, for example: (Giannakopoulos et al., 2009; Scherer, 2005; Lang et al., 2005; Plutchik, 1962, Russell, 1989).

Lichtenstein et al. (2008) compared the dimensional approach (SAM) with the basic emotions identification approach (consisting of pictures or descriptive words). The authors wanted to understand which of the two approaches could better explain the variance in physiological reactions while participants watched specific films. Although the metrics used in the experiment showed that the basic emotions model allowed a better representation of the variances, the participants preferred the dimensional approach.

As per Scherer (2005), *"while both non-verbal behaviour (e.g. facial and vocal expression) and physiological indicators can be used to infer the emotional state of a person, there are no objective methods for measuring the subjective experience of a person during an emotional episode"*. Scherer (2005) advocates that, since we are dealing with a highly subjective theme that reflects unique experiences (emotional episodes), the only way to assess this information is by asking the individual to tell us about the nature of his experience. The author lists some methods that are usually applied in order to interview participants.

Ravaja et al. (2005) mixed self-report questionnaires with physiological data collection in their study on the relation between presence and emotions. Similar to the approach proposed by Mandrik, Atkins and Inkpen (2006), they recorded the Electrocardiogram (ECG) from participants. Mahlke and Minge (2008) argue that in order to consider the multiple elements that compose emotions, the studies in human-technology interaction should consider a combination of questionnaires, physiological and expression measures, self-assessment ratings and behavioral information.

This review is not meant to be exhaustive. The intention is to provide an overview about ongoing researches on emotional and affective evaluation − with their different approaches − in order to allow a discussion on their application to social software.

4. Perspectives on the evaluation of affective quality of social software

Pereira et al. (2010a) define Social Software as *"systems that allow people, in their particularities and diversity, to communicate (interact, collaborate, exchange ideas and information) mediating and facilitating any kind of social relationship and favouring the*

emergence of a collective wisdom and a bottom-up organization". According to Pereira et al. (2010c) and Smith (2012), a system can be characterized as social software by presenting a subset of seven functional elements: identity, presence, relationship, reputation, groups, conversation, and sharing. Smith (2012) represents these elements in a framework named Honeycomb, which may guide the design of social software by providing a basis for identifying each of these elements.

Relating SS definition to the affective quality concept, one may see evaluation of SS as the analysis of the set of properties that a SS may have, including its ability to evoke emotions from users or groups of users.

All SS evoke some kind of emotion from users, be it positive or negative, strong or weak. Even when "indifference" is the emotional response from the user, "indifference" is already a response, and there can be contexts in which it is a positive response. As the design of social software takes into account human factors, group dynamics, social and psychological aspects (Pereira et al., 2010a), emotions can emerge from different dimensions: from the interaction with the software (human-computer interaction – HCI), from the group relation (human-computer-group interaction – HCGI) or even from the mediated contact with another person (human-computer-human interaction – HCHI). In the last two dimensions, emotions may be evoked both by the content itself and by the interlocutor who originated that content, which represents an additional challenge when evaluating SS.

To understand how the affective evaluation of social software could provide the recognition of emotions and potentially an indication of success of that SS, in Table 2 we identify some concerns and opportunities regarding the three mentioned dimensions.

In bold the elements of the Honeycomb Framework (Smith, 2012) are considered.

Table 2 – Concerns on affective evaluation of SS and possible methods

HCI	Aspects such as aesthetics, usability, and accessibility may be the first step to adopt or not social software. SAM (Lang et al., 2005) may be applied to recognize the basic elements that lead the users to create their identity within the SS.
	*.Does the way the users' **presence** is represented express their emotion about being part of the SS? Does the user feel safe and secure **sharing** personal data on SS? What kind of emotion related to trust is supported by the SS resources and features?* *.Is the way one's **reputation** is expressed to others compatible with their view about themselves?*

HCGI	The emotions that are expected to be evoked are related to the social connectedness, which is defined as the sense of belonging, based on the personal appraisal of having enough social contacts (Santos and Pitt, 2010). This aspect may be the reason for keeping using or to abandon specific SS. The evaluation depends on the nature of the social software, on the context and environment, and on the emotional balance of the group (Santos and Pitt, 2010). For example, a mixture of anxiety and fear might be expected in some games, but not in the SS (Moncur, 2007) for sharing motherhood experiences. Surveys to measure group engagement or inquiring users about emotions could be applied in this dimension.
	*.What are the elements that make the group **identify** itself as a group?* *.The use of visualization tools is common in SS to have a perception of who is attracting others, establishing a **relationship** with others. What kind of emotion do they afford?* *.How does received feedback when **sharing** contents evoke emotions? How is it related to the sense of **group**? Is the engagement a possible parameter to be associated with the sense of belonging?* *.How can group **conversations** supported by the SS features and resources evoke emotions?*
HCHI	When a relationship between two people is mediated by social software, it is possible to measure a connectedness feature that supports intimate social relationship (Jansen et al., 2010). When social software is not effective to facilitate a relation, it may be abandoned. Physiologic responses and inquiring users may be combined to evaluate aspects such as presence, sharing and conversation, especially to differentiate emotions evoked by the content or by the interlocutor.
	*.Users want to know who is online, available or nearby. Presence makes a person feel more comfortable. How to measure it? How the **presence** representation in the SS could promote (positive/negative?) responses in the user?* *.Different contexts and kind of **relationships** may imply different measures. i.e.: measuring emotions to solve workplace incivility (Santos and Pitt, 2010).* *.Engagement concerns focused attention, novelty, endurability, involvement, aesthetics and hedonic quality, important criteria to invite the user to continue using it to share experiences. How to isolate factors inherent of the tool from those due to content? Is there ontology dependence between **sharing** and collaboration?* *.How to measure the subjective experience of a person during a **conversational** episode mediated by SS? (Scherer, 2005)*

One of the definitions of the word 'social' is: *"relating to or designed for activities in which people meet each other for pleasure"*[2]. Being essentially social, SS should then have an intrinsic ability to promote pleasant activities by evoking positive emotions from the participants of that web community. In order to study the viability of evaluating affect and emotion in SS, in the next section we consider *Vila na Rede*[3], an Inclusive Social Network (ISN) system.

4.1 Preliminary thoughts on affective qualities in Vila na Rede

In order to further discuss the possibilities in methods for affective evaluation and provide members of web communities with a better understanding of our proposal, we present the analysis of an online SS: Vila Na Rede.Vila na Rede is a social software developed as a conjoined effort from community leaders, end users and researchers from diverse fields of knowledge. The features of this ISN were designed to support the needs of varied social groups in Brazil in a way to make sense to the users in their daily reality. Aiming at reaching the Brazilian population in its widest possible range – including the illiterate, the elderly, those with some kind of disability etc. –, this SS was intended to be a source of opportunities for creating a digital culture among the least favoured part of the population. One of the reasons why we chose Vila na Rede was that it started with a non-online community, and its needs and abilities were collaboratively and gradually built into the online community. This participative process gave us the opportunity to observe the communication and expression of affect and emotion that take place in a real life scenario (Hayashi and Baranauskas, 2010; Santana and Baranauskas, 2010; Reis et al., 2010).

