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## MOOC education for sustainable development. The Erasmus+ project experience

**ABSTRACT:** The paper presents the scope of the international curriculum developed under the MOOC4ALL project financed by the Erasmus Plus Strategic Partnerships Program for the MOOC platform <https://platform.mooc4all.eu/>. The project partners were research units and non-profit organizations from Germany, Poland, Romania and Hungary. Developed under the project, the curricula covers topics in the “green area” such as renewable energy sources, waste management and sustainable development. Research conducted in the consortium countries has demonstrated the need to create online courses in these subject areas to respond to market demand and achieve the goals of the 2030 Agenda for Sustainable Development. Green education is essential for safeguarding a sustainable world, maintaining it and preserving it for future generations. Currently, in times of climate crisis, increasing public awareness through non-formal education is of key importance. In the field of education, MOOCs have attracted a lot of attention as tools for open distance learning in the last

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decade. They make it possible to use the potential of new technologies in the didactic process and enable a reduction in the differences between developing and developed countries thanks to new interactive digital learning channels, which transpired to be particularly important during the Covid-19 pandemic. The online courses developed as part of the project are available to participants free of charge in five languages – English, German, Polish, Romanian and Hungarian.

KEYWORDS: renewable energy sources, sustainable development, open education, MOOC

## Introduction

One of the main goals of the United Nations Education Scientific Cultural Organization (UNESCO) Agenda for Sustainable Development (UNESCO Agenda 2030) is to take urgent action to combat climate change and its impacts. This can be achieved using essential tools to raise public awareness through education focused on sustainable development, including renewable energy sources (RES). Since the earth's natural resources are limited and the natural environment degrades, the harmonization of human activities is the obligation to pursue sustainable development (Jiricka et al. 2016; Yi-Chen Lai et al. 2020; Mróz et al. 2020; Holfelder 2019; Tomaszewska et al. 2018).

Education for sustainable development means adopting a holistic approach that allows acquiring the knowledge, skills, attitudes and values necessary to shape a sustainable future. The United Nations Educational, Scientific and Cultural Organization (UNESCO) has been promoting education for sustainable development since the early nineteen-nineties (UNESCO Guidelines 2002). The new UNESCO Framework on Education for Sustainable Development (ESD) for 2030 – towards achieving the SDGs places of teaching and learning in the center of the necessary transformation towards a more sustainable and equitable world (BildungsCent). The UNESCO ESD 2030 Programme was submitted to the United Nations in September 2019 and adopted by the UN General Assembly on December 19, 2019 (unesco.org). The demands on education to shape the necessary transformation processes towards sustainable development are described in Point 4: Transformative actions, and Point 5: Implementation Framework of the program. Emphasis is placed on the need to extend education beyond the formal one.

Non-formal education including lifelong learning is important to allow learners to acquire knowledge and information that will enable them to critically analyse and understand the complexity of the reality around them (Tresa et al. 2021). In particular, on issues related to the rising economic growth and sustainable development. Since some of the long-standing ESD efforts to change people's behavior concerning energy-saving, resource management and a green environment which manger be relevant to the transition to green technologies through equipping people with the required green skills. While ESD contributes to all seventeen sustainable development goals (SDG), it continues to have particular relevance for the global education agenda enshrined

in SDG 4, in which ESD has a distinct place. ESD is a key element of quality education. Its cross-cutting competencies in cognitive, socio-emotional and behavioral dimensions of learning bear relevance to all areas of education. Its places particular emphasis on competencies related to empathy, solidarity and action-taking and can help advance SDG 4 towards the future where education contributes not only to the successes of individuals but also to the collective survival and prosperity of the global community. It will additionally help the global education agenda move away from an exclusive focus on access and quality measured mainly in terms of learning outcomes towards an increased emphasis on learning contents and their contribution to humanity. The project presented in the article contributes to the implementation of the ESD strategies by creating massive open online courses (MOOCs) that support the transformation and sensitization of society in a sustainable sense.

Against the backdrop of climate change, resource scarcity and declining biodiversity, the topics which have been selected, such as renewable energies (especially photovoltaics and geothermal energy), waste management and nature conservation, are suitable for training skills that are in demand across borders. It also is in line with Goal 7 (Affordable and Clean Energy) of the UNESCO Agenda. This aspect is also addressed in a study from the predecessor project “EUBILD-UNAKLIM” (Rahner et al. 2018; Tomaszewska et al. 2018). This study aims to present the concept of teaching in the MOOC method to secure sustainable development in the time of limitations resulting from the COVID-19 pandemic.

## 1. Why the MOOC?

Nowadays, the requirements for many professional positions change too quickly for workers to sit back on what they were taught at university and demand the constant renewal of skills. Additionally, most forms of employment are no longer for life: navigating the labor market at frequent intervals requires the ability to demonstrate the latest marketable skills (The Financial Times 2019). Open and distance learning tools (ODL) are helpful for this demand. ODL focuses on open access education to free learners from time and place constraints, offering flexible learning opportunities which constitute one of the most rapidly growing education fields with an impact on all education systems. UNESCO gives high priority to ODL to reach adults in all life stages. Distance learning can reach an enormous number of participants, especially in developing countries and remote areas; students are free from the burden of traveling and are able to learn at their preferred time and speed.

