

Teaching sustainable development in higher education - Changing attitudes in a digital era

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ABSTRACT

Sustainable Development (SD) is an increasingly important topic. Humanity has an absolutely vital dependence on a set of natural and artificial resources. The advancement of knowledge needed to adequately manage these resources has traditionally been achieved through specialization. In this strategy of *dividing and ruling*, what was gained in depth was lost in coverage. Yet, the most recent problems are intensely interdisciplinary, revealing that the previous *specialization* strategy is currently not wrong, but clearly insufficient. Strangely (or not), various courses in higher education continued to follow the traditional *specialization* strategy. As a result of this state-of-affairs, several conferences currently exist, both in the field of Education or in the field of Sustainability, but it has been particularly difficult to attract participants to deepen the theme of Teaching Sustainability. As an attempt to contribute to clarifying the needs of the present and future, this TEEM'21 track presents itself as a space for presenting results and debating works and strategies that involve both domains: Teaching and Sustainability.

CCS CONCEPTS

• **Social and professional topics**; • **Professional topics**; • **Computing education**; • **Computing education programs**; • **Computational science and engineering education**;

KEYWORDS

Remote Laboratory, Sustainable Education, Automation, Engineering Education

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1 INTRODUCTION

Development has been highly supported on energy availability and consumption, and on the intensive use of resources. Additionally, the exponential growth of World population is leading to the non-renewable resources scarcity and their use under the linear economy model has proven unsustainable [1]. Concerning energy, and although non-renewable energy can be much more controllable than renewable energy, the fact is that there is still much road to walk through before energy can be provided exclusively by renewable sources. Further, consumption of fossil derived energy is one of the primary causes of negative environmental impacts that cause climate change [2] but some renewable sources of energy are also vital resources currently used for food and feed purposes. Thus, it is now evident that being renewable is not enough to state these sources of energy are sustainable as this not only compromises the future generations survival but also causes other environmental issues, namely in what concerns the management of the resulting waste materials. This state-of-affairs has brought to light the need for a different approach when new problems arise, making it evident the need to educate professionals that not only are specialists in their particular field but also understand there are strong constraints in other more or less related fields of expertise. In this respect, the concept of Sustainable Development (SD) has been on the basis of some changes on the Educational paradigm, particularly at the Higher Education level. Different approaches can be used to teach sustainability. These include, among others: a) the creation of stand-alone courses where the matter is explored, mostly out of real context where the problems exist and not linked to one particular major/minor/bachelor; b) the creation of specific courses integrated in a major/minor/bachelor; c) the creation of blocks of courses within a particular major/minor/bachelor where the related matters are explored, trying to intertwine them and explore the several related issues. While for the exact sciences the goals of SD can be reached via the metrics established for each particular goal, there are also other sectors of human activity that could benefit and mostly contribute to help reaching many of the goals. Thus, sustainability should also be taught/learned in social sciences and for all other Higher Education fields. In previous editions of the TEEM conference, this was demonstrated in a similar track. That was the case of TEEM'20, track 9 [3], where Shamila Janakiraman [4] demonstrated how games could be used as an apparently effortless mechanism to help change attitudes towards sustainability and Karkina et al. [5] applied to musical education the principles of Sustainable Development. In a different approach, Sudeh Dehnavi [6] could demonstrate how a Joint Exchange MSc Program in Integrated Water Resources Management focused on Middle East and North Africa could build capacity in Higher Education towards Sustainable Development. In the same TEEM'20 track 9, Pereira

and Felgueiras [7] demonstrated the development of a set of remote laboratories used to improve and support Automation teaching and learning in electronics and automation courses, supporting education on Sustainable Development. In some of these presentations it was also demonstrated how digital tools could be used to teach/learn Sustainable Development principles and attitudes towards its achievement. Having this in mind, and after the analysis of the papers accepted for presentation in TEEM'21 Track 16, it is obvious that the education on Sustainable Development needs and includes new approaches given the fact that we are now in a digital era.