The *Vila na Rede* was launched with a small group composed by community leaders from a neighbourhood in Brazil and some end users from that neighbourhood. The SS was a result from many face to face encounters with the entire group during participatory design practices conducted by our research group. Researchers not only conducted the activities to motivate the initial use of the online SS, but they also actually took part on it, sharing their interests within *Vila na Rede*.

Since the launch, the number of participants has increased in more than 100 times the initial population (Vila na Rede has currently around 370 users), expanding to other Brazilian cities, states and even abroad. Nowadays, four years later, *Vila na Rede* is still active, being maintained only by the interest of its users. The sustainability of that SS even after the end of technical support, and despite of the dissemination of Orkut and more recently of Facebook, can be considered an indication of success. Therefore,

[2] *Oxford Dictionaries Online. http://www.oxforddictionaries.com/*

[3] Vila na Rede. http://www.vilanarede.org.br

the analysis of its features based on our proposed perspective might contribute to the understanding of affective evaluation of SS.

While *Vila na Rede* was collaboratively created in a conjoint effort from researchers and the actual community of users, the analysis we present here was performed by researchers only. Table 3 lists Vila na Rede's main features and their brief description. Underneath the uses of Vila na Rede, emotional and affective aspects lay on a subtle level, as the engine that motivates all social interactions. The feeling of being part of a group (the group of the digitally literate), being aware of the (virtual) presence of others, the conversations that take place at a geographical distance, the need for setting and showing their identity, etc., might all be related to the actual need for affective liaisons or approval. While all the other elements from the Honeycomb Framework (Smith, 2012) − together with other values from Pereira et al. (2010b) − compose the spinal cord that supports the existence and maintenance of a SS, the elements Emotion and Affect, together with Hedonic Quality, compose a (sometimes unconscious) primary core that directly influences or create the proper ambience for the presence of the other elements and values.

Since its initial phases of development, users already manifested their opinion and feelings towards the system. In the activities for eliciting requirements for the Conversas Online (the instant messaging tool built for Vila na Rede), two posts surprised the researchers. These posts were not directly related to the conversations in place; they were directed the entire group: even those who were not exchanging messages (e.g. the researchers that were only observing and taking notes of the activity). The messages were posted as to express the person's feelings towards the activity. They read: "I love you all" and "thanks for this opportunity" (Almeida et al., 2010). Despite the participants' difficulties with the written language, she wrote these messages and posted to the group as an expression of the feelings that this activity brought to her. This result indicated the advantage of having systems or methods that support users in their expression of affective and emotional responses.

Physiologic responses might be used to evaluate aspects of presence and mediated conversation. In a controlled setting (e.g. participatory practice), researchers could register participants' physiologic indices (i.e. EGG) that are supposed to indicate levels of satisfaction or excitement and compare the results when the user is: alone, with friends or with strangers, as done in (Mandrik et al., 2006; Ravaja et al., 2006). The problem, though, would be to apply this evaluation to the online settings of ongoing SS. Still the persistent questions to be answered would be: how the representation of the presence of other participants in the SS could promote (positive/negative) responses in the user? Do participants feel better knowing that they are part of a popular SS or the number of followers does not matter? To what extent could one consider these feelings to be a relevant fact in determining the success or failure of a SS?

Table 3 - Overview of Vila na Rede's main features

Features of Vila na Rede	**Description of the feature**	**Dimensions of Interaction**
Profile	Participants can leave (public or restrict) multimedia data about themselves	HCI, HCGI
Conversas Online	Instant messaging system (Almeida et al., 2010).	HCGI, HCHI
Graphical representation of the conversations	A graph that shows who are the participants that are engaged in a conversation. It also represents who is talking to whom (Almeida et al., 2010).	HCGI, HCHI
New users list	Users who have recently joined *Vila na Rede* are listed.	HCGI, HCHI
Online users list	Users who are online at the moment are listed.	HCGI, HCHI
Central do Vila	Recent updates (on announcements) that are of interest of that user.	HCI, HCGI, HCHI
Announcements	The main feature of *Vila na Rede*, where participants can share their services, products or upcoming events with others.	HCGI, HCHI
Collaboration tool	*Vila na Rede*'s mechanism of allowing participants to help others in the creation of their announcements.	HCGI, HCHI
Comments	Announcements can receive comments from other participants or even from users who are not members of *Vila na Rede*.	HCGI, HCHI
Meta-communication	An inclusive and multimodal scaffolding mechanism intended for both the expert and the novice users of technology (Hayashi et al., 2009).	HCI
WELFIT	Developer's tool for tracking client side data for evaluation purposes (Santana and Baranauskas, 2010).	-
Semantic Search	Search engine specifically designed for the context of digital inclusion (Reis et al, 2010).	HCI
Tailoring	Interface adjustable to fit users' preferences and needs (Neris and Baranauskas, 2009).	HCI

One possible way to allow Web based community members' emotional expressions to be taken into account would be to furnish the system with a hedonic poll tool. Such feature would not only let users talk to the system, but also it would help developers to monitor the ISN, identifying the acceptance of new releases, or allowing them to recognize necessary adjustments to maintain users' engagement. Nevertheless the choice of the instrument and method to be used for the evaluation of emotional responses should vary

according to the characteristics of the participants of the SS, and the intentions behind the evaluation (e.g. specific for one feature or general; focused on specific values, interaction dimension, etc.). The complexity of emotional and affective reactions and interpretations is vast and yet, the options for evaluation methods are still limited, which opens venues for further investigation.

5. Conclusion

Social Software and the investigation of what motivates participants to use them is a topic of interest to researchers from different communities, including system design and web-based communities. The nature of Social Software brings to discussion elements not usually dealt with on regular software. In this paper we aimed at exploring its relation to emotional and affective issues to foresee implications regarding the success of a SS.

Affective and emotional processes are very complex, composed of and stimulated by a myriad of factors and researchers have not yet completely explored this field. Nevertheless, the methods available in literature to evaluate the affective quality of software provide a way to measure the emotions on each user individually during his interaction with the software. When we relate these processes to SS's components – and with the values that could be cultivated from the interactions that take place in and with SS −, we find even more venues for investigation. The discussion brought by this work represents an initial step towards work in emotional and affective evaluations of SS and indicates the need for further investigation on the relationship between interface elements and the way they may evoke emotional and affective states among the members of an online community.

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Appendix B

Energy Consumption Awareness in the Workplace: Technical Artefacts and Practices[1]

Abstract

Despite all technological advances in the energy research field and the ubiquitous presence of technology in all aspects of life, the lack of information is still recognized as a gap to engage people in a pro-environmental behaviour towards energy conservation. Consumption feedback is elementary to tackle this paradox, but not enough to trigger a social change. It is still necessary to motivate people in order to raise awareness effectively. This study associated the feedback provided by smart monitors with a debate tool and a tangible motivational device for building energy awareness collectively in a workplace. The analysis of the role of each technology considered assessments and interviews, and also the content of the online discussion, which encompassed more than 170 ideas for changing behaviour for around 100 issues about how the energy has been consumed. Results demonstrated that for raising energy awareness, beyond technology, it is also necessary to deal with formal and informal elements, such as institutional practices and individual's motivation. These technical, formal, and informal levels shaped our qualitative analysis to identify elements participants considered relevant to learn and to discuss, suggesting their importance to similar initiatives that aims to raise energy awareness in a wider perspective.

