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TRANSFORMING EDUCATIONAL ENVIRONMENT THROUGH GREEN INTERNET OF THINGS (G-IOT)

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Abstract: *Despite the numerous benefits Information and Communication Technology (ICT) brings in education, it should be remembered that the ICT utilization is energy and resource intensive, embraced with escalating volumes of electronic waste (e-waste) and toxic pollution. To minimize harm and maximize benefits of the ICT usage in educational environments, moving towards green ICT, which is health and environment aware, appears as the key solution. Having in mind the significance of the Internet of Things (IoT) in education, applying the green version (G-IoT) should bring much more benefits. It is anticipated that the education and learning environments of tomorrow will be, not just better and high-quality, but also economically, socially and environmentally sustainable and that G-IoT will play a significant role in achieving this goal. Therefore, this paper presents the ideas and concepts of G-IoT and highlights the potential benefits G-IoT offers at educational institutions.*

Key Words: Education/Environment/ICT/G-IoT

1. INTRODUCTION

Nowadays the Information and Communication Technologies (ICTs), especially Internet of Things (IoT) are becoming ever more ubiquitous within the education sector and it is considered as a key role in improving education quality. Involving novel technology solutions in supporting the teaching and learning processes in the classroom, and in a whole educational system, have the potential to bring significant value to higher education institutions, making educational processes more effective and meaningful [1]. The benefits of ICT and IoT in educational activities are direct relevance to sustainable development such as improving accessibility for disadvantaged groups, individualization of learning, interactivity, distance and climate insensitiveness, uniform quality, high-speed delivery of information and the low cost of education [2]. The main strengths of IoT involvement in the education sector, besides creative, active, integrative, collaborative and evaluative learning, are also anyplace and anytime learning.

The numerous benefits of technology involvement in educational practices are accompanied by 'hidden' environmental, and, sometimes, social costs, which are usually underestimated [3]. With the rapid ICT growth, large quantities of smart devices are present in everyday activities. Various estimates anticipate that 19-40 billion smart devices will be in operation by 2019 [4]. The production and disposal of these devices are accompanied by the release of many hazardous air, water and land pollutants, usage of large amounts of energy and water, generation of escalating volumes of waste, and sometimes involvement of dangerous and exploitative working activities [3]. Hence, there is an essential need to reduce the possible negative impact of novel technology products and solutions on human health and the environment. This is the reason why society is moving towards green solutions. Green ICTs and Green IoT (G-IoT) encompass environmentally aware production, using and disposal of ICT equipment and solutions.

Having in mind the importance of education in society growth and the role of technology involved in the educational sector, this paper analyses the possibility of Green IoT (G-IoT) inclusion in educational activities and the potential benefits and contribution to sustainable development. The actions which are necessary to be carried out and anticipated outcome of the G-IoT full integration in the education sector have been discussed in the rest of the paper.

2. G-IOT IN EDUCATIONAL ENVIRONMENT

There are currently seven categories of technologies, tools, and strategies that bring numerous innovation and benefits in the education sector: Consumer Technologies, Digital Strategies, Enabling Technologies, Internet Technologies, Learning Technologies, Social Media Technologies and Visualization Technologies [5]. The IoT, as a part of Internet technology, supports education in various ways [6]. Even connected devices are already present in the classroom, the IoT lead to new levels of connectivity and learning approaches [7]. As the smart devices are Internet capable and controlled, the IoT by means of smart devices transforms knowledge delivering and obtaining creating a virtual, shared, and intelligent experimental teaching and learning environment (Fig. 1) [8].



Figure 1. Smart classroom [9]

Embracing the power of ICTs and IoT in educational practice, students benefit in numerous ways. Technology helps them to address all learning styles, to interactive participate in knowledge obtaining and sharing, all education activities are student centered and supported, making the learning personalized, dynamic, collaborative and up-to-date. Furthermore, learning goes beyond the classroom. Interacting with so many everyday objects connected to the web, students have access to unlimited information from anywhere, anytime, in customizable learning manner [10].