2 CHANGING ATTITUDES IN A DIGITAL ERA

Attitudes are the, sometimes unconscious, result, of very long periods of education. Changing behaviors is very difficult and takes a long time, e.g., decades or generations. If studying and learning are hard acts, changing behavior as a result of taking action is even more violent. However, changing behavior can be facilitated if it is the result of explaining and presenting evidence. In this way, TEEM'21 Track 16 participants presented their experiences from their own courses, showing that important changes in attitude can take place after the introduction of some experimental changes.

Viegas et al. in their paper, *How may teaching contribute to sustainability in a small scale but with wide use?* studied and identified the positive impact resulting from the use of technology strategies in Education during the COVID-19 (Severe Acute Respiratory Syndrome Coronavirus 2, SARS-CoV-2) Pandemic. These teaching strategies allowed to better understand students of almost all levels and additionally positive effects in relation to sustainability were reported. Authors developed a questionnaire that was conducted in order to assess if students felt any resource effective in their learning and would like to keep it, contributing to lessen their ecological footprint. The more advantages to sustainability they recognize, the more educational resources they would like to keep using, and the more favorable they are for an hybrid educational regime. The study involved a total of 315 students/valid answers that came from students in 8 countries (Argentina, Brazil, Germany, Greece, Portugal, Russia, Spain and UK) and represent 59 different institutions. In the end, the majority of the students recognized that the more productive classes for their learning were the ones with interaction, regardless the resources used. Most students also revealed they kept using some of the new developed resources after the Pandemic situation (only 11% claimed otherwise). Furthermore, in almost all areas of study, informative videos, online sessions involving teachers/colleagues and projects were clearly identified as valuable resources to keep. The methodology of maintaining an hybrid regime was identified as advantageous in this study applied to higher education. Although most students revealed a small ecological footprint in relation to their mode of transport, this was the factor most identified by students concerning the issue of sustainability.

Arlette Audiffred-Hinojosa, in her paper, *Challenge base learning 360 filmmakers: perspectives and advance positive action toward the sustainable development goals to empower learners as creators and changemakers*, presented a study that explores the use of digital imaging media in the production of pedagogical means related to

water management as a vital and scarce resource. This is indeed a good example that explores the digital media of our era as a teaching support for sustainability. In fact, transmitting information immersed in the form of virtual reality headsets and 360° video is becoming more and more common. Video resources have thus gained more efficiency compared to those that contain only the same information using text with images. These new forms have implications for the psychology of virtual reality and practical applications for immersive journalism in particular, and interactive media in general. High school students at PrepaTec Morelia developed an immersive, 360°, 4k resolution virtual reality narrative video aimed at the problem of water scarcity in their city, Morelia Michoacán Mexico. These videos were uploaded to the United Nations Showcase via Digital Promise's My World 360°. The pedagogical evaluation of these media was frankly encouraging. The use of current digital media such as virtual reality to advocate a sustainability issue encourages students to become agents of change in their communities and, at the same time, acquire social-emotional skills, critical thinking, communication and digital literacy.

Gutiérrez et al. in their paper *The pedagogical and user interface usability evaluation of a mobile app that can be used as a resource to guide university students to live sustainably*, presented a study about digital disclosure of reliable information related to sustainability. In fact, one of the possible ways to promote a sustainable life is through education and awareness arising from the dissemination of information in different media. Several international Non-Governmental Organizations (NGOs) have presented various platforms, such as the AWorld, a mobile application that provides clear and accurate information from reliable sources. This application uses multiple functionalities with the aim of seeking to change the habits and behavior of its users to help improve the planet. A question arises: "Can AWorld be considered an educational mobile app to promote sustainable living in university students?" In this work, the authors present the results of the pedagogical evaluation and the usability of the AWorld user interface. The assessment was carried out by twenty-five experts through a questionnaire to assess the quality of mobile learning applications. The pedagogical and user interface usability assessment carried out to evaluate the AWorld app suggest that it can be considered an educational mobile app for promoting sustainable living in university students. The exhaustive assessment through the questionnaire provided data that can help improve the application and thus help users to learn better. This improvement is particularly important given that mobile technology is widely used. The results also suggest that AWorld's functionalities must be improved to respond to the continuing global changes, the needs of higher education in the digital era. The authors understand that this work has all the conditions to proceed, focusing on the identification of some specific needs for educational platforms.

