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THE USABILITY EVALUATION OF AN ECO-FEEDBACK APPLICATION

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Abstract: Eco-feedback technologies provide feedback on individual and group environmental behaviour with the goal of reducing their environmental impact. Individuals are generally not provided with environmental information regarding their use of electricity, water and waste management. An Eco-Feedback application was developed and implemented at the Nelson Mandela University (NMU). The aim of the study was to evaluate the usability of an Eco-Feedback application. The application could be used to create environmental awareness amongst NMU stakeholders, in order to encourage positive environmental behaviour and reduce the environmental impact on campus. The findings indicated that the Eco-Feedback application was effective and efficient and that the users were satisfied with the design and layout of the Eco-Feedback application.
Keywords: Environmental awareness, Eco-Feedback application, usability analysis.

1. Introduction

Researchers have developed various Eco-feedback technologies to provide feedback on individual and group behaviour with the goal of reducing environmental impact [1, 18]. Creating and emphasising environmental awareness is of critical importance and the development of applications to assist individuals with monitoring their environmental impact is increasing [2]. Globally, organisations are increasingly promoting improved environment friendly behaviour and practices to promote sustainability [3]. Various technological applications have been introduced to address a form of communication to promote sustainable environmental behaviour. The use of modern technologies are increasingly being used to communicate environmental alerts, awareness and concerns in order for individuals to increasingly become aware and promote eco-friendly behaviour [4].

Information about electricity and water use can be used by individuals and organisations to make better decisions and create environmental awareness [5]. A shift in environmental awareness allows organisations to implement more sustainable practices and increase their competitive advantages [6]. Universities and other organisations are increasingly being

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required to practice sound environmental practices and educate all stakeholders on their responsibility to be aware of their environmental impact [6].

Individuals who are aware of their environmental activities, can lead to a decrease in the electricity and water consumption [7]. Decreased consumption may lead to individuals moving towards sustainable development practices. According to Jakobi and Schwartz [1] invisibility causes a lack of awareness and the inability not to be able to effectively manage the Environment Management System (EMS) in an organisation, creating a lack of motivation by all stakeholders to become eco-friendly.

Awareness of an EMS recording and reporting on all environmental data, such as electricity and water usage, including waste disposal information, may help reduce the environmental impact. Universities will be able to reduce energy consumption in buildings with new technological applications, that will allow information sharing, such as electricity usage [8]. This paper investigates the usability of the Eco-feedback application implemented at the Nelson Mandela University (NMU), Port Elizabeth, South Africa, in order to motivate individuals to be more environmentally conscious and reduce their environmental impact. The literature review (Section 2) provides a background to the study, the research methodology is explained (Section 3) and the usability results are highlighted (Section 4). A discussion of the findings and recommendations for universities are outlined to provide a contribution to the implemented application (Section 5).

2. Literature review

2.1. Background

Environmental issues such as climate-change, water disposal, waste management, global warming, and bio-diversity affect our environment. The environment is a place that provides development and growth and needs to be preserved for the future generations. An increase in the negative effects on the environment will have an undesirable effect on future generations. It is therefore important to be aware of the activities that contribute to the carbon footprint. The main cause of global warming is associated with the burning of fossil fuels [9]. Institutions are increasingly reporting on greenhouse emissions and they need to find a solution to control the emissions to become more sustainable. The amount of energy spent by institutions needs to be closely monitored and recorded [10]. The visualization of electricity and water usage in buildings can create awareness and help decrease the impact on the environment [11].

In a recent publication by the Intergovernmental Panel for Climate Change, it was indicated that the largest growth in carbon emissions has come from electricity generation, transport, industry and above all, from buildings [12]. According to ASHEE [13], educational institutions emit a large amount of greenhouse gas emissions through electricity. The use of limited electricity, water and recycling efforts in promoting sustainable development gives a positive impact on the environment.