The platform that offers e-learning is massive open online courses (MOOC) providing mass learners with open education service (Hew et al. 2014; Su et al. 2021). MOOC refers to online courses used predominantly in higher education and adult education, which usually have large numbers of participants because they do not have access and admission restrictions. Based on the open educational resources movement initiated by Massachusetts Institute of

Technology (MIT), many universities are currently trying to set up sustainability education curricula on MOOC platforms (Zhan et al. 2015; Li and Zhou 2018; Tabuenca et al. 2019). MOOCs as well as digital learning have been in the pipeline for many years both nationally and internationally. They are the subject of many European programs and agendas (inter alia, Europe 2020 Strategy, growth and jobs in Europe, new skills for labor markets and training strategies (ET 2020), Renewed European Agenda and Policy for Adult Learning; Smart, sustainable and inclusive growth – 7 flagship EU initiatives contribute to the 2020 targets, EPALE: Electronic, Platform for Adult Education in Europe. In addition, most of the European Union countries also have national programs, such as the German Digital Agenda 2014-2017, which focuses on seven key actions, including digital environments in society and education research, science, culture, and media.

### COVID-19 pandemic and the increased need for digital learning

The COVID-19 pandemic that spread across the world in 2020 is not only a global health crisis but is in fact a crisis affecting every aspect of our lives, including education. It should be noted, however, that the pressure to digitize education in the world occurred even before the COVID-19 pandemic broke out. In March 2020, home schooling started with inappropriate means because of pandemic, leaving many children without opportunities to learn, especially those in small and overcrowded flats, with a migration background, no support by the parents, no computers or other technical devices. Young people could not continue their vocational training, and lots of adults had their work confined to a home office from one day to the next. The digital home environment has been proven to be not appropriate; there were no devices (i.e. printers, fax machines, scanners, software, communication lines) and the internet connection in many places was either lacking or constantly breaking down due to overload. Due to the lockdowns enforced in order to contain the Corona pandemic, more than 168 million children worldwide have already been unable to attend school for a year (Fig. 1) (Blasberg et al. 2021). This alarming figure was announced by the children’s aid organization UNICEF in a recent report today (UNICEF

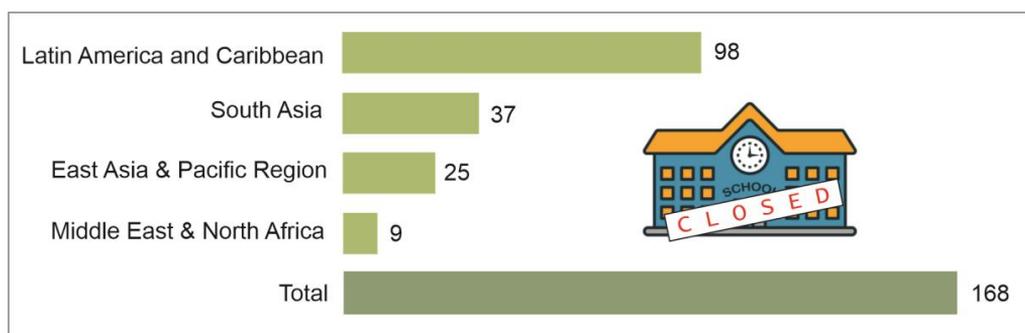


Fig. 1. Many schoolchildren have not received education since 11 March 2020, worldwide [millions], excluding East and Southern Africa, West and Central Africa, Europe & Central Asia due to lack of data (based on UNICEF 2021b)

Rys. 1. Miliony uczniów na całym świecie nie miało dostępu do kształcenia od 11 marca 2020 r. z wyłączeniem Afryki Wschodniej i Południowej, Afryki Zachodniej i Środkowej, Europy i Azji Środkowej z powodu braku danych

2021a,b). One in seven children worldwide missed more than three-quarters of their lessons during the pandemic. For example, in Latin America and the Caribbean, some ninety-eight million children have already been affected by Corona-related school closures for a year (UNICEF 2021a). In South Asia, it touches thirty-seven million children, and in the Middle East and North Africa, around nine million (Statista 2021). Country data was based on instructional days from March 11, 2020 to the end of February 2021, from preschools to upper secondary, and reflects the status of school closures over the past eleven months. Data for East and Southern Africa, West and Central Africa, and Europe and Central Asia could not be obtained (UNICEF 2021b). Therefore, the number of children who have been affected by school closures for a year is therefore likely to be higher than reported (Blasberg et al. 2021).

Statistics estimate that more than twenty-four million children and young people worldwide might never return to school again, would be lost to the education process and would never catch up again, especially in countries with lesser opportunities, such as Brazil, India, South Africa and others (Blasberg et al. 2021). Since parents lose their jobs, children have to start work and contribute to the family income. They will be lost with regard to education forever and remain in poverty and in badly paid jobs. In many cases, the school had been the place where children received their only proper meal of the day.

Digital collaboration has taken up speed across the planet over the course of the last year. It is, therefore, necessary to quickly create and design online courses for training and education for different age groups: from kindergarten, through school, universities, and general adult learning. It has been during this last year, that the immediate pressure for “going digital” resulted in a boost in digital technology, procedures and customization from the people’s side.

However, not only do pupils and students have to be trained in digital learning skills, but also trainers and teachers need to deliver the training courses online. Trainers and teachers must be properly prepared for digital training due to the differences in the way topics are presented in each environment. The Corona pandemic has changed our way of working and learning. This is why people will never return to the face-to-face working mode entirely. Most of them stay in a hybrid mode, a mixture between online and offline. In designing online training, we have to respond to this fact.