[1]**Article published and awarded as the Best Paper "Piccolo, L., Baranauskas, C., Fernandez, M., De Liddo, A. and Alani, H. (2014) Energy Consumption Awareness in the Workplace: Technical Artefacts and Practices. Proceedings of IHC 2014 - Brazilian Symposium on Human Factors in Computer Systems."**

Keywords: Energy consumption; Awareness; Collective knowledge construction; Organisational semiotics

1. Introduction

The great majority of efforts to introduce innovation in the way energy is generated, distributed and consumed are actually coping strategies to deal somehow with the limit of the planet regarding natural and socioeconomic resources. New policies or economic models are also attempts to reconsider this system that is in fact one of the foundations of the social life in the planet. Framed in the Human-Computer Interaction (HCI) field, this study is grounded in the conviction that there is no effective change in such a complex system when human aspects are not centrally considered. People must be engaged in innovation development to the same extent as technology, however according to a recent official European report [1], *"the interaction between humans and new energy technologies remain challenging"*. Cultural factors and the cognitive impact related to the design of feedback devices are among the outlined reasons.

Raising awareness of energy consumption is then a research topic that represents the challenge of assigning responsibility also to individuals to make the energy system more sustainable and efficient. Awareness is understood as a necessary, although not sufficient, condition for changing behaviour towards conservation, which occurs whether the person is also motivated. Promoting awareness embraces from *"making energy visible"* [2] in daily routine to providing *"knowledge about how and why to reduce waste by operating devices more efficiently"* [3].

Despite the ubiquitous presence of technology (and of energy) in all aspects of life, people still know very little about their own energy consumption, even in the developed contexts. This recent study [4] points out that consumption is usually understood at a high level, being related to seasonal effects as the weather, and rarely associated with appliances usage itself. Providing appropriate information is the first step to raise awareness. For [5], the lack of information is also the main gap that needs to be bridged to transform awareness into behaviour change. To make different choices that sometimes impact in their comfort, people must be aware of the benefits too.

Different motivations drive people to be engaged in saving energy [6]. Some are concerned about money, others about the environmental impact and, while some do not care about it, other people are keen to study and disseminate ideas for conservation. We argue that exploring the energy consumption topic by sharing experiences within the social group, and then building awareness collectively, may be a promising way to fill the gap of information towards a social change.

This study addresses energy awareness in the workplace, particularly in a computer

science research lab in the United Kingdom, where people are closely acquainted to technology. In this context, people usually bring from home different experiences with energy consumption in such way that the individuals' perception, control and autonomy to act are rather different. We therefore applied three different technologies to support this energy awareness study: 1) a social tool for sharing knowledge and debating about perceptions and experiences; 2) smart monitoring devices for learning about individual consumption; 3) the Energy Tree, a tangible device used as a feedback of contributions to the debate tool to motivate engagement.

By analysing the content generated by participants and their evaluations within the study, this paper discusses how these technologies contributed to the process of raising awareness and presents some findings related to relevant information to be provided for promoting energy conservation in a workplace.

The paper is organized as follows: Section 2 contextualizes studies that address energy awareness collectively and consumption perceptions. Section 3 conceptualizes the role of technology to promote social changes and briefly describes the three technical artefacts applied in this study. Section 4 defines the study methodology. Section 5 reports results that are discussed in Section 6. Section 7 presents our conclusions.

2. Related studies

Building awareness collectively and considering the external forces that influence social changes is an emerging approach in the HCI domain. The studies have been mostly focused on providing feedback of consumption to individuals instead [6]. A collaborative approach was found in [8] relying on collective saving with the clear objective of reducing energy generation. The authors propose alternatives for design such as projecting consumption data in the street for engaging neighbours to work together.

In the workplace, studies are more focused in promoting energy literacy than assessing consumption reduction. Holmes [9] placed an artwork in a university building to represent instant data from the automation building system regarding water and energy consumption. The artwork represents how green (in number or trees) or grey the building is at the moment. Watt-Lite [10] was another initiative to publicly represent statistical data of energy consumption in a factory. Three oversized torches projected real time data on the floor. Results indicated the importance of choosing the right installation place in sociable areas, such as those close to a coffee machine, to have better engagement results. It resulted in situated engagement, but not enough to lead people to visit the project website. In [11], after building a baseline with 5 months of consumption in a working environment, researchers conducted a series of workshops to promote reflections and then tracked behaviour change. They evidenced that workers do take responsibility

for conservation if they get adequate support for that, and recognized the importance of building consensual collective practices, especially towards shared equipment such as printers. They also noticed that people prefer to keep individual consumption as private.

2.1 Perceiving energy consumption

Darby [12] investigated qualitatively how people perceived energy according to the Theory of Affordances [13], a concept from Ecology that refers to the relationship between physical properties of the environment and a personal experience. She evaluated how different types of feedback affect the perception and found out that people mostly pay attention to information related to the payment of the bill instead of consumption; the In-Home Displays (IHDs) are the physical presence with the potential to lead to savings, but their effect last for few weeks only; and the online feedback requires extra effort and determination to look up consumption data. When social aspects are present, such as comparison with other people or even competition, motivation for engagement might go beyond monetary and environmental aspects.

To deal with changes in behaviour, it is necessary first to appreciate how people understand the phenomenon of energy by themselves [14]. In line with that, Schwartz et al [15] investigated what and how people in a living lab learned about energy consumption by monitoring it online. People tend to use feedback for few weeks, becoming more aware of appliances consumption level (also in stand-by), typical consumption level by the time of the day, including always-on consumption in the evening, and consequently details about the energy contract.

How people make sense of the IHD was also the focus of [2] and [16], who found out that monitoring consumption can either empower users to bring consumption into discussion among the family and to change behaviour or, in the contrary, raise a feeling of frustration or guilt by the few monetary or environmental achievements. This study also brought to light that energy consumption is a social and collective process rather than individual, and it must be discussed as a first step towards changes.

In [17], the authors conceptualize energy culture and propose a framework that helps to identify both individual and social factors that influence behaviour in social groups. The core concepts of the framework are those cultural, such as values and knowledge, grouped as Cognitive Norms; Material Culture, which encompasses technology usage and building forms; and Energy Practices that determine how people use technology.

3. Motivation, Behaviour and Technology

Motivation gives force and direction to behaviour [18]. As also observed in the literature review, some theories from Psychology [18][19] state that motivation does not rely

only on internal reasons. Social and cultural factors facilitate or undermine people's resolution for acting. The way people perceive and relate to energy is also shaped by culture, which is not only learned but also acquired.

Motivation drives behaviour, which in turn happens according to three modes that alternate in dominance, according to Hall's anthropological perspective [20]: the informal mode, which is made up of activities done automatically and learned in everyday life; the formal mode which is regulated by rules and for this reason is resistant to change from the outside; and the technical mode, where artefacts support and reinforce behavioural patterns.

