Environmental Engineering and Management Journal *August 2019, Vol. 18, No. 8, 1833-1842*
http://www.eemj.icpm.tuiasi.ro/; http://www.eemj.eu

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MASSIVE OPEN ONLINE COURSES (MOOCs) WITH OPEN EDUCATIONAL RESOURCES FOR TOXICOLOGY LEARNING – DRUGS AND POLLUTANTS AS XENOBIOTICS

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Abstract

Due to the lack of European Massive Open Online Courses (MOOCs) in the field of the Toxicology and the major differences in the styles of teaching and learning of this important subject in amongst various European life science-oriented institutions, the European Erasmus+ project "Learning Toxicology through Open Educational Resources (TOX-OER)" was developed and implemented. Considering the complexity and heterogeneity of the toxicology field, the TOX-OER project main objective was to develop and share toxicology-related knowledge and skills among students/ earners from seven countries, which promote the internationalization of Higher Education Institutions in Europe but also in countries from other continents. The project was coordinated by Universidad de Salamanca (Spain), and the partners were: Space Research and Technology Institute (Bulgaria), Univerzita Karlova V Praze (Czech Republic), South-Eastern Finland University of Applied Sciences (Finland), Università di Bologna (Italy), Universidade do Porto (Portugal) and Universitatea Transilvania din Brasov (Romania). One of the goals/ objectives of the project is the dissemination, popularizing the information and reaching potentially interested people who can benefit from the offered courses. The aim of this paper is to present and analyze part of the TOX-OER's outcomes developed by the project's partnership, especially the modules/ topics related to the drugs, gaseous and persistent organic pollutants, as the principal groups of xenobiotics.

Key words: drugs, massive open online courses, open educational resources, pollutants, toxicology

Received: July, 2018; Revised final: March, 2019; Accepted: May, 2019; Published in final edited form: August, 2019

1. Introduction

The creation of the International Council for Open and Distance Education (Canada, 1938), and of the Open University (UK, 1969) can be considered as main precursor of the openness in education, or open education, as an evolving phenomenon (Chiappe-Laverde et al., 2015).

Massive Open Online Courses (MOOCs) are already used either to replace traditional "brick-and-mortar" education, or to offer supplementary educational contents for the more traditional courses, both inside and outside the educational community being interested in MOOCs. This learning platform is not only used by learners, but also by instructors, aiming to gain more experience in teaching and learning (Burge, 2015).

A critical review, based on hundreds of published papers (between 2007 and 2013) and practical experiences with MOOCs reveals the

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increasing interest in both understanding MOOCs features and promoting the pedagogic framework and the concept of openness embedded within this type of courses. Considering the impact on education of the Open Educational Resources (OERs), it is appreciated that a possible development is to move from OER production to Open Educational Practices (OEP), thus making the practices also more open (Chiappe-Laverde et al., 2015).

MOOCs have the potential to fill in educational gaps, by offering high quality courses, free of charge, to persons with Internet access, although it is accepted that MOOCs, being largely courses tailored English speaking audience, may not be accessible to non-native English language speakers (Uchidiuno et al., 2016).

MOOCs are also presented from the specific perspective of the interaction between the student enrolled in such a course and the course materials. Although MOOCs have the potential to become a major new mechanism for learning, they are still relatively unexplored and poorly understood (Anderson et al., 2014).

Online toxicology courses are often offered in the United States of America. Some examples are given: the University of Florida's has online clinical toxicology graduate programs (https://clintox.cop.ufl.edu/programs/courses/), the Society of Toxicology has continuing education courses online (https://www.toxicology.org/education/ce/onlineCourses.asp), while the Department of Pharmacology at Michigan State University also gives master of Science degrees in Pharmacology and Toxicology, online program (https://phmtox.msu.edu/education/online-ms-programs/ms-pharmacology-toxicology/). In Europe, 16 institutions in the United Kingdom are offering Toxicology courses with On-campus or Online/ Distance options (https://www.hotcoursesabroad.com/study/training-degrees/uk/distance-online/toxicology-courses/loc/210/smode/3/cgory/rh.465-4/sin/ct/programs.html).