Individuals need to have environmental knowledge and know their behavior patterns as these patterns influence the adoption of environmental applications [14]. An important context of raising environmental awareness is access to relevant and well-presented information. A key driver of environmental awareness is a contributor to help create change in environmental education [11].

2.2. Environmental education

Environmental education aims to increase individuals' environmental awareness [1, 18]. Institutions strive to involve sustainable development in educational institutions. To create sustainable development, institutions need to have an environmental focus [6]. Higher educational institutions that address involve and promote positive environmental behavior help individuals practice sustainable lifestyles [9].

In order to raise environmentally aware individuals and work towards institutions' visions, technologies such as eco-feedback applications should be implemented to help raise awareness and motivate eco-friendly behavior [19]. If individuals are made aware of the negative consequences of their daily activities and how their activities impact the environment, they would be more concerned about the environment [7]. One of the problems that cause the lack of awareness amongst individuals is the inability to identify the means of how to effectively contribute to the environmental impact [1].

Universities' participation in more sustainable development emphasises the crucial need for students and staff to be aware of their environmental impact. Through environmental education in universities, individuals can develop positive environmental attitudes, which in turn encourage environmental participation [15]. Individuals lack the awareness of environmental information in institutions, such as universities. The correct knowledge can equip individuals to contribute to sustainable practices [7]. Eco-feedback applications can help universities be aware of the energy and water consumption, which will make them more energy efficient [16].

2.3. Eco-feedback technologies

Eco-feedback applications provide information as a means to promote environmental behaviour, change and information on an individual's participation in environmental activities. It is noted that, in order for one to obtain the required information, the layout and navigation construction of an Eco-feedback application needs to attract attention for better understanding [19]. Although many factors contribute to influencing individuals' desire and ability to conserve resources, it can be connected to "environmental ethics" [7]. Key motives such as knowing the energy consumption in comparison to others can be seen as a driver to sustainable behaviour. This encourages individuals to play their role in the earth's stewardship and equip them with behavioural, norms, values and knowledge to reduce their impact on the environment [7].

Eco-feedback applications use different icons, screen layouts and designs. The icons are programmed to display environmental data that has been collected, stored and processed [17]. The design and layout of the icons and the presentation of environmental information is of utmost importance. The visualisation of the icons, specifically making use of colours, assists in alerting individuals of warnings, e.g. high-energy consumption or water usage. The use of well-designed icons will make the user more aware of the environmental indicators. Furthermore, data collected and correctly presented impacts the efficient behaviour of an individual [17]. In return, individuals can become more responsible and take corrective action to conserve energy and water usage.

3. Research Methodology

In this study, the Design Science Research Methodology (DSR) was used to create an artifact, namely an Eco-feedback application. A literature review was conducted and various prototypes developed. The aim of the study was to develop an application, which could be used to make individuals aware of their impact on the environment and to motivate them to change their behavior to reduce their environmental impact. The evaluation of the Eco-feedback application included a usability evaluation by NMU stakeholders. Sixteen participants participated in the usability testing of the application.

The Eco-Feedback application was developed by creating various prototypes and evaluating various screen designs, icon layouts and colour schemes. The final screen design and layout is presented in Figure 1. The layout included icons (tiles) for electricity usage, water usage and waste disposal. Users could select the data to be displayed, for example per campus, per building or per department. Current and historical data could be displayed, as well as current

usage and target settings per category. The data was retrieved from the Environmental Management System prototype implemented at NMU. In Figure 1, the electricity usage is high (indicated in red), the water usage is moderate/high (indicated in orange) and the waste disposal is low/positive (indicated in green).

The Eco-feedback application was evaluated using the Post Study System Usability questionnaire (PSSUQ) to rate their satisfaction of the Eco-Feedback application based on the completion of the tasks in a specified task list. The usability tests required that the participants complete various tasks to determine whether they could obtain the information regarding buildings, water and electricity usage at NMU.