A way to introduce cultural changes is through the technical mode. At this mode changes are easily observed and transmitted to others, establishing the basis for new formal systems. When accepted and adopted, changes become embedded in the informal mode. Behaviour in the formal mode, instead, means following rules, like acting in a specific way to respect work practices. In the informal level, behaviour happens without reflection, for instance, by following other people's typical reactions. Persuasive technologies [21] are examples of technical devices designed to facilitate changes in behaviour. They act in the technical mode by persuading the way to act, for example by means of visual feedback, alarms, etc. Nevertheless, for [15], to be effective in changing behaviour, indeed, persuasive technology still needs to take individual motivation into account.

In this work, three complementary technologies were then introduced aiming at raising energy awareness from the technical to the informal modes. By exploring the social aspect of energy consumption through discussions, as pointed out by [16], the debate tool aims at building awareness collectively, while the smart energy monitors are essential learning tools [2]. The Energy Tree takes motivational aspects into account, which is a gap highlighted by [16], with the purpose of promoting engagement.

3.1 The debate tool

For bringing social aspects to the study, the Evidence Hub is an online discussion tool for argumentative knowledge construction [22], with which users can collaboratively build knowledge by sharing not only comments and ideas, but raising arguments in favour or against them. These Contested Collective Intelligence Platforms [23] do not aim to find the best and quickest answer to a question, but rather to develop critical thinking and collective assessment of several solutions. This approach to debate is particularly interesting in complex socio-technical domains, such as energy consumption where there are no right answers.

Users can create **issues**, such as "printers are constantly on" and **ideas** to overcome those issues: "turn off printers in communal areas as well as in the offices at night". Issues

and ideas can be supported or countered by **arguments**, promoted by **votes for**, or demoted by **votes against**. Users can also add **Facts** or Web **resources** to enrich the debate. Ideas, issues, facts, arguments are all connected by themes, such as Behaviour Change or Consuming Energy, or by tags. Interactive maps of connected ideas and people strength the tool social aspect.

3.2 Smart energy monitors

Smart energy monitors are the main instrument to overcome the lack of information regarding how the energy is consumed. Connected to the In-Home Displays (IHD), the smart plugs may provide feedback of specific appliances, indicating to what extent they affect the general consumption. It is well known in literature the potential of feedback to promote savings from 5 to 15% [24], but not necessarily the devices promote users' motivation [16]. The way the information is presented in terms of frequency, granularity, place and time, whether it is in an attractive way or not, are factors that might influence the feedback efficacy [25].

Participants of our experiment received a kit [26] composed by a sensor to be clipped close to the meter for getting the overall consumption, an IHD, a set of smart plugs, and a Web device to make the consumption data available online. The objective of this study is not to reproduce results from literature regarding the impact of feedback (i.e. [2][12][16][24][25]), but to evaluate how the smart monitors complement the whole experimental setting.

3.3 The Energy Tree

The Energy Tree, illustrated in Figure 1, is a tangible motivational device created to favour a new social affordance of energy consumption, which means new patterns of behaviour that are shared in a social community for a specific time [27]. The metaphor of a tree aims at connecting energy consumption to the natural environment. Functionally, it consists of a led-lights tree that can be solar powered with 7 branches that get illuminated independently. The way in which the tree lights represents achievements of collective actions. Initially conceived to represent collective savings for a period of time [28], it was applied as a feedback of engagement to reflect contributions to the debate tool. The effect of the Energy Tree to promote social engagement has been also evaluated in a different context in Brazil.

Figure 1 – The Energy tree

4. The Study Methodology

The study happened during October and November of 2013, involving a total of 33 participants, most of them researchers in the university department. It was composed by 4 phases: 1) Online survey; 2) Two workshops on the debate tool; 3) Smart monitors trial; 4) Sample interview.

The online survey comprised 3 topics: ideas to save energy in the workplace, ideas for personal behaviour change, and problems related to the building, splitting individual responsibilities from installation issues or working practices. The survey aimed at collecting preliminary ideas for populating the debate tool, avoiding the potential inertia from people to start using an "empty" social software.

The Energy Tree was connected to the debate tool during phases 2 and 3. In phase 2, the two workshops (WS1 and WS2) were planned for exploring the debate tool and also to evaluate the impact of the Energy Tree to motivate engagement. Half of attendees started promoting or demoting Facts related to Consuming Energy by voting, then discussed and prioritized Issues. The other group created Ideas for Behaviour Change, voted for or against these new ideas, and then provided pro and cons arguments. After 20 minutes, they swapped roles. The groups engaged in some face-to-face discussions, but most of the activities were done online, on the debate tool. Contributions created in the WS1 were not visible for the participants of WS2, and vice versa, to avoid influencing the creation of new content. Both workshops had the same dynamic, except for the presence of the Energy Tree in the WS2, placed in the centre of the room (Figure 2), as a feedback mechanism by reflecting the number of new contributions submitted to the debate tool. It was expected that the Energy Tree would motivate a higher number of contributions to the debate tool in WS2.

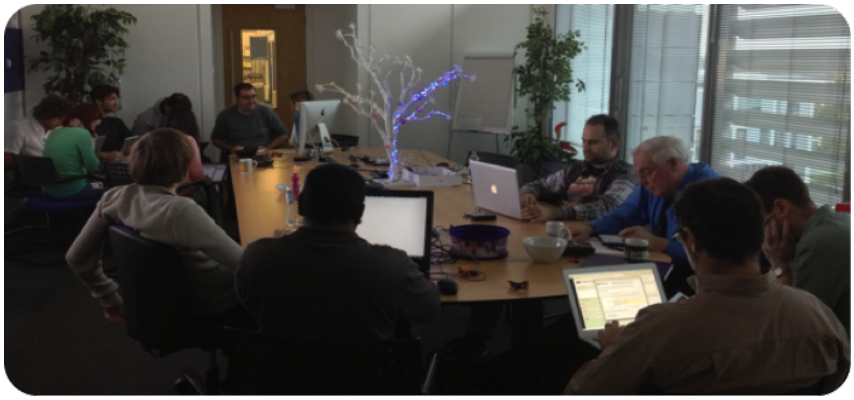

Figure 2 - The WS2 workshop with the tree

In phase 3, volunteers of both workshops were asked to install the smart monitors at home or in the office to learn about their consumption, and sharing their findings in the debate tool during the following week. During that time, the Energy Tree was placed in a social area of the department as a feedback of engagement. Every 60 new contributions to the tool (new issues, ideas, arguments, facts, resources or votes) turned on a new branch of the tree. Results of each group were identified and kept alternating from time to time.

In phase 4, after the trial, a sample of participants, including the top and bottom contributors, was interviewed about their motivations, perception of the tree and the smart monitor as well as their overall experience with this study.

4.1 Analysing energy consumption dynamics

Aiming at understanding how people perceive energy consumption and how technology is related to this process, concepts of the Organisational Semiotics (OS) [28][30] have been applied to analyse the collected data. Aligned to the three modes of behaviour from Hall [20], through OS, every technical system is within the core of a socio-organisational context and surrounded by the formal and informal layers of the society or the social organisation. Thus, the technical systems are under the influence of both formal and informal levels and, at the same time, they have an impact on them. The relations among the informal, formal, and technical levels of the information system are explained through the metaphor known as the "organisational onion", illustrated in Figure 3. The aspects underlined in the Figure are those introduced by this study.