During the COVID-19 pandemic, MOOC seminars have experienced an enormous increase. Various online platforms that offer MOOCs reported an increase in users from 400 to over 600% (Gomez and Gomez 2021; Sá and Serpa 2021; Yang and Lee 2021). The average MOOC course has been found to enroll around 43,000 students, 6.5% of whom completed the course (Sammoor et al. 2019). Enrolment numbers are decreasing over time and are positively correlated with course length. Many people take MOOCs for the pleasure of learning, but badges and certificates are also available (Neubock et al. 2015).

## 2. Key aspects of sustainable education in MOOC4ALL Project

Mankind has always faced crises, not only in today's times, the most important being climate crisis, dwindling resources, social inequalities and huge differences in the development stage. This is why education for sustainable development is so important. It should be based on an interdisciplinary and holistic approach and on values of sustainable development.

A European educational concept as the MOOC was designed with the international cooperation of five partners from four countries (Germany, Hungary, Poland, and Romania). The project goals focus on enhancing digital learning, easier access to knowledge, and enabling participation from remote areas in addition to contributing to EU-wide standards for education concepts. As a result of this new and transversal knowledge, international green networks are created as is new expert knowledge that could reduce misfits between knowledge and market demands. To achieve this, the consortium created digital learning MOOCs in the partners' national languages (English, German, Hungarian, Polish and Romanian). The chosen theory and practical topics are close together in order that students could participate in diverse seminars in the field of natural sciences in their four national languages or in English and gain extra knowledge for their future career. MOOC seminars offer a wide range of theoretical backgrounds with practical instructions that can be put into practice relatively easily.

Several guidelines have been taken into consideration during the creation of MOOC courses (based on [Lackner et al. 2014](#)):

- ◆ Build a “learning culture” that supports and values eLearning. This culture should take online learning just as seriously as classroom training.
- ◆ Set up clear expectations from the beginning. Include expected behaviors either in a syllabus or at the start of the course.
- ◆ Shorter videos are particularly engaging.
- ◆ Videos that show the face of the speaker are more motivating.
- ◆ Videos that are perceived as personal are particularly stimulating.
- ◆ Videos in which teachers tend to speak quickly and with high enthusiasm are more motivating.
- ◆ “Khan-style” tutorials are more motivating than normal PowerPoint slides.
- ◆ Individual videos should not be too long.
- ◆ You should film in a more informal setting.
- ◆ One should combine movement and visual flow with the natural flow of speech.
- ◆ Teachers should be suitably instructed beforehand to speak as enthusiastically as possible.
- ◆ Set clear expectations upfront from the beginning. Include expected behaviors at the start of the course.

One of the biggest difficulties with digital learning is keeping learners engaged. The COVID-19 situation showed that moving from the “traditional” into a digital learning space is rife with challenges, especially when it comes to keeping learners entertained, engaged, and eagerly

learning from start to finish (Rodriguez et al. 2022). Therefore, good study practices can be strengthened by regular questions, quizzes or exams.

In a survey presented by Spitzer (2015), respondents were asked what students are also busy with during the lessons. Figure 2 presents activities that 774 surveyed students often or very often perform during traditional seminars (blue column) and online seminars (red column).

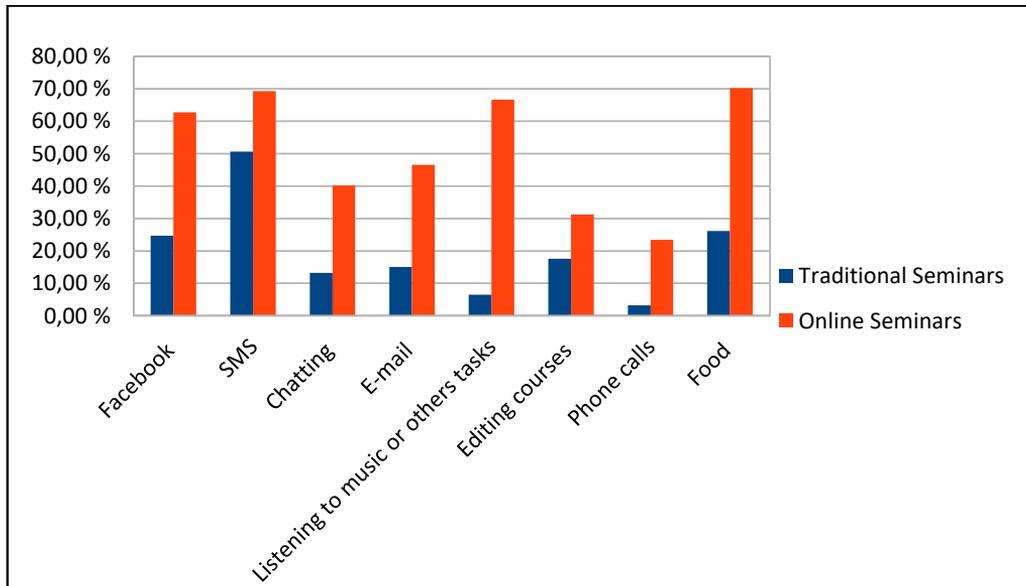


Fig. 2. What students are busy doing during a lecture (online versus traditional, based on Spitzer 2015)  
 Data: Facebook 24.7–62.7%, SMS 50.6–69.3%, chatting 13.2–40.2%, e-mail 15.0–46.5%, listening to music or others tasks 6.5–66.6%, editing courses 17.6–31.2%, phone calls 3.2–23.4%, food 26.1–70.2%, drinking 56.8–79.3%