With the help of tracking devices (e.g. smart ID cards and wristbands) time-consuming activities like recording attendance can be minimized. Such activities and classrooms equipped with IoT help teachers to minimize their roles in administrative procedures and spend more time on learning activities that have the biggest impact on students. With the help of IoT, large quantities of gathered data on student performance and statistics are available. This information can be used by teachers to improve lesson plans and quality of teaching. Additionally, evaluation of student performances can become more seamless, less manual and time-intensive [11].

Even the IoT can help solve diverse challenges across an educational sector, it is mandatory to minimize potential harmful effects of IoT on human and the environment, and reduce costs and resource usage. Moving towards the G-IoT appears as an adequate solution. The sustainability of the ICT resources in educational institutions requires greener behavior by the schools, universities, staff members, students and administration people [12]. G-IoT, through the following tasks, holds the potential to transform the educational environment, making it economically, socially and environmentally sustainable [3, 6, 12-14]:

- Purchase appropriate equipment to reduce energy consumption and environmental impacts: efficient hard drives, thin client approaches, the right-sized monitors, multifunctional equipment (printer, copier, scanner, fax), low-cost sensors, smart grids and alternative renewable energy sources.
- Switch personal computers and other ICT equipment off when they are not utilized (e.g.

at night or in holiday periods), enable and use the standby/sleep mode and power management settings, turn down the brightness settings on monitors, and avoid screensavers;
- Enable remote access to equipment;
- Virtual meetings and learning sessions (e.g. e-learning approach, teleconferencing, video conferencing, web conferencing and online collaboration tools);
- Use cloud computing and big data analytics, distributed computing and/or outsourced/shared service solutions;
- Storage consolidations and optimization and virtualization of server resources (e.g. elimination of data storage that is no longer needed, increase of the proportion which utilizes low energy storage);
- Share printers, include development of a green printing strategy (e.g. reducing printing and configuring low toner mode) and maximizing print substitution (e.g. sending documents as email attachments);
- Minimizing generation of waste, and maximizing recycling and reuse of ICT equipment via reassigning old IT devices when possible, reuse and repair ICT equipment before replacing or donating it and recycle old ICT devices in an eco-friendly way;
- Increase G-IoT practice awareness among all the stakeholders of education establishment like an administration, school, university, students and top management people.
- Improve design of school and universities buildings, designing ICT-intense 'smart' buildings which minimize energy consumption through better monitoring and management of activities such as HVAC (heating, ventilation and air conditioning), the integration of these activities with other building services, and through other means, and applying dematerialization by substituting electronic activities or products for physical ones. With the help of smart devices (e.g. smart doors, locks, RFIDs - Radio-Frequency IDentification, cameras, and connected devices) monitoring and surveillance of entire buildings are possible, enabling in such way a secure and safe learning environment (Fig. 2).



Figure 2. The smart IoT educational environment

- Using wearable technology for monitoring student health status in a non-invasive and non-obtrusive manner, enable getting real-time actionable insight into health status influence to the student's overall academic performance.

- Streamlining the process of facilities usage and optimization can help achieve financial savings and lead to sustainability.

3. CONCLUSION

Among numerous aspect of life that are reshaped and improved by the IoT, the educational sector appears as one of the key sectors where the IoT shows its potential. The IoT, through creating smart schools, universities, and classrooms, enables a completely novel interaction between people, things, and the environment. Learning and teaching processes become faster, easier, more quality, interactive, collaborative and available anywhere, anytime. However, the G-IoT takes advantage over IoT in order to add additional benefits to the educational sector - economically, socially and environmentally sustainability. Following G-IoT practices, the usage of facilities becomes more efficient through minimizing energy and other resources consumption. This lead to preserving natural resources, minimal or no impact of the technology on the environment and human health and significant cost reduction. From the G-IoT involvement in the education sector, all participants will benefit, student and teachers will improve their activities in safe and secure educational environment, while management, organizational structures, and a government will achieve significant financial savings what will significantly contribute to sustainable development of whole education sector.

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