In this context, electrical appliances in general, the smart monitors, and the Energy Tree are in the technical level. Between the technical and the formal is the debate tool that aims at supporting the collaboration by connecting people to discuss about energy consumption. In the formal level are the policies, institutional practices and the workshops (phase 2) realized to engage people. The informal level contains the cultural and individual aspects: habits, motivations, beliefs, perceptions as well as the expected collaboration to the study.

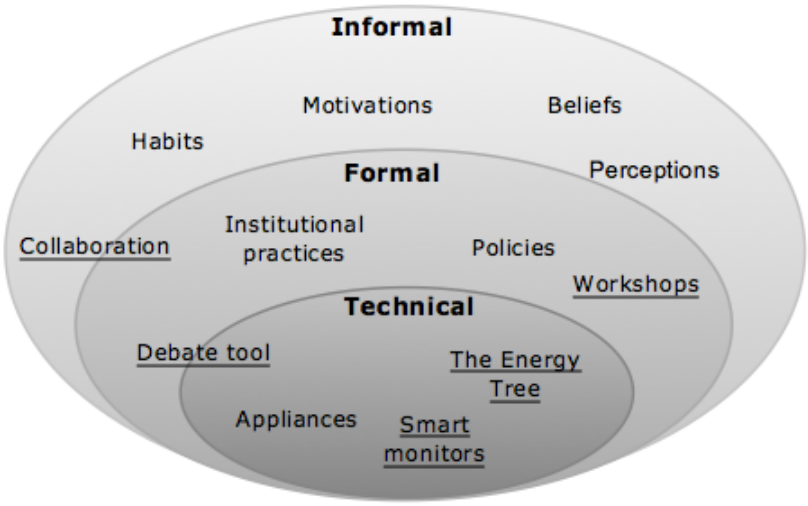

Figure 3 - Energy Awareness "Organisational onion"

5. Results

The next sections present results related to participants' interaction with the three technologies: the debate tool, the smart monitoring, and the Energy Tree.

5.1 The online debate in numbers

A total of 19 people filled out the phase 1 online survey. As already mentioned, the answers to the survey were added to the debate tool as the initial input for both workshops.

The workshops attracted 24 people (12 each), including 10 of those who answered the online survey. Five people in each session volunteered for the smart monitor trial. The online discussion started with the workshops (phase 2) and continued for the smart monitor trial (phase 3), spontaneously attracting also people who did not participate in previous activities. Table 1 synthesizes the total of contributions to the debate tool for both Group 1, in the WS1, and Group 2 in the WS2. Group 1 had a lower number of contributions in the workshop compared to Group 2, which had the tree. But the score inverted in the following week when both groups had the tree as a feedback in the public space.

Group 1 created a total of 92 ideas for 58 issues and voted 430 times. Group 2, instead, pointed out 84 ideas for 46 issues and gave 331 votes. The chart in Figure 4 presents the distribution of types of contribution within the groups.

Table 1 - Total of contributions to the debate

	Group 1	Group 2
In the workshop	348	542
After the workshop	247	78
Total of contributions	595	620

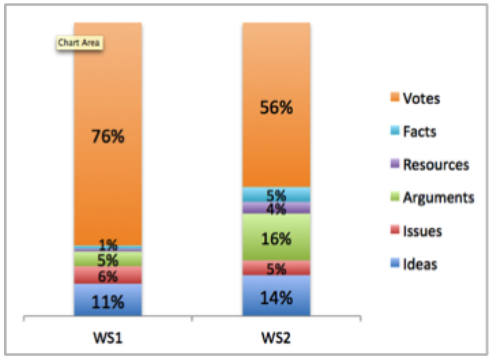

Figure 4 - Types of contributions

The five most cited appliances/devices were: Lights (26%), Computers (17%), Kettle (8%), PC monitors (7%) and Printer (7%). New posts on the debate needed to be annotated by the user with one or more of the six themes: Behaviour Change, Consuming Energy, Institutional Actions, Environmental Actions, Good Practices, and The Tree. Discussions about possible Behaviour Change engaged most, representing 41% of issues, ideas, arguments, facts and votes. 30% discussed how the energy has been consumed. Institutional actions were 21%. Good practices and discussions about the study were few, 6% together, and only 2% discussed about Environmental Impact, as in Figure 5.

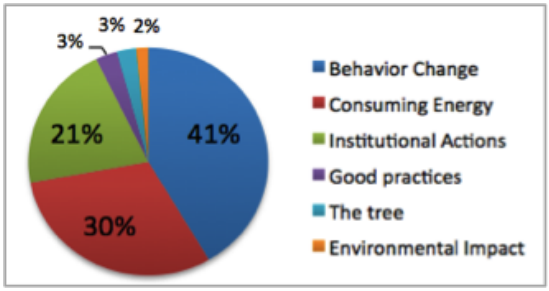

Figure 5 - Distribution of contributions' themes

People who did not contribute pointed out the complexity of the debate tool as a reason. Such perception of complexity was also evidenced by user experience evaluation

with workshops participants. However, details of this evaluation are out of the scope of this paper.

5.2 Monitoring consumption

Volunteers monitored consumption during the phase 3 of the study and reported difficulties when installing the smart monitor devices at the office during that time. The issues were mostly related to network security constraints that prevented the setup of the Web device, and to clip the sensor close to the main meter, which is hidden and locked. So, most of them took the kit home instead.

Even though, only 2% of the contributions within the debate tool referred to data collected from the monitoring devices or shared experiences about the usage/installation. When asked to score from 1-5 how they like the equipment, 83% of respondents of the sample survey scored with the maximum value (5), and 17% scored as 3.

5.3 The Energy Tree and motivation

Participants' motivation and the impact of the Energy Tree were assessed by means of the sample interview (phase 4) with 10 participants, 4 people from Group 1, and 6 from Group 2, including both: those who most contributed and those who did not contribute at all after the workshop. When asked to choose up to tree reasons to be engaged in this study, the Energy Tree was in the second place, leaded by the interest for the energy topic: 1) To learn about energy (33%); 2) To see the tree functioning (26%); 3) Interest in the smart monitor devices (19%); 4) The social aspect of the activity (7%); Others (4%).

Participants were also asked to score from 1 to 5 the level of attention they spent to the tree during the WS2 and during the time it was installed in the public area. The public space gathered more attention (Figure 6). The average score of attention in the workshop was 3.5, while in the public space was 3.9.

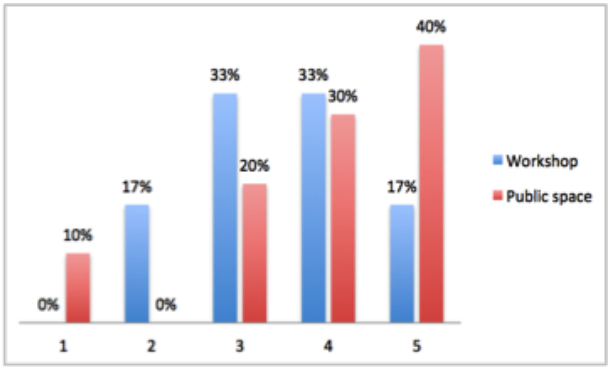

Figure 6 - Score of the level of attention to the tree

6. Discussion

Based on qualitative analysis of the contributions to the debate tool and feedback from participants, the role of the technologies to raise energy awareness is discussed in the next sections, evidencing how participants perceived and used them. This analysis also led to a categorization of topics of discussion and to a list of information of interest to promote awareness.