A survey of MOOCs distribution by fields of study, available in 2015, is presented in Figure 1.a. We have noticed that formal sciences and natural sciences domains are represented by only 8%, and respectively 9% of all MOOCs developed in Europe until 2015 (www.mooc-maker.org/?dl_id=30). On the other hand, Fig. 1b reveals the MOOCs distribution per countries in Europe in 2015 (https://elearninginfographics.com/european-moocs-scoreboard-infographic/), where countries like United Kingdom and Spain having the higher contribution to the MOOCs development.

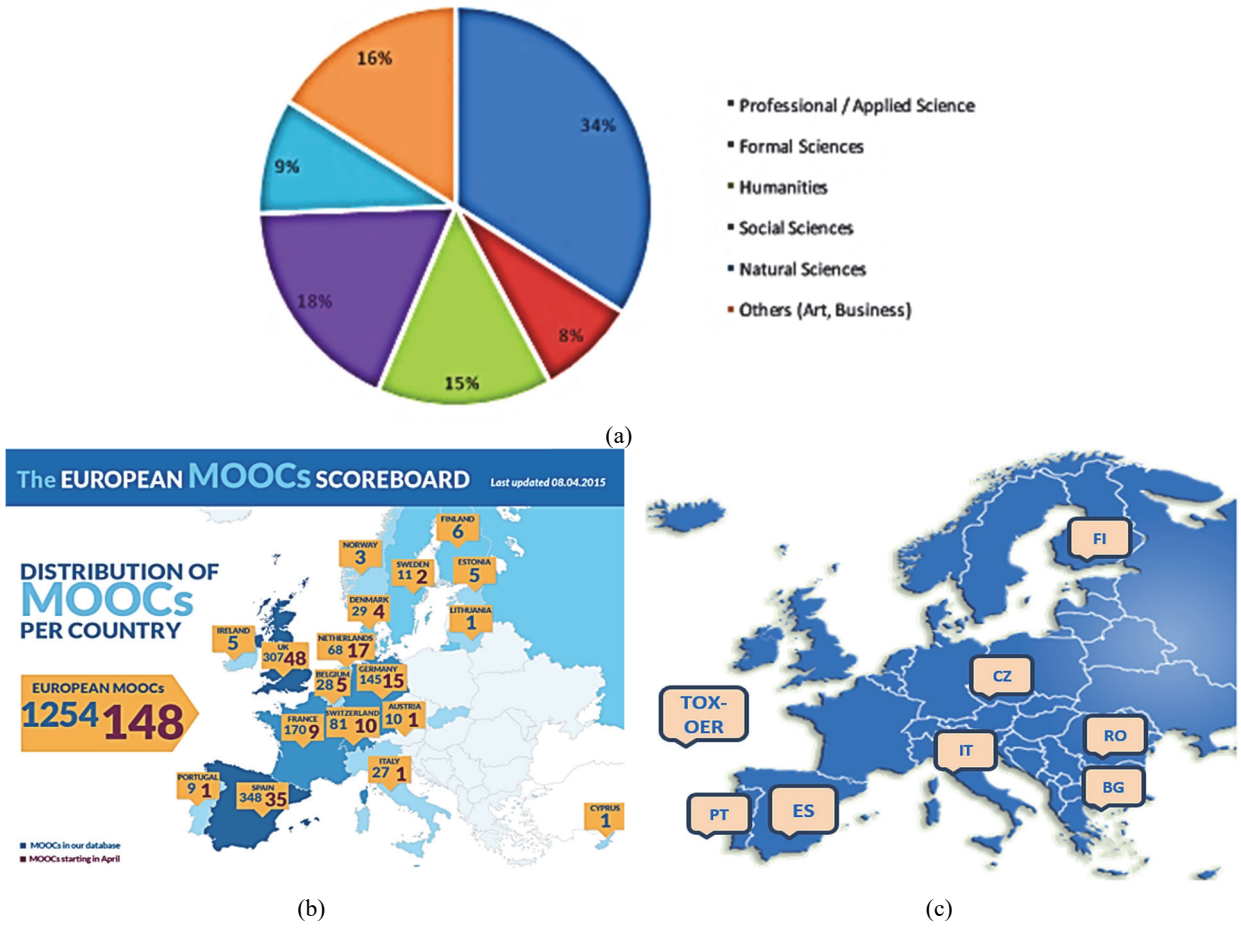


Fig. 1. MOOCs distribution in Europe by fields of study, in 2015 (a); developed MOOCs recorded on April 2015 (b); TOX-OER contribution to MOOCs in Europe (c).

In the context of identifying a lack of European MOOCs in the field of Toxicology, came the need to propose and design the European Erasmus+ project "Learning Toxicology through Open Educational Resources (TOX-OER)" (project run between September 2015 – February 2018), which is a novelty in this domain. Taking into account the complexity and heterogeneity of toxicology field, TOX-OER aimed to develop and share toxicology-related knowledge and skills among Higher Education Institutions from seven European Union countries: Universidad de Salamanca, Spain (USAL, project coordinator); Space Research and Technology Institute, Bulgaria (SRTI-BAS); Univerzita Karlova V Praze, Czech Republic (CUNI); South-Eastern Finland University of Applied Sciences, Finland (XAMK); Università di Bologna, Italy (UniBo); Universidade do Porto, Portugal (UPorto); Universitatea Transilvania din Brasov, Romania (UTBv) (Fig. 1c).

TOX-OER project, offered not only a new learning platform available for learners interested in toxicology related fields, but also an incredible experience for the authors to build up a MOOC and to feed it with all the required OERs, all in eight languages: video courses, supplementary texts and additional study documents, as well as test for evaluation. TOX-OER MOOC is a pedagogical platform used to develop and share knowledge and skills related to the toxicology field. The project aimed to improve the access to learning toxicology – by using active, virtual and blended learning (https://toxoer.com/). The aim of this study is to present the TOX-OER project and partially analyze its outcomes, describing the OERs development as new learning environment, characterized by the availability, flexibility, accessibility, and ease of use, focusing on the description of the modules/ topics related to the drugs and selected pollutants.