Rys. 2. Czym studenci są zajęci podczas wykładu (kształcenie online versus tradycyjne)  
 Dane: Facebook 24,7–62,7%, SMS 50,6–69,3%, czat 13,2–40,2%, e-mail 15,0–46,5%, słuchanie muzyki lub inne zadania 6,5–66,6%, kursy edycji 17,6–31,2%, rozmowy telefoniczne 3,2–23,4%, jedzenie 26,1–70,2%, picie 56,8–79,3%

Results showed that students use more social media platforms and emails, chatting, website checks, answering phone calls, eating food, editing other courses and also listening to music. It should be noted that in online courses and in remote training, people are confronted with a new way of learning and taking in information. Young people have a different approach to finding information and thus gaining knowledge compared to the older generation. They do it mostly solely via mobile devices and the internet instead of using books. They shift from one topic to the next, they skim easily obtainable information. However, if the young generation passes the exams with good results and become useful professionals, then why should this way of acquiring knowledge be less good than the traditional method?

The presented pedagogic online course showed some differences between gaining knowledge and the ability to solve issues. Suggestion based on the ideas and experiences gained from the MOOC4All Project are:

- ◆ Make it interesting, include the audience in creating the knowledge (i.e. “could you please check, when this person was born, and can you please find the exact title of the law?”), incorporate these research results in your lecture.
- ◆ Value the research results during online lectures.
- ◆ Value questions resulting from research on social media platforms, and chats, while listening.
- ◆ Keep your audience “hooked” by asking for input and ideas, presenting your thoughts and having them questioned.

Nowadays the role of the teacher/trainer is changing to pass on knowledge, but in addition to training the audience on how and where to acquire knowledge, distinguish true and fake news and check information on logic. The modern (online) trainer shifts into being a knowledge facilitator. More democratic teaching perspectives blur the importance of the teacher role. The training methods change into more democratized methods since knowledge acquisition is different from the past century (CalmerClassrooms 2021). Acquiring knowledge is much less controllable and is also dependent on the location. If we want to control the training results in online training, we must work on goals and results, not on good behavior in the classroom.

### 3. Renewable energy education for sustainable development

Since the change in energy policy and energy consumption in the world requires a holistic approach, education should be considered as one of the main tools to achieve that. Elaboration within the MOOC4ALL Project curricula covers a wide range of topics related to energy and the environment. The education concept has been based on research about furthering existing education programs, experiences, needs and requirements elaborated under the UEUBILD-U-NAKLIM Project (Tomaszewska et al. 2019; Rahner et al. 2019).

Renewable energy sources are widely recognized nowadays as an effective response to the global issue of climate change (Ocetkiewicz et al. 2017; Holfelder 2019; Park et al 2020). Therefore, the project included two MOOCs courses related to sources of clean energy and the potential of their use: geothermal energy and solar energy.

Elaboration under the Project Geothermal MOOC will familiarize the recipients with fundamental knowledge of geothermal resources. It covers natural conditions, production and utilization, as well as the economic and environmental impact of geothermal energy. The purpose of the module is to provide a broad understanding of geothermal energy utilization which will prove useful in practice. In this course, special attention was given to issues related to the management of spent geothermal waters. Due to the high costs of drilling deep boreholes or the insufficient absorption capacity of reservoir rocks, the injection of spent waters into rock mass is not a com-

mon practice. In many cases, cooled waste geothermal waters are utilized through discharge into surface watercourses. The course materials will familiarize participants with the possibilities of the rational use of these waters. Taking into account that the problem of water deficit, especially high-quality water, affects more and more countries, education in this field is significant. The presented examples of solutions to this problem cover treatment or desalination, which provides water for both crop irrigation as well as industrial and municipal purposes.

The solar-energy module gives an overview of technologies and uses in the field of solar, and photovoltaic facilities and the use of these technologies in the building and power industry. This module displays the advantages and challenges of solar energy installations. It will provide participants with an understanding of solar energy in thermal applications, in particular the awareness of the interdependencies between technological, economic and ecological aspects.

Due to the fact that the current linear economy does not put any emphasis on the efficient management of resources and improvement of the quality of the environment, the path of transformation requires the acquisition of skills, know-how and, above all, an appropriate social attitude. Therefore, education in this field is crucial. In response to this demand, a waste course has been developed. It will provide a solid and up-to-date insight into the theoretical and practical foundations of waste topics.

## 4. Discussion

At a time when drastic actions are needed to combat climate change, UNESCO has identified seventeen goals for sustainable development ([UNESCO Agenda 2030](#)). One of the most important goals is education (Goal 4) because this leads to the success of all sustainable development goals. Without education, it is impossible to make progress in any other areas: health, sustainability of development, consumption and production, climate change or gender equality. Education encourages people to change their behavior and make informed decisions and motivates the young to take action. In the future, the young generation (“Z”) is expected to determine sustainable development; therefore, education at an early stage of life is so important. Despite broad agreement among experts on the necessity of sustainable development education, the question is how to fit the existing educators’ practices to ensure effective education on climate change ([Reid 2019](#)).