6.1 Technical artefacts

The three technologies are represented at the core of the semiotic onion, however the impact of them is disseminated through the formal and informal levels in different ways, as described below.

6.1.1 Learning about consumption

The knowledge acquired by means of smart monitors constitutes an important source to guide perception and choices in the informal level. The short-term aspect of the study due to a time constraint prevented longer-term adoption evaluation. Answers to the interview evidenced how that smart monitors were used. The results are in line with [15] findings, obtained in a longer and broader term.

- For learning about the cost of specific appliances consumption: *"I have calculated some basic costs of e.g. a washing cycle, a toast, one year of fridge"*, reported a participant.

- For tracking the consumption along the day: *"I am usually monitoring consumption of specific devices over a period of a few days and using the general meter reading to pay attention to the energy intense usage periods during the day."*

- For comparing consumption appliances: *"I observed consumption while the laundry or pot is running: reasoned that pot even if it runs for a short period of time and such a small electrical device it actually consumes a lot of energy"*, and guiding choices: *"(. . .) it has changed the way we use quite a few things in our house. For example, we don't cook rice using the electric cooker or microwave because it consumes too much energy. Instead we use a pressure cooker. We also stopped using the kettle to boil water"*.

- For understanding cause-effect: *"I was using the smart devices at KMi. I was curious how much energy does my laptop and monitor use on daily basis and also whether the monitor keeps using energy while in standby mode. This was the reason*

why I now started switching the monitor completely off before going home every day".

- For mapping consumption in the house: *"creating usage stats for the following items, so that I can then target high usage areas. Monitoring Fridge, Freezers, Dish Washer, Washing machine, Kettle, Two TV's, Home Server, Printers, PC, Lighting".*

One participant reported the preference for seeing the consumption online instead of by the IHD because of the need to plug it on. As already mentioned, information related to monitoring consumption was not typically discussed in the online debate. Instead, it was observed that the discussions about the device installation and the findings obtained by using them happened among colleagues mostly at the informal level, during coffee breaks, lunchtime or around the tree installation, for instance. A possible reason is that personal information like *"the old one (fridge) is consuming twice as much as a new one would. Could half my energy costs for the fridge per year down to £25 or so"* was considered of private interest, and not suitable to be shared trough a "formal" social tool.

6.1.2 Formalizing the knowledge built collectively

Besides promoting an online environment to build awareness collectively, the debate tool plays the role of formalizing the discussion.

The number of arguments and votes suggests that the tool was effective to promote the debate. The screenshot of the Evidence Hub in Figure 7 illustrates the knowledge tree of the discussion about how to motivate people to save energy, considering the issue that *"saving energy is a very boring thingy".*

The software was perceived as a working tool. In spite of that, people usually expressed themselves like in an informal conversation (the hierarchy seems to not have affected discussion). They did not restrict the discussion to possible behaviour change, some evidenced behaviour pro-conservation they already had, suggested things for the current study, and others pointed out Web references, which demonstrates that they had often analysed the topic before adding a new idea, issue, fact or argument. The online discussion also attracted people in the department beyond the participants. It was rarely accessed to post domestic consumption data.

Some posts reflected participants' expertise, such as ideas for new research developments, like this external resource posted about Collective Action Theory [31].

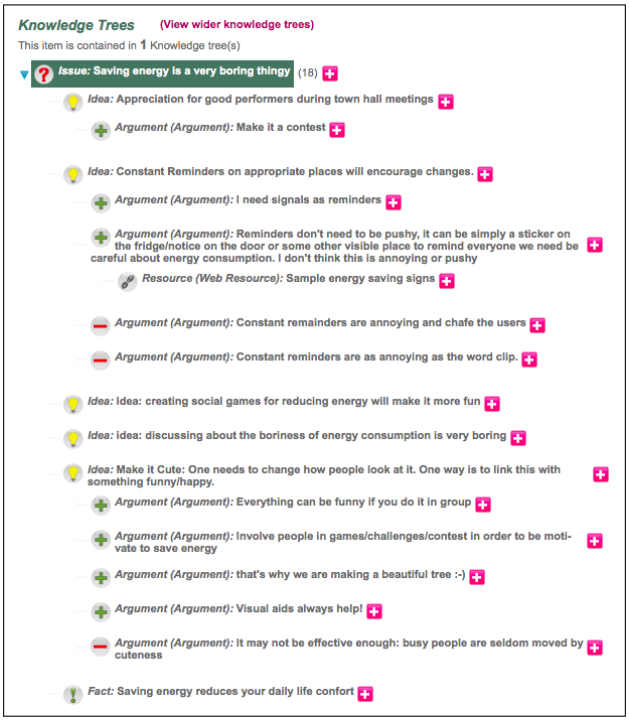

Figure 7 - Knowledge Tree in the debate tool

Being the most simple and direct action, voting represented the majority of contributions (Figure 4). Nevertheless, it was not clear how people evaluated the voting action, whether considering it by the relevance or as a feeling evaluation (good or bad). As an example, the fact of informing the amount of annual money spent in the building and comparing it to the number of houses that could be powered received 3 votes promoting it and 4 votes demoting. The complexity of the tool seemed to affect contributions, being told as one of the reasons that prevented some people to generate more contributions.

6.1.3 Informally motivating engagement

The presence of the tree in the WS2 and in the public space seems to have influenced participants' perception and motivation, both informal level aspects. The workshop that had the tree produced more, but interestingly, seems to have hampered their motivation in the phase 3. A participant declared: *"I left the workshop with the feeling of mission accomplished, we lighted the tree on. It did not make sense to me to light the tree once again"*.

Considering that during the workshop people spent most of the time working on their laptop, the tree in the public space was more effective in attracting participants' attention (Figure 6). When asked about their thoughts when they saw the tree in the public area, participants of Group1 and Group 2 reported different perceptions:

- Group 1: Competition - *"Shamelessly competitive: Is my group doing best?"* and *"is our team ahead?"*; how much progress was done *"I wanted to see all the lights on"*; collectivity: *"some people are saving energy"*.

- Group 2: For the group that did not create new posts after the workshop, the tree had a negative feeling. Three people mentioned being guilty, like *"it makes me feel a bit guilty when it is switched off - like I am not fulfilling my responsibilities"*, other two people were always comparing to the other group. One participant highlighted the characteristic of the tree of being both decorative and meaningful together.

The comparison (and consequent competition) between groups caused a bad feeling for the group that was not doing well. The Energy Tree definitely worked as a symbol, a reminder of the ongoing activity, as illustrated by this post: *"It looks like thanks to the tree we started switching off the lights during the day"*.

6.2 Technical, formal and informal levels

The tag cloud in Figure 8 highlights the most frequent words of phase 1 survey evidencing an issue: *switching off the lights in the office*. The content analysis pointed out that people **want** to switch the lights off, but they cannot due to the automation system, which is ineffective. It evidences that behaviour change is not only a matter of applying **technologies**, but there is a system composed by individuals, **formal** environment constraints and the culture, perception and motivation (**informal** level) of people that shapes both current behaviour and possible changes. These tree levels of the organisational onion, technical, formal, and informal, set up the analysis on what interests people for sharing and learning.