Kadyirov et al. in their paper *Implementation of digital photographic in design education for sustainable development*, addressed the issue of the use of digital technologies in the professional training process of future designers, namely in teaching students to develop projects on various topics related to the development of ecological culture, using technological, constructive and artistic-compositional techniques that guarantee the environment friendliness of the developed subject-space environment. Presently, modern design covers almost the entire space-subject environment of

a human habitat and plays a special role in the process of ensuring sustainable development in its social, cultural, economic and environmental components. At first glance, it seems that the designers' activities are simply aimed at creating new products and supporting the economy, but in fact, their activities are very far-reaching and affect the ecological and social spheres of society. Designers contribute significantly to solving the problems of Sustainable Development, since design products not only provide and functionally organize people's lives, but also affect, among others, their physiological and psychological state, since the layout of the environment subject-spatial affects human quality of life, health status, psychophysical comfort. The design process today must be environmentally and socially responsible, and design thinking must be not only mobile and creative, but also sustainable. Environmental education must be implemented in all spheres of society and must first be part of design education. In fact, many modern design trends, including eco-design, could not exist without the development of computer technology. Digital technologies are particularly important as they have provided the development of computational art, digital art, digital photography and digital video, 3D graphics in animated graphics and many other areas of design. The role of digital technologies and photography in integration with computer graphics in the context of professional training of future designers in the name of sustainable development is essential, since there is the development of logical, figurative, abstract thinking, practical skills of working in computer programs when solving real professionally oriented problems. In addition, students acquire the ability to work with information, apply methods of analysis and synthesis, skills of teamwork, self-expression, and also develop an aesthetic taste and their own creative manner of working.

Kadyirov et al. in their paper *Forming socially responsible design for sustainable development*, present their experience with students who study design at the Federal University of Kazan (Volga Region) in subjects such as history and theory of design, as well as art history, mainly at the level of the ecological component of sustainable development is discussed. These disciplines address the issues of designer social responsibility, the ecological perspective in design, and sustainable design. The issues of perception of sustainable development by design students are investigated. The importance of an ecological culture that guides the designer is emphasized. It also emphasizes the importance of an aesthetic understanding of the problem and the formation of a sensual image of nature, the planet and the human being, in order to obtain a response from the public, drawing attention to the problems of sustainable development. Most of the students connect the idea of socially responsible design with the environmental problem. Terms such "green design", "emerald design", "eco-design", "natural materials", "bionics", "bio-tech", "sustainable development", "bio-design" are used in the same semantic row. However, these terms not only have different shades of meaning, being often a contradictory interpretation, and sometimes mutually exclusive. Students turn to all three facets of the topic in the course of work on educational projects. Quite often students identify the long-term public welfare and benefit with eco-friendly raw materials, unprocessed chemicals, a design focus on natural forms of plants and animals, and recycling of used materials. For example, "Green design" is more often understood as design made of natural materials that are not harmful to humans; "Sustainable

design" is more often understood as non-harmful to the environment; "Eco-design" refers to previously mentioned terms, as well as the use of bionic forms and all landscape design. In the educational process, it is necessary to understand and differentiate the concepts, taking into consideration that all of them are important in various types of design. In fact, all of them, without exception, are design abilities and opportunities to save, protect and preserve the natural heritage. In the end, the awareness and involvement of students in this problem reflects the level of environmental culture of the future designer. The authors present some examples of collaboration between science, art and design.