2. Methodology

Based on the need analysis, and combining the research in the field of toxicology with MOOC pedagogical design, the TOX-OER project followed well established methodology, in order to develop a new learning environment:

1. design of the new syllabus on toxicology;

2. development/ creation of accessible OERs; course & modules management;

3. implementation, monitoring and evaluation of individual learning activities.

This methodology contributed to the promotion of learning outcomes and delivery of the new learning environment to students, trainees, and adult learners, represented by professionals in the field and/ or interested general audience.

The fundamental variables taken into consideration by the project partners in TOX-OER MOOC platform design were: human resources; platform (MOOC); target groups; contents; teaching formats of the MOOC; competencies (aims and learning objectives, learning outcomes, work load/ time required); teaching; assessment (intermediate and final tests, other tools and methods, like gamification); certificate/ certification (Guerra and Ferrari, 2018). Of all these variables, this paper focuses on those related to the contents, competencies and assessment, following the methodology: design, development and implementation.

3. Results and discussion

3.1. Design of the syllabus on toxicology

OER process model was proposed, consisting of 4 stages, each containing a number of activities (Camilleri, 2012):

1. design – by specification (defining of the learning outcomes), outline (design of the curriculum/ syllabus) and position (analyzing the degree of openness);

2. learning – by guiding (learning support) and document;

3. assessment – by verification and testing;

4. awarding – by certification or recognition;

Following the OER process model, the project consortium, representing seven research groups (from universities and a research institution), defined the learning outcomes, each module and topic being described in detail in terms of goals and objectives, contents, learning outcomes, work load, possible audience and available languages, as presented in Table 1 (https://toxoer.com/). These descriptions allow the learners to be informed about the scope and contents of the OERs modules and topics to be followed.