Figure 8 - Initial survey tag cloud

The qualitative analysis of the contributions of Groups 1 and 2 taken together identified the topics more explored; therefore supposedly considered more relevant by the participants. This subjective analysis took into account some tags initially added by participants to the items in the debate tool. Other tags were added during the analysis and

grouped by affinity leading to a set of 18 distinct topics. Table 2 enumerates these topics ordered by number of post, indicating which level(s) they impact more, (T)echnical, (F)ormal, and (I)nformal.

Table 2 - Summary of topics by posts

Number of contributions about		T	F	I
40	The working environment (comfort)			x
37	Switching off, turning-off, shutting-down, unplugging, stand-by	x		x
27	The automation system efficiency (sensors)	x	x	
27	Working infrastructure (computers, kettle, phones)	x	x	
22	Efficient usage of appliances (battery x power, configuration, adjustments)	x	x	
19	Reminders for conservation	x	x	x
19	Personal attitude towards saving			x
16	Replacing devices (cost of manufacturing)	x		x
15	Motivation strategies (group work, competition, games…)			x
15	Costs of consumption in £ (monitoring or Web resources)	x		
15	Reviewing working practices (printing, coffee breaks, meetings, working time)		x	
12	Outcome (feedback of performance and claims for rewards)		x	x
11	Instructions for changing behaviour	x	x	
10	Claim for getting more information about consumption (institutionally or personally)	x	x	
6	Presentation of consumption feedback (personalization, granularity, etc)	x		
6	Report of appliances consumption (monitoring or Web resources)	x		
5	Dealing with stakeholders		x	
4	CO2 emission			x

6.2.1 The technical level

The 2nd most voted contribution is the issue that refers to the lack of information: *"People usually have very few information about the impact of their consumption"*. In general, 20% of ideas, issues and arguments together refer to claims for information about individual or institutional consumption, outcomes or suggestions about how to present feedback, reinforcing the lack of information as a gap for awareness. What was considered

relevant to be informed and how to present reminders are the main results of the technical level. What to inform:

- Quantify the benefits of shutting-down, or unplugging every day use devices, comparing to stand by mode.
- How to configure or adjust appliances to use it efficiently (ex: monitor brightness, cooler speed, etc.).
- Direct costs of daily actions, i.e. *"how much do I spend laundering during all the year"* or the cost of using a kettle for making the daily teas. Cost was also the argument against the issue about big monitors consumption: *"the consumption is 19.8 kWh/month, between 2.12£ and 3.31£ per month depending on the energy supplier"*.
- The energy spent to produce new devices and hints about when replacing them. *"The energy required to produce 1 PC is more or less the same as what 3 family members use in 1 year!"*, is an example.
- Reminders. They were stated by participants as necessary, but how to present them was deeply discussed: *"People are already bombed by caution messages everywhere in their daily life ("mind the gap", "fire safety",...). Such reminders shall be carefully chosen not to be categorized in a person's perspective as " not so necessary" messages."*. Energy saving stickers were suggested as a kind of reminder to be evaluated. A *"cute and non-intrusive way"* of reminding people about savings was also a supported idea.

Automation is a topic, besides information, that is worth to be mentioned in the technical level as a lesson learned. It was evidenced that sensors in the workplace have not worked properly: *"The automatic lights are sometimes on, even during bright sunny day!"* was the 3rd contribution that received more votes. It suggests that not always an automation system is the best solution in terms of energy savings, and it might even prevent the control by the people who want to save energy. This issue justifies why lighting was the most cited appliance.

6.2.2 The formal level

In line with [11], the need of institutional support was found as the main message of the formal level. This support is necessary to keep people motivated to act and to promote the feeling that individuals' efforts compose a bigger initiative. Participants identified the need of support for:

- Providing simple instructions of what to do, such as "switch off the printer after using it" or "replace your fridge when...".
- Publishing outcomes. *"Provide monthly figures about how much energy/ money has been saved by following simple instructions such as: turning off monitors, PCs, lights, etc."* was the 4th idea most voted among all contributions.
- Reviewing working practices, such as promoting paperless behaviour.
- Assigning responsibility for people switching off appliances and devices.
- Publicly recognizing good behaviour both namely or in general. A suggested way was by promoting achievements, such as using a sign *"congratulations for using the stairs! We can save # of CO2 (or £) in a year if # people do the same everyday"*.
- Making sure and evidencing that shared infrastructure is energy efficient, such as kettle, hand dryers, etc., as suggested by the contribution *"Buy new kettles that allow you to set the temperature"*.
- Evidencing that saving energy is not a disconnected action from the whole organisation and policies, and other necessary stakeholders are involved.

Still in the formal domain, the debate expanded from energy consumption to general sustainable practices such as promoting virtual meetings instead of travelling and promoting car sharing initiatives.

6.2.3 The informal level

The informal level encompasses individual and cultural aspects such as feelings, motivations, perceptions, etc., which should be promoted to influence individuals' engagement:

- Recognition. The most supported contribution in the debate tool is a fact declaring a good behaviour: *"I always shutdown the computer at night"*. It reinforces the formal level result about the importance of rewards or recognition.
- Deal with comfort. People are worried about loosing comfort due to energy saving *"knowing what the long term benefits are could offset the short term inconvenience"*. A fact informing the consumption of big monitors and the negative votes it received is another example. Instead of feeling threatened by consumption information, people must receive instructions to avoid energy wasting, i.e. turning off monitors when they are not in use. How motivated a person is determines his/her willing to leave the comfort zone, witch is a subjective variable too.

- Consider different levels of motivation. Some people just want to learn about the topic, or to listen other people's ideas. Not all of them are willing to change behaviour. But it is important that everybody feel motivated to engage with the awareness initiative in order to instigate such motivation. As a research-working environment, the interest to learn about energy as a research topic was also declared as a motivation for being engaged.

- Keep personal data as private. The preference for not sharing personal data was evidenced not only by the few who reported consumption data from home, but also by posts like this one: *"access to information about our energy use at a useful (but not too personal) level of granularity"*.

- Make it funny. A cute and non-intrusive reminder was claimed, as well as initiatives to work in groups. *"Everything can be funny if you do it in group"*.

- Environmental appealing must be promoted. Only one participant declared to be motivated for being part of the study by environmental reasons. The very few number of items connected to the theme Environmental Impact also evidenced that. Despite being the main reason behind the study, the connection with the natural environment was not an attractive perspective for people in this scenario. The fact *"approximately 48 trees are needed to absorb the CO2 equivalent an 11 months of using a 27" monitor 6 hr/day"*, for instance, did not have any repercussion.

Summarizing the analysis, the main new elements that emerged from the debate content that can contribute to raise awareness were then added in italic to the semiotic onion in Figure 9: Information about efficient use and configuration of appliances, reminders, clear instructions, publishing outcomes and rewards, review of institutional practices.