At present, a growing interest in the use of geothermal water and energy in the world is being observed ([Bertani 2015](#); [Pająk et al. 2020](#); [Wachowicz-Pyzik et al. 2020](#); [Hutter 2020](#); [Soltani et al. 2021](#); [Lund and Toth 2021](#)). Among renewable resources, geothermal energy is the most reliable option because of its independence from weather and geographical conditions. It contributes to the economic development of regions and the improvement of the living conditions of society. Furthermore, it positively influences the improvement of air quality and amenities resulting from the beneficial power of water ([Szulc-Wrońska and Tomaszewska 2020](#)).

Although geothermal energy is one of the cleanest sources of energy, its development faces barriers, mainly social, related to insufficient knowledge on this subject (Kasztelewicz and Kępińska 2015). The reluctance to use renewable energy sources (RES) resources is partly due to a lack of positive attitude, understanding and openness to changes. Negative or incomplete public understanding of any technology challenges sustainable development (Ocetkiewicz et al 2017). Additionally, the development of this sector requires broadening the knowledge of future specialists. Therefore, for this reason, the constant acquisition of knowledge and dissemination is required. Despite there being a large number of online courses on renewable energy, none of them cover the topic of geothermal energy comprehensively. The MOOC4ALL Project tries to meet these expectations.

In recent years, universities have been experiencing a set of important changes induced by the technological and social trends toward digitalization (Abad-Segura et al. 2020); additionally, the COVID-19 pandemic that has been going on since 2020 is accelerating this process (inter alia, Sa and Serpa 2020; Aristovnik et al. 2020; Gomez et al. 2021). The digitization of teaching has become, in a way, a necessity for universities during the COVID-19 pandemic; moreover, it also allows attracting more students, and above all, it gives the possibility of additional training for all interested parties. One of the main factors of success in teaching is, according to students, an interesting issue. The situation is different when the topic is less interesting and it is required and necessary to achieve the learning outcomes of a given subject. Innovative teaching methods, especially those using modern technologies, can come in handy. Thanks to these, the form of the presentation (e.g. interactive presenter, mind maps, mood boards and others) is much more attractive. To achieve this, there are many tools available on the market, e.g. for sharing content, for group work or gamification. The use of such tools in the didactic process depends mainly on willingness and ability to enter the digital world of educators because students are already well-versed in it (Ordu 2021). The present generation “Z” likes to express their opinion, and representatives of this generation like to share their thoughts, conclusions and remarks with others, especially when they can do it with the use of social media. However, how can we ensure that their need is met during classes conducted using the lecture method, especially if the lecture is online? In response to this demand, some applications (e.g. Wakelet, Elevate, Padlet, Lumocity) give educators such an opportunity and allow the lecture to become interactive and participatory, even when it is conducted at a distance. The tools used to create polls, questionnaires, and quizzes apply to MOOCs. Their handling is simple and intuitive. Importantly, it can be used via a mobile phone, which is an additional attraction for students. It is worth noting that one of the typical features of the “Z” generation is the willingness to share knowledge, information and cooperation in the name of a common, preferably environmentally friendly, goal (Schmeichel-Zarzezna 2019).

Open source MOOC platforms provide the opportunity to exchange knowledge, experience and innovation. Moreover, they facilitate access to knowledge, especially for developing countries, which may reduce these differences (Impey and Formanek 2021; Dewar et al. 2014; Kanwar and Daniel 2020; Ma and Lee 2018). Rich and developed countries are currently leaders in international cooperation and sharing technology and, thanks to platforms such as MOOCs,

they offer an opportunity to participate in courses created by specialists from around the world. Access to inclusive and equitable education thanks to MOOCs can help to provide the population with the tools necessary to develop innovative solutions to problems such as climate change (Abad-Segura et al. 2020). Another advantage of MOOCs is the ability to deliver courses at a time convenient for the learner. It is extremely important for professionally or academically active people who do not have to give up their activities. They indicate the benefits of attending MOOCs as the main goal of improving their current job or finding a new role (Gomez and Gomez 2021; Zhenghao et al. 2015).

## Conclusions

- ◆ The growing demand for energy consumption as well as restrictions on fossil fuel utilization and water set the need for knowledge acquisition. Education is a key tool for achieving a more sustainable world, and promotes the development of the knowledge, understanding and skills that ensure environmental protection and promote social equity.
- ◆ Incorporating technology into social life has changed both the nature of services and products, and the importance of working time, including learning processes.
- ◆ The novel educational MOOCs presented in this paper have been developed as a response to market and climate needs. The market research on the course carried out as a part of the project has shown that the innovative strength in the field of “green professions” is growing disproportionately compared to other traditional professions. At the same time, there is a discrepancy between jobs that are in demand and training opportunities.
- ◆ Elaborated MOOCs include contributions from international researchers and practitioners. The online courses are available on the platform <https://platform.mooc4all.eu/>.