Ramírez-Montoya et al., in the paper *Scaling complex thinking for everyone: a conceptual and methodological framework*, presented a proposal for a framework with the aim of helping to overcome the difficulty of developing multidisciplinary solutions. Currently, complex thinking remains a critical issue for researchers and academics in higher education as it is considered a core competence to design and develop proposals for solutions to current social problems. However, there is still a need to create and implement innovative teaching-learning systems and initiatives that support the training and development of desirable transversal and disciplinary skills that promote complex thinking in students. In this context, *Open Science* is a fundamental resource to accelerate research processes, to enrich education, to build new ways to analyze complex social realities and eliminate unfair gaps in different regions. This article presents the Interdisciplinary Research Group "Reasoning for Complexity" (R4C-IRG) that connects and develops these themes, providing a conceptual and methodological framework with three fundamental approaches: (i) Open Science, (ii) Open Innovation and (iii) the structure of Education 4.0. These areas of development allow proposing an Open Collaborative Network Model for: (i) knowledge generation and transfer initiatives, (ii) the development of collaborative and entrepreneurial projects and (iii) technology transfer to complex thinking scale levels for higher education students. Some of the expected outcomes of the R4C-IRG in the short term include developing an *Open Science* model to scale complex thinking, including diagnosis, future scenarios generation, proof-of-concept, validation of the model, and design of the transference process.

Castro et al., in the paper *Open science laboratory for manufacturing: an education tool to contribute to sustainability*, presented an example of a laboratory with a strong digital component that allows a sustainable answer to educational issues. It is a Physical Cyber System (CPS) laboratory based on Open Design, called Open Science Laboratory for Manufacturing (OSLab4Man), that has educational and research purposes and direct contribution towards some of the Sustainable Development Goals. On one hand, Sustainability became a major global issue for political, economic, social and research reasons. On the other hand, Education plays a central role in the individual, community, and social awareness towards sustainability once it enhances the relation between global education and education for sustainability. Concerning manufacturing education and research, CPS is considered to be a critical issue for Industry 4.0, and a requirement system to deal with the increase of manufacturing and engineering problems complexity and dynamic environment. The integration of physical equipment processes and computational processes is important within the CPS research work

perspective, although this kind of laboratories represents heavy investments for educational and research organizations. Considered to be a new approach to science and with increasing relevance in the educational and research communities, *Open Science* (OS) aims to promote collaboration and educational/learning dissemination by using digital technologies and tools. One branch of the OS is the Open Lab, in which a laboratory is developed under Open Design (OD) concept. In order to develop educational and research laboratories adopting reproducibility and replicability (R&R) practices, many educational and research communities are embracing these practices for CPS. OD delivers software and hardware design development in open-source and is freely available in digital community-based platforms.

3 THE EFFECTS OF THE PANDEMIC ON EDUCATION METHODOLOGY

The framework imposed by the COVID-19 pandemic over the past two years has imposed deep changes in education. Educators and teachers worked a miracle to change and adapt their teaching strategies overnight. The negative impact of the restrictions imposed by the pandemic was very high and its real effects, especially those in the long term, have yet to be quantified. But there were also positive effects from the pandemic: teachers and students repeatedly missed the face-to-face classroom environment, that they previously did not recognize. This made us aware that traditional education, as we know it, is not only a right but a privilege. During the pandemic, methods and strategies were applied that proved to be especially interesting, if used in order to respond to the Sustainable Development Goals. Nevertheless, the online teaching methodology also highlighted and deepened the existing social differences of resources and opportunities.

4 CONCLUSIONS

Track 16 of TEEM'21, once again, aims to promote open discussion on the topic of education for Sustainable Development. In

this path, we showed that the change of attitudes by students in higher education can be promoted using simple digital media, with a huge impact on the development of nations. We have more and better digital media available. Its use also requires a very active participation of educators and students, in an inclusive process for all actors involved. The 9th edition of TEEM was again a privileged space to present and discuss the different results and experiences, aiming to respond to educational challenges on Sustainable Development. Sustainable Development is expanding continuously and effectively. Changing attitudes? Digital media and digital tools are now embedded in the paths of our era educational system.

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