Table 1. Modules and topics descriptions

Module description	***Topic description***
Name of the module; date of release/ last update; author/s	Name of the topic; date of release/ last update; author/s
Short descriptions (goals, learning objectives, contents, activities → if/ when expected, evaluation → if/ when expected)	Short descriptions
Intended learning outcomes	Intended learning outcomes
Module structures (topics)	
Estimated workload (total no. of hours to complete the module)	
Audience (possible targets)	Audience (possible targets)
Available languages	Available languages

A new Syllabus on Toxicology, consisting of seven OER modules and topics was also developed, the learning contents of which are presented in Table 2 (https://toxoer.com/). The topics have been chosen and developed in accordance with the specific skills of the project partners.

Table 2. Learning contents developed by TOX-OER consortium

Modules/ topics	***ECTS***	***Partners***
Module 1: General Concepts		
1.1. Glossary (terms and concepts)	1	UPorto
Module 2: Pharmaco-Toxicokinetic		
2.1. ADMET, Membrane and Transport Mechanisms	1	UPorto
2.2. ABC Transporters, BB Barrier	1	UPorto
2.3. Absorption, Distribution, Excretion	2	UPorto
2.4. Xenobiotic Metabolism	2	UPorto
Module 3: Principal Groups of Xenobiotics		
3.1. Prescription Drugs	*2*	*UniBo*
3.2. Drugs of Abuse	*2*	*UniBo*
Module 4: Environmental Pollutants		
4.1. Gaseous Pollutants	*1*	*UTBv*
4.2. Heavy Metals	1	CUNI
4.3. Persistent Organic Pollutants	*1*	*UTBv*
4.4. Pesticides I	2	SRTI-BAS
4.5. Pesticides II	2	SRTI-BAS
Module 5: Target Organ Toxicity and Biomarkers		
5.1. Cardiovascular	2	CUNI
5.2. Pulmonary	1	CUNI
5.3. Renal	2	USAL
5.4. Liver	2	UPorto
5.5. Nervous System	1	USAL
Module 6: Environmental Toxicology		
6.1. European Union and National Regulations Related to Environmental Quality	2	UTBv
6.2. Control of Emissions from Anthropogenic Activities and Safety	2	XAMK
6.3. Introduction to the Environmental Quality Monitoring System	1	UTBv
6.4. Monitoring the Environmental Quality – Air, Water, Soil	2	UTBv
Module 7: Patents and Patent Application 7.1. European legislation, Patentability, Structure of patents, Forensic applications of patents	2	UniBo
Total ECTS	35	

Modules and topics dedicated to xenobiotics like drugs, gaseous pollutants, and persistent organic pollutants (POPs) are of interest for this study.

3.2. Development of Open Educational Resources

For each ECTS (28 conventional hours), the OERs authors produced a series of courses contents, along with their related learning support, for each agreed module/ topic (Table 3, https://toxoer.com/).
The TOX-OER MOOC has different levels of access and certification (https://toxoer.com/)

1. free level – OERs are open to different target groups: this level does not release a certificate of attendance, or credits;

2. certificate of attendance – after following the courses and taking the tests (passing the exam), an automatic certificate of attendance (with grades) may be generated to the attendees; this certificate does not have any legal value;

3. credits for recognition – the certificate of attendance can further be used by the attendees, together with the course description (including the number of credits) to apply for recognition of the course at the home university, as part of their studies (Remiao and Makela, 2018).