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## References

- ABAD-SEGURA et al. 2020 – ABAD-SEGURA, E., GONZÁLEZ-ZAMAR, M.D., INFANTE-MORO, J. and RUIPÉREZ GARCÍA, G., 2020. Sustainable Management of Digital Transformation in Higher Education: Global Research Trends. *Sustainability* 12(5), DOI: 10.3390/su12052107.
- BARRON et al. 2022 – BARRON, R., MARIA, R., COBO, R., MUNOZ-NAJAR, J.C., CIARRUSTA, A.S. and INAKI, A. 2022. Remote Learning During the Global School Lockdown : Multi-Country Lessons (English). Washington, D.C.: World Bank Group. [Online] <http://documents.worldbank.org/curated/>

- en/668741627975171644/Remote-Learning-During-the-Global-School-Lockdown-Multi-Country-Lessons [Accessed: 2022-10-26].
- BERTANI, R., 2015. Geothermal Power Generation in the World 2010–2014 Update Report. [In:] *Proceedings World Geothermal Congress 2015*.
- BildungsCent. [Online] <http://www.bildungscent.de/bildungscent/bildungscent-ev/> [Accessed: 2022-10-25].
- BLASBERG et al. 2021 – BLASBERG, M., HÖFLINGER, L., KUNTZ, K. and SCHAAP, F. 2021. Generation Lockdown. Schoolchildren Around the World Face a Steep Uphill Battle. *Der Spiegel* 9. [Online] <https://www.spiegel.de/international/world/generation-lockdown-schoolchildren-around-the-world-face-a-steep-uphill-battle-a-58d3ad33-32f1-4f96-97cc-940e72ab03a9> [Accessed: 2022-10-25].
- CalmerClassrooms 2021. [Online] <https://calmerclassrooms.today/the-pros-and-cons-of-teaching-styles/> [Accessed: 2022-11-05].
- DEWAR et al. 2014 – DEWAR, E., UHOMOIBHI, J., ROSS, M. and HUTTY, D. 2014. MOOCs development and implementation: The challenges and prospects of higher education in emerging countries. *THF working paper* No 5, The Head Foundation (2014). [Online] [https://headfoundation.org/wp-content/uploads/2020/11/thf-papers\\_-MOOCs-Development-and-Implementation.pdf](https://headfoundation.org/wp-content/uploads/2020/11/thf-papers_-MOOCs-Development-and-Implementation.pdf) [Accessed: 2022-10-25].
- ESD Roadmap 2020. Education for Sustainable Development Roadmap. UNESCO, France. ISBN 978-92-3-100394-3. [Online] <https://unesdoc.unesco.org/ark:/48223/pf0000374802.locale=en> [Accessed: 2022-10-25].
- HEW, K.F. and CHEUNG, W.S. 2014. Students' and instructors' use of massive open online courses (MOOCs): Motivations and challenges. *Educational Research Review* 12, pp. 45–58.
- HOLFELDER, A.K. 2019. Towards a sustainable future with education? *Sustainability Science* 14, pp. 943–952, DOI: 10.1007/s11625-019-00682-z.
- HUTTER, G. 2020. Geothermal power generation in the world 2015–2020 update report. [In:] *Proceedings of the world geothermal congress, Reykjavik, Iceland, 26 April–2 May 2020*.
- GOMEZ, F.G. and GOMEZ, P.M. 2021. Use of moocs in health care training: A descriptive-exploratory case study in the setting of the covid-19 pandemic. *Sustainability* 13(19), DOI: 10.3390/su131910657.
- IMPEY, Ch. and FORMANEK, M. 2021. MOOCs and 100 Days of COVID: Enrollment surges in massive open online astronomy classes during the coronavirus pandemic. *Social Sciences & Humanities Open* 4(1), DOI: 10.1016/j.ssaho.2021.100177.
- JIRICKA et al. 2016 – JIRICKA, A., FORMAYER, H., SCHMIDT A., VOLLER, S., LEITNER, M., FISHER, T.B. and WACHTER, T.F. 2016. Consideration of climate change impacts and adaptation in EIA practice – Perspectives of actors in Austria and Germany. *Environmental Impact Assessment Review* 57, pp. 78–88, DOI: 10.1016/j.eiar.2015.11.010.
- KANWAR, A. and DANIEL, J. 2020. *Report to commonwealth education ministers: From response to resilience*. Commonwealth of Learning, UNESCO. [Online] <https://iite.unesco.org/wp-content/uploads/2020/06/Report-to-Commonwealth-Education-Ministers.pdf> [Accessed: 2020-10-25].
- KASZTELEWICZ, A. and KĘPIŃSKA, B. 2015. Public Perception of Geothermal Energy in Selected European Countries. *Proceedings from the World Geothermal Congress 2015*, 19–24 April 2015, Australia–New Zealand.
- LI, C. and ZHOU, H. 2018. Enhancing the Efficiency of Massive Online Learning by Integrating Intelligent Analysis into MOOCs with an Application to Education of Sustainability. *Sustainability* 10, DOI: 10.3390/su10020468.
- LACKNER et al. 2014 – LACKNER, E., KOPP, M. and EBNER, M. 2014. How to MOOC? – A pedagogical guideline for practitioners. Roceanu, I. (ed.). *Proceedings of the 10<sup>th</sup> International Scientific Conference “eLearning and Software for Education” Bucharest, April 24–25, 2014*. Publisher: Editura Universitatii Nationale de Aparare “Carol I”