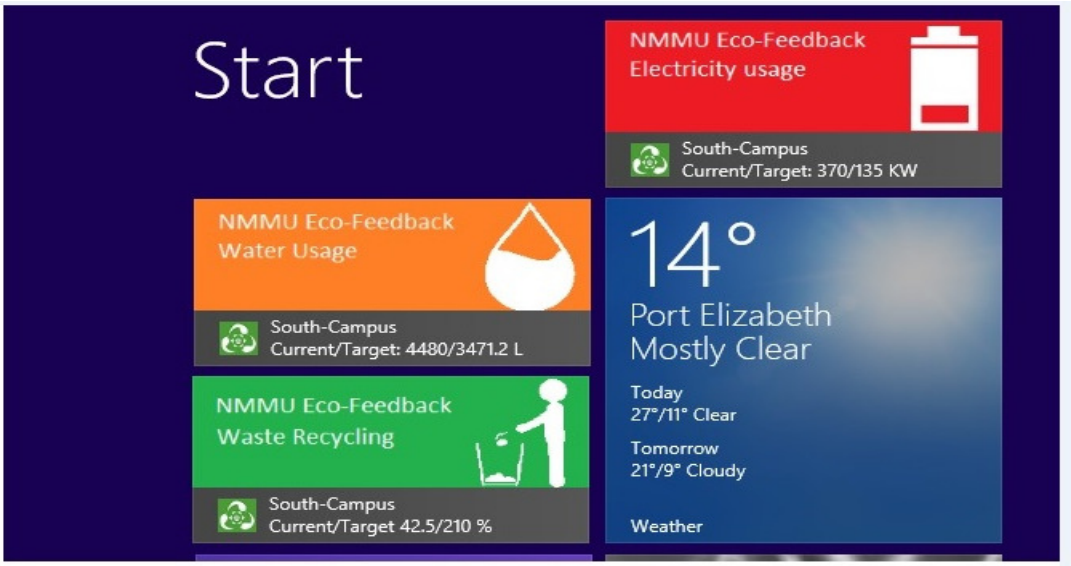

Figure 1: Final Eco-Feedback application design.

The following tasks were performed by each user:

1) Customise the Live Title to display the Embizweni building's electricity and water level and tips;

2) Navigate to the Windows Start screen and monitor the environmental Tile (application)to rotate through its queue to see if it updated correctly;

3) Find the Library's electricity reading for June 2016;

4) Find the expected water usage of the Indoor Sport Centre and record it;

5) Determine which departments on Campus were performing the poorest.

4. Results

The usability evaluation was conducted to give a clear indication of how well the application fulfils the users' specific needs and how effectively they can use the system's functions. In the usability evaluation, the metrics that were evaluated were task success, time-on task,

errors, efficiency and learnability. Sixteen participants from the NMU's Computer Science Department Honours class participated in the study. All participants were immediate to expert computer users and most students have used Microsoft Windows applications. Seven students were evaluated during the field study and the others participated in usability evaluations in the NMU usability lab, using an eye-tracking system. The gender distribution (Figure 2) indicated an fairly equal gender distribution with 47% female participants. Twelve students (75%) had experience in using Windows applications and 50% had limited experience using Windows 8.