In support of the learning goals of speakers of English as a Second Language (ESL) (Uchidiuno et al., 2016), the TOX-OER team has decided that all the videos, texts and tests will be produced in English and then translated in all seven native languages of the seven partners (Bulgarian, Czech, Finish, Italian, Portuguese, Romanian and Spanish), being thus available in eight languages. This is another novelty of the TOX-OER MOOC.

Table 3. Description of contents and evaluation tests developed by the OERs authors (1 ECTS)

	Description	***Unit***	
Content	introduction text to the module	number	1
	introduction video to the module – 3 minutes	number	1
	multimedia learning content – video courses/ commented slides: 2x15 or 3x10 minutes for each content	number	2 or 3
	text-based learning content for further reading: learning resources (text contents) or additional readings (papers, book chapters)	hours	4
Evaluation/ assessment	self-evaluation tests (quiz)	number	2
	final test	number	1

Drugs as Xenobiotics

Module 3, Principal Groups of Xenobiotics, describes the main toxicological features of both prescription drugs and drugs of abuse (classic and novelty ones): toxicology, forensic analysis, and case reports. The differences from the legal and scientific points of view are described and discussed, together with the analytical methods for their qualitative and quantitative determination in different biological and non-biological matrices. The most important aspects of regulatory policy in the pharmaceutical sector are also provided and explained: GLP, GMP, certification, accreditation, ICH, case studies (http://moodle.toxoer.com/course/index.php?categoryid=6).

For each class of prescription drugs and drugs of abuse, all the main scientific concepts are reported in order to make students able to cite and identify the main compounds included in each class; hypothesize possible analytical strategies for qualitative/ quantitative evaluation of such compounds; perform an effective literature search of relevant papers and guidelines for their sampling, sample pre-treatment and analysis; contribute to decisional processes and practical work related to forensic and highly regulated analytical fields; participate in certification and accreditation procedures. Module contents have been illustrated through practical examples and descriptions of real cases as well as citing the more recent and significant scientific literature relevant to pharmaceutical and forensic analysis.

Gaseous Pollutants as Xenobiotics

Module 4, Environmental Pollutants, describes the impact of selected pollutants (gaseous pollutants, heavy metals, POPs and pesticides) on human health, as well as on the environment. For this study we will focus mainly on the gaseous and the persistent organic pollutants.

Topic 4.1. was developed in order to provide an integrated view on gaseous air pollutants, by presenting the primary and secondary pollutants produced by various pollution sources, and which are recognized to induce severe adverse effects on human health and on natural and/ or built environment.

The content was developed in order to give the learner basic information on the pollution concept: the main categories of air pollution sources for gaseous air pollutants; the transport of pollutants in the atmosphere, which requires knowledge of pollutants' physical and chemical properties; the indoor and outdoor pollutants behavior, by exemplifying their effect on human health, and on the natural and built environment. Based on the information provided, the learner is expected to have an understanding of the gaseous pollutants as causing harm to human health and environmental quality.

The pollutants, both primary and secondary, discussed in this topic are those nominated by European Union documents as key atmospheric pollutants, due to their harmful effect on human health: nitrogen dioxide, tropospheric ozone, particulate matter (https://www.eea.europa.eu/publications/air-quality-in-europe-2017). Sulfur dioxide is also described as being known as a major gaseous pollutant causing acute pollution episodes, in the beginning of the XXth Century, and even much earlier. The source, physical and chemical properties (relevant in the environmental transport of the pollutant) and the effects on human health, natural and built environment are presented for each pollutant.