- LUND, W.J. and TOTH, A. 2021. Direct utilization of geothermal energy 2020 worldwide review. *Proceeding World Geothermal Congress 2020+1*, Reykjavik, Iceland, April-October 2021. Paper 01011.
- MA, L. and LEE, C.S. 2018. Understanding the Barriers to the Use of MOOCs in a Developing Country: An Innovation Resistance Perspective. *Journal of Education Computing Research* 57(3), DOI: 10.1177/0735633118757732.
- MRÓZ et al. 2020 – MRÓZ, A., OCETKIEWICZ, I. and TOMASZEWSKA, B. 2020. What should be included in education programmes. The socioeducation analysis for sustainable management of natural resources. *Journal of Cleaner Production* 250, DOI: 10.1016/j.jclepro.2019.119556.
- NEUBOCK et al. 2015 – NEUBOCK, K., KOPP, M. and EBNER, M. 2015. What do we know about typical MOOC participants? First insights from the field. *Research Track, Proceedings of the 3<sup>rd</sup> European MOOC Stakeholder Summit 2015*, Mons, Belgium.
- OCETKIEWICZ et al. 2017 – OCETKIEWICZ, I., TOMASZEWSKA, B. and MRÓZ, A. 2017. Renewable energy in education for sustainable development. The Polish experience. *Renewable and Sustainable Energy Reviews* 80, pp. 92–97, DOI: 10.1016/j.rser.2017.05.144.
- ORDU, U. 2021. The Role of Teaching and Learning Aids/Methods in a Changing World. *BCES Conference Books* 19. Sofia: Bulgarian Comparative Education Society, ISSN 2534-8426.
- PAJĄK et al. 2020 – PAJĄK, L., TOMASZEWSKA, B., BUJAKOWSKI, W., BIELEC, B. and DENDYS, M. 2020. Review of the low-enthalpy Lower Cretaceous geothermal energy resources in Poland as an environmentally friendly source of heat for urban district heating systems. *Energies* 13(6), pp. 1–14, DOI: 10.3390/en13061302.
- PARK et al. 2020 – PARK, C.-H., KO, Y.-J., KIM, J.-H. and HONG, H. 2020. Greenhouse Gas Reduction Effect of Solar Energy Systems Applicable to High-rise Apartment Housing Structures in South Korea. *Energies* 13(10), DOI: 10.3390/en13102568.
- RAHNER et al. 2018 – RAHNER, S., WINTER, I., HARTMANN, M., WITTIG, F., KASZTELEWICZ, A., TOMASZEWSKA, B., PAJĄK, L., DENDYS, M., OPERACZ, A., MRAZ, M. and NISTOR, S. 2018: Study on national activities and funding opportunities of furthering education programs for unemployed academics. *E3S Web of Conferences* 66, DOI: 10.1051/e3sconf/20186603004.
- REID, A. 2019. Climate change education and research: possibilities and potentials versus problems and perils? *Environmental Education Research* 25(6), pp. 767–790, DOI: 10.1080/13504622.2019.1664075.
- SMOL et al. 2020 – SMOL, M., ADAM, C. and PREISNER, M. Circular economy model framework in the European water and wastewater sector. *Journal of Material Cycles and Waste Management* 22, pp. 682–697, DOI: 10.1007/s10163-019-00960-z.
- SPITZER, M. 2015. Cyber sick! Digitized life ruins our health (*Cyberkrank! Wie das digitalisierte Leben unsere Gesundheit ruiniert*). Ulm: Droemer HC (in German).
- SOLTANI et al. 2021 – SOLTANI, M., KASHKOOLI, F.M., SOURI, M., RAFIEI, B., JABARIFAR, M., GHARALI, K. and NATHWANI, J.S. 2021. Environmental, economic, and social impacts of geothermal energy systems. *Renewable and Sustainable Energy Reviews* 140, DOI: 10.1016/j.rser.2021.110750.
- SA, M.J. and SERPA, S. 2021. The covid-19 pandemic as an opportunity to foster the sustainable development of teaching in higher education. *Sustainability* 12(20), pp. 1–16, DOI: 10.3390/su12208525.
- SAMMOUR et al. 2019 – SAMMOUR, G., AL-ZOUBI, A. and SCHREURS, J. 2019. Deployment of MOOCs in Virtual Joint Academic Degree Programs. [In:] *Proceedings of the 21<sup>st</sup> International Conference on Enterprise Information Systems (ICEIS 2019)*, pp. 637–643, DOI: 10.5220/0007754806370643.
- SCHMEICHEL-ZARZEZNA, M. 2019. The digital generation how the world changed the young and how they will change the world. Vol. 1 (*Pokolenie cyfrowe jak świat zmienił młodych i jak oni zmienią świat*).