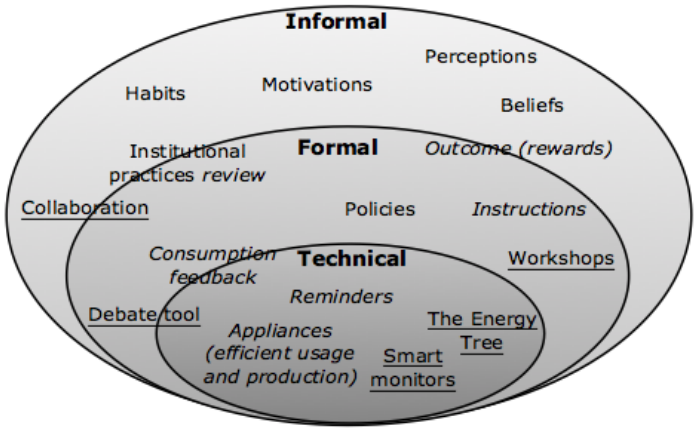

Figure 9 - "Organisational onion" with resulting elements

7. Conclusion

This study evaluated the role of three technologies to promote energy awareness in a research workplace: a debate tool, smart monitors, and a tangible device to motivate engagement. The analysis evidenced the lack of information as a barrier towards conscious consumption of energy even in a developed scenario, and also pointed out that providing new technical artefacts as a consumption feedback is not enough for promoting awareness. The artefacts actually need to dialogue with the formal context where current institutional practices are, and also with informal and personal elements, such as motivation to deal with comfort and the existing (or not) environmental concern.

The debate tool has demonstrated to be adequate for gathering opinions to build awareness collectively. As a simple action, voting was an effective way to engage people in the discussions. The possibility of easily interact with other people's opinion might be a motivation to engage those who are not willing to change behaviour initially, but are interested in learning. On the other hand, it was perceived as a working tool, in which private consumption data, which was supposed to be shared, did not appear. Exchanging experiences and ideas about how to save energy is an important way to raise awareness, but real consumption measurements play a fundamental role to complement this scenario with contextual and personalized information. However, in this cultural context, this information is not suitable for a public discussion according to the results.

The motivational role of the Energy Tree was noticed, but it may not have been the only factor promoting participants' motivation. Nevertheless, its role as an attractive reminder was evidenced. The three technical elements complemented each other and together promoted ideas, issues, arguments, and facts that were analysed pointing out aspects that people are interested to discuss in an energy awareness initiative in the workplace.

A resulting limitation of the study was the connection between energy consumption and the natural environment that did not flow spontaneously in the discussion. The reasons could not be evaluated suggesting, therefore, the need for further investigations. It can be expected that the role these technologies play differ according to the workplace scenario mainly due to the sociocultural influences. Complementary studies have been handled to evaluate their impact in raising awareness in a broader perspective, considering also socially disadvantaged groups in a developing scenario. Still, the "intangible" aspect of energy has been evidenced as a global challenge that can be tackled by from different perspectives when technology and people, with all their complexity, are equally considered as part of a solution.

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Appendix C

Ontology Chart notation

Ontology Chart notation

An Ontology Chart (OC) is a Organisational Semiotics artefact applied to model patterns of behaviour within an organisational (the problem domain). The agents and affordances (the patterns of behaviour), are the focus of representation.
The chart should be read from left to right, starting from the root agent, which represents the social group in which all members share some fundamental concepts and cultures.
Table 1, based on Liu (2000), describes the notation applied to Ontology Charts.

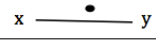
Graphic	Meaning
	Agent – someone can act and take responsibility.
	Affordance – agent's ability (everything he performs is a pattern of behaviour).
	Ontological dependency. *x* is an affordance of *A*.
	Determiners. Properties that differentiate agents and affordances' instance from another. *x* has a determiner *y*. E.g.: name, hair-colour of a person.
	Whole/part relation. *y* is part of *x*.
	Roles. E.g. *A* is the agent *Person* and *x* is the affordance *sells*. *A* assumes the role of *seller*.

Table 1 - "Ontology chart notation"

For more information:
Liu, K. Semiotics in Information Systems Engineering. Cambridge University Press, 2000.

Appendix D

Term of Consent

Senhores pais,

A Escola Jovelino Lanza está fazendo parte de um projeto de pesquisa da UNICAMP – Universidade Estadual de Campinas apoiado pela Cemig.

Na semana de 13 de maio será instalado na escola um equipamento educativo sobre consumo de energia elétrica e meio-ambiente.

Para o envolvimento dos alunos, precisamos da sua autorização e também do apoio da família dentro de casa.

As crianças irão propor desafios de redução de energia com a duração de 5 dias. Uma árvore instalada na escola alimentada por energia solar irá acender cada dia mais, de acordo com a economia conseguida pelo grupo.

A redução de consumo é pouca, simbólica, algo como algumas horas de lâmpadas acessas ou de TV ligada.

O cálculo da economia será feito automaticamente se a sua casa estiver no projeto Cidades do Futuro da Cemig. Se não estiver, seu filho(a) deverá anotar o valor do medidor de energia todos os dias antes de ir pra escola, por 4 dias.

É importante ressaltar que **o consumo da sua casa** fará parte do cálculo, mas **não será divulgado e nem exibido pra ninguém. O sistema só mostra o resultado de economia do grupo!**

Se você autorizar, fotos dos grupos de alunos e da árvore poderão ser exibidas na página do projeto na Internet.

Para fazer parte, por favor, preencha o verso dessa folha:

Nome do aluno: _____

Eu, (nome do responsável)_____,
autorizo e apoio a participação do aluno na atividade.

Assinale aqui se você aceita ou não:

☐ Se necessário, **aceito** contribuir respondendo a algumas rápidas perguntas do pesquisador na minha casa sobre efeitos do experimento.

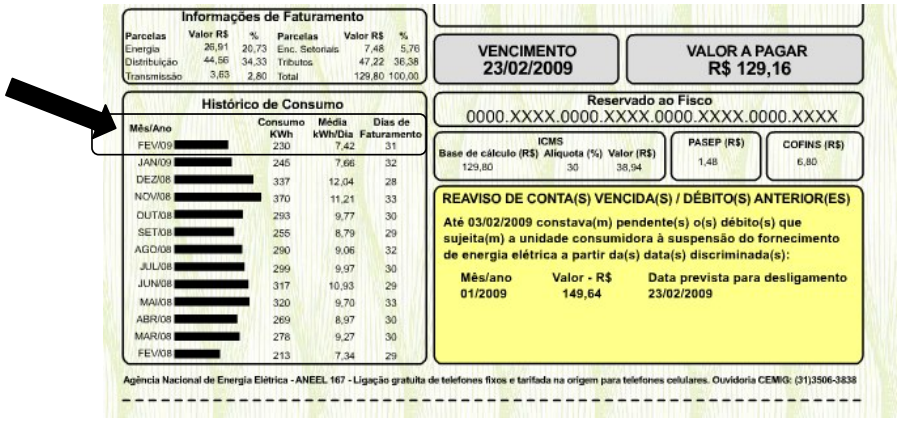
☐ **Não quero** que fotos do aluno apareçam no site do projeto.

Para iniciar o desafio, precisamos de alguns dados da sua conta da Cemig:

Nº de instalação: _____

Último consumo em KWh dessa conta: _____

Dias de Faturamento: _____



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