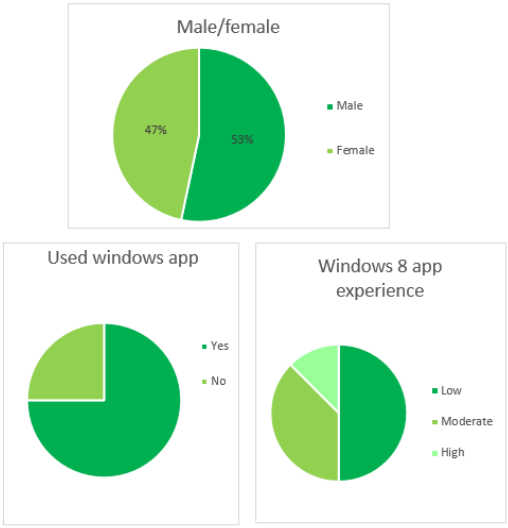

Figure 2: Participant Biographical Distribution

The participants were required to complete a Post Study System Usability questionnaire (PSSUQ) to rate their satisfaction of the Eco-Feedback application based on the completion of the tasks in the task list. The Eco-Feedback application provided a highly rate of satisfaction by all users on all criteria (Figure 4). Ratings of 4 and 5 (5 point Likert scale), dominated the overall impression, information quality and system quality, with no scores lower than 3, or neutral ratings, specified. Participants were also highly satisfied with the application's interface with 72%, 32 comments, relating to positive aspects and only 12 comments, relating to negative aspects. It is therefore safe to say that the Eco-Feedback application provided a high level of user satisfaction.

The environmental *Tips* (Figure 3) included in the application were "Switch bathroom lights off", "Fill kettles with enough water for the number of cups required" and "switch geysers off during day times". These *Tips* were displayed every time the environmental data was

updated. The results (Table 1) further indicated that 41% of the users became more aware of their environmental, specifically of the electricity, water and waste disposal data of buildings on campus.

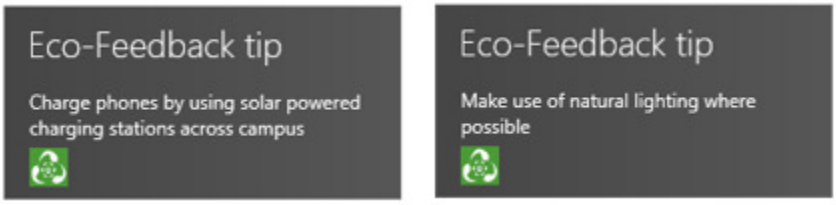

Figure 3: Examples of Eco-Feedback *Tips* provided to users.