- Cz. 1). [Online] <https://epale.ec.europa.eu/pl/blog/pokolenie-cyfrowe-jak-swiat-zmienil-mlodych-i-jak-oni-zmienia-swiat-cz-1> [Accessed: 2022-10-26] (in Polish).
- SU et al. 2021 – SU, P.Y., GUO, J.H. and SHAO, Q.G. 2021. Construction of the quality evaluation index system of mooc platforms based on the user perspective. *Sustainability* 13(20), DOI: 10.3390/su132011163.
- SZULC-WROŃSKA, A. and TOMASZEWSKA, B. 2020. Low enthalpy geothermal resources for local sustainable development: A case study in Poland. *Energies* 13(19), DOI: 10.3390/en13195010.
- TABUENCA et al. 2019 – TABUENCA, B., KALZ, M. and LÖHR, A. 2019. Massive Open Online Education for Environmental Activism: The Worldwide Problem of Marine Litter. *Sustainability* 11, DOI: 10.3390/su11102860.
- TOMASZEWSKA et al. 2018 – TOMASZEWSKA, B., KASZTELEWICZ, A., DENDYS, M., BUJAKOWSKI, W., RAHNER, S., HARTMANN, M. and WEINREICH, J. 2018. European educational concept in environmental nature- and climate protection to safeguard a cross border sustainable development. *E3S Web of Conferences* 66, DOI: 10.1051/e3sconf/20186603005.
- TRESA et al. 2021 – TRESA, E., BURAZERI, G., VAN DEN BROUCKE, S., QIRJAKO, G. and CZABANOWSKA, K. 2021. Nonformal education as health promotion method among European youth: The example of transitional Albania. *Health Promotion International* 36(5), pp. 1463–1472, DOI: 10.1093/heapro/daab005.
- UNESCO Framework ESD for 2030. Towards achieving the SDGs (UNESCO ESD 2030 Programme).
- UNESCO Guidelines 2002. Guidelines for Open Educational Resources (OER) in Higher Education; United Nations Educational, Scientific and Cultural Organization: Paris, France, 2002.
- Unicef 2021a. [Online] <https://www.unicef.org/cuba/en/press-releases/around-2-3-children-are-still-out-of-classroom-latin-america-and-caribbean> [Accessed: 2022-10-25].
- Unicef 2021b. [Online] <https://www.unicef.org/india/press-releases/covid-19-schools-more-168-million-children-globally-have-been-completely-closed> [Accessed: 2022-10-25].
- YANG, Q. and LEE, Y.C. 2021. The critical factors of student performance in MOOCs for sustainable education: A case of Chinese universities. *Sustainability* 13(14), DOI: 10.3390/su13148089.
- YI-CHEN, L. and LI-HSUN, P. 2020. Effective Teaching and Activities of Excellent Teachers for the Sustainable Development of Higher Design Education. *Sustainability* 12(1), DOI: 10.3390/su12010028.
- WACHOWICZ-PYZIK et al. 2020 – WACHOWICZ-PYZIK, A., SOWIŹDŹAŁ, A., PAJĄK, L., ZIÓLKOWSKI, P. and BADUR, J. 2020. Assessment of the effective variants leading to higher efficiency for the geothermal doublet, using numerical analysis-case study from Poland (Szczecin Trough). *Energies* 13(9), pp. 1–20, DOI: 10.3390/en13092174.
- ZHAN et al. 2015 – ZHAN, Z., FONG, P.S.W., MEI, H., CHANG, X., LIANG, T. and MA, Z. 2015. Sustainability Education in Massive Open Online Courses: A Content Analysis Approach. *Sustainability* 7, pp. 2274–2300, DOI: 10.3390/su7032274.
- ZHENGHAO et al. 2015 – ZHENGHAO, C., ALCORN, B., CHRISTENSEN, G., ERIKSSON, KOLLER D. and EMANUEL, E.J. 2015. *Who's benefiting from MOOCs, and why?* Harvard Business Review. [Online] <https://hbr.org/2015/09/whos-benefiting-from-moocs-and-why?> [Accessed: 2022-10-25].
- The Financial Times 2019. Richard Waters. – [www.ft.com/content/60e90be2-1a77-11e9-b191-175523b59d1d](http://www.ft.com/content/60e90be2-1a77-11e9-b191-175523b59d1d) elearningindustry.com. [Online] (<https://elearningindustry.com/subjects/elearning-articles/elearning-best-practices>) [Accessed: 2022-10-25].

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## Edukacja MOOC na rzecz zrównoważonego rozwoju. Doświadczenia projektu Erasmus+

### Streszczenie

W artykule przedstawiono zakres międzynarodowego programu nauczania typu MOOC (Masowy otwarty kurs online) opracowanego w ramach projektu MOOC4ALL finansowanego z Programu Erasmus+. Partnerami projektu były jednostki naukowe oraz organizacje non-profit z Niemiec, Polski, Rumunii oraz Węgier. Opracowane w ramach projektu programy nauczania obejmują tematy z zakresu zielonych obszarów, takie jak odnawialne źródła energii, zrównoważony rozwój oraz gospodarka odpadami. Badania przeprowadzone w krajach konsorcjum wykazały potrzebę tworzenia kursów online w tych obszarach tematycznych, by odpowiedzieć na zapotrzebowanie rynku oraz osiągnąć cele „Agendy na rzecz zrównoważonego rozwoju 2030”. Edukacja ukierunkowana na zielone tematy jest niezbędna do ochrony zrównoważonego świata, jego przetrwania i zachowania go dla przyszłych pokoleń. Obecnie w dobie kryzysu klimatycznego zwiększanie świadomości społecznej poprzez edukację pozaformalną ma kluczowe znaczenie. W dziedzinie edukacji MOOC-i jako narzędzia otwartego uczenia się na odległość wzbudziły w ostatniej dekadzie duże zainteresowanie. Umożliwiają one wykorzystanie w procesie dydaktycznym potencjału nowych technologii, dają możliwość zmniejszenia różnic między krajami rozwijającymi się a rozwiniętymi, dzięki nowym interaktywnym kanałom cyfrowego uczenia się, co okazało się to szczególnie istotne podczas pandemii Covid-19. Kursy online opracowane ramach projektu dostępne są dla uczestników bezpłatnie w pięciu językach: angielskim, niemieckim, polskim, rumuńskim oraz węgierskim.

SŁOWA KLUCZOWE: odnawialne źródła energii, zrównoważony rozwój, otwarta edukacja, MOOC