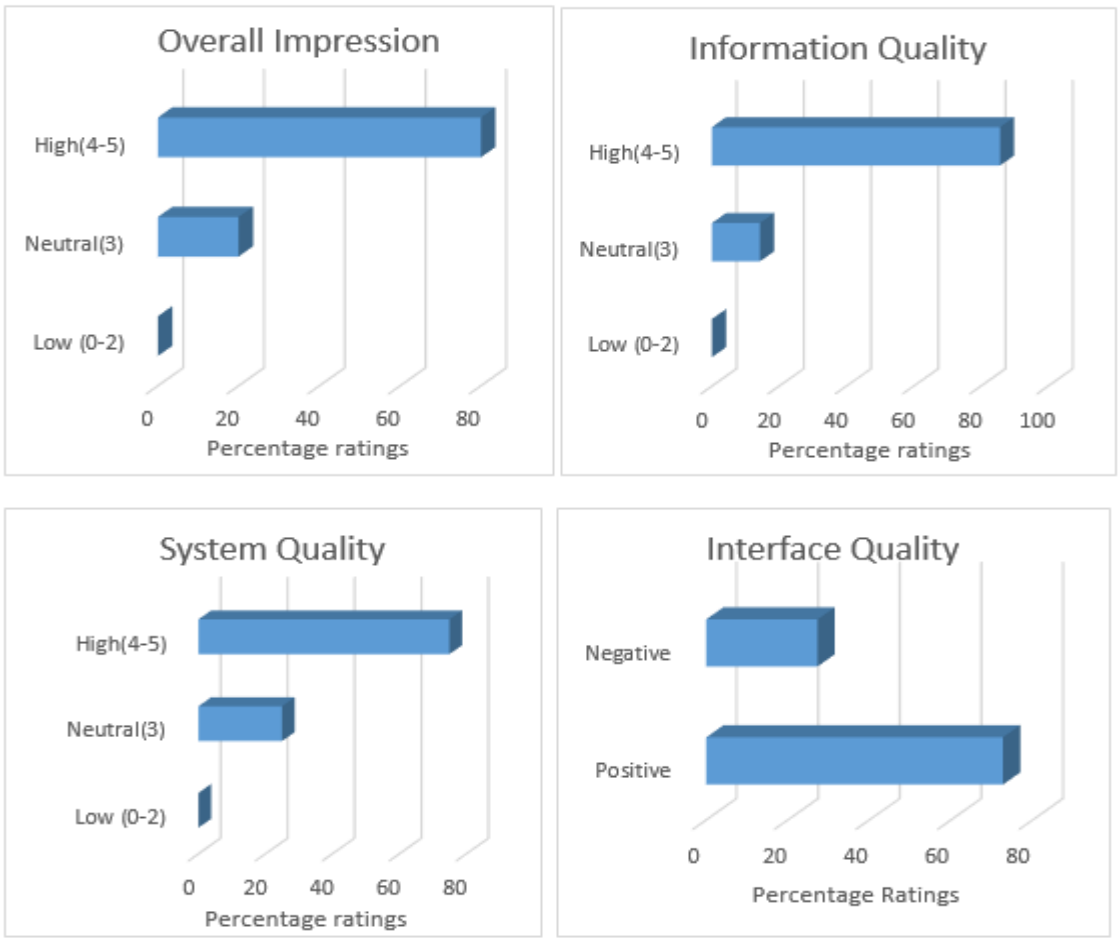

Figure 4: PSSUQ results

Participants indicated that the Eco-feedback application provided them with relevant information. The analysis of the tasks performed (Table 1) shows that 56% of the participants indicated that being able to compare the environmental impact levels across buildings and other impact levels helps boost their environmental awareness. 29% became more aware of

electricity, water and recycling information and 24% appreciated the *Tips* provided to reduce their environmental impact.

Question	Create awareness	System function	Increase
2	Impact levels.	Display environmental impact levels and comparisons	41 %
3	Activitiesthat contribute to environmental awareness.	Display and categorise electricity, water and recycling waste levels	29 %
4	Environmental impact of building in which participant operate.	Display impact levels of each building, customise live tile to display data of specific building	44%
6	What changes in activities can reduce impact?	Provide tips on how to reduce impact, customise Live Tile to display tips	24%
7	Which specific buildings contribute to impact to what extent?	Compare impact levels across buildings and other impact levels	56%

Table 1: Awareness questions linked to system functions

5. Recommendations and Conclusions

Participants approved of the visualisation techniques used in the Eco-feedback application that displayed electricity, water and waste disposal figures for specific buildings and departments. The findings support literature findings that reporting environmental information encourage social engagement and creates environmental awareness [1, 18]. Participants also mentioned that it provided them with *Tips* to reduce their impact on the environment, which influenced them to become more environmental conscious and change their environmental behaviour.

The usability results indicated that participants were able to identify the environmental information of buildings and departments and become more aware of the electricity and water consumption in specific buildings, thus creating an increased awareness of the NMU impact on the environment. The usability evaluations indicated that the users required detailed information on each building and a data slider to view historical information and a drill-down facility on the environmental information.

Participants stated that the application could create increased environmental awareness on campus.

The application further had to be aware of novice users and provide a simpler and adaptable user interface. The evaluations indicated that the visualization and use of the icons were positive, allowing for easy understanding and reading, specifically the use of different colour schemes. The results of this study suggest that an Eco-feedback application can be used to create environmental awareness and reduce impact on the environment at a university.

Overall, the Eco-feedback application evaluation was efficient and effective providing relevant environmental information. It motivated and influenced individuals to monitor their environmental data, specifically the electricity and water usage. The Eco-feedback application effectively increased awareness through its implemented functionalities. The study was a preliminary study and future studies can evaluate the application using a larger stakeholder population. Rapid technological changes and the growth in the use of the Eco-Feedback applications can increase individual environmental awareness and reduce the impact of all stakeholders on campus.

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