A significant part of the population lives in urban area and works in office environments, since the postindustrial era brought a shift from the manufacturing sector towards the service and knowledge-based sector. Consequently, modern people spend more than 90% of their time in indoors, and thus the indoor microenvironment quality plays an essential role in ensuring the quality of life. However, there are a myriad of inorganic/ organic or biological indoor pollutants which pose a risk to human health that have indoor concentration higher than the outdoor ones (Bernstein et al., 2008; Boor et al., 2017; Salthammer et al., 2016; Vassura et al., 2015). An overview of the indoor pollutants is therefore provided within the topic, considering indoor pollution sources, the pollutants emitted and their effect on human health. There are also indoor microenvironments which pose potential risk to human health presented as examples: the energy access indoors, the sleep microenvironment, and the school environment

The topic is structured in three learning units (U1 – U3):

- U1 – Sources of gaseous pollutants in urban atmosphere – with 2 video presentations;
- U2 – Transport of gaseous pollutants in urban atmosphere – with 5 video presentations;
- U3 – Indoor pollution – with 1 video presentation.

The eight video presentations cover more than 60 minutes. Additional materials, in the form of text are provided for each of the learning units, to give more insight on the gaseous pollutants. To check their understanding, the learners can complete two intermediary tests and one final test. The certification of course completion brings to the students 1 ECTS.

Persistent Organic Pollutants as Xenobiotics

Persistent Organic Pollutants (POPs) are subject of interest for topic 4.3, where the following units are described: Persistent Organic Pollutants – Introduction, Short-Chain Chlorinated Paraffins (SCCPs), Pentachlorophenol (PCP), Hexachlorocyclohexanes (HCHs), Polycyclic Aromatic Hydrocarbons (PAHs), Polychlorinated Biphenyls (PCBs), Polychlorinated Dibenzo-p-Dioxins (PCDD) and Polychlorinated Dibenzofurans (PCDF).

POPs are both natural and anthropogenic, organic compounds resistant to chemical, photolytic or biological degradation, characteristics that lead to their (bio)accumulation in terrestrial and aquatic ecosystems. Humans can be exposed to POPs through

diet, occupational accidents or in the environment, including indoor air. Exposure to POPs, either acute or chronic, can be associated with a wide range of adverse health effects, including illness and death. Some POPs, such as PCBs, may persist in the environment for long periods of time and bioconcentrate (Betianu and Gavrilescu, 2008; http://www.euro.who.int/__data/assets/pdf_file/0006/298482/Health-risk-assessment-air-pollution-General-principles-en.pdf?ua=1); https://www.wipo.int/edocs/trtdocs/en/unep-pop/trt_unep_pop_2.pdf.

POPs were produced and used in industry and in agriculture since the 1920s-1950s, and they are still present in the environment (Dobrinas et al., 2004; Smaranda and Gavrilescu, 2008) although most of them are now banned. These pollutants are transported across international borders, far from their sources, even to regions where they have never been produced or used (open oceans, glaciers, deserts) affecting wildlife species and humans. The ecosystems and indigenous people of the Arctic are particularly at risk because of the long-range environmental transportation and biomagnification of these substances. The Baltic and the Alpine regions are examples of POPs deposits in Europe.

Because POPs pose a permanent threat to the environment and to human, animals and vegetation health, international actions are needed to reduce and eliminate the production and use of these compounds.

The main learning objectives of this module are: (i) to identify POPs and their sources; (ii) to understand POPs persistence in environment; (iii) to describe the impact of POPs on human health, as well as on the environment; (iv) to analyze a case study.

The POPs topic was developed for 1 ECTS, and from didactic point of view consists of 5 videos of more than 40 minutes, in total: one introductory video, three general videos about POPs and one video of conclusions. After following the video lessons, the students are invited to complete their knowledge with seven text units, of about 90 pages, containing well-structured information about each category of POPs. There are two intermediary tests and one final test available for issuing the certificate for attending the topic.

3.3. Preliminary impact of the OERs

Based on the statement that MOOCs started with the promise to open up quality education for everyone, not just for specific target groups (Jansen and Konings, 2017), TOX-OER foster the free access to educational resources (OERs) that can potentially be used by various trainees, as presented in Table 4.

During the project life time, several multiplier events were organized by CUNI, UniBo and UPorto, where a general presentation of the project outcomes was done, and tested parts of the TOX-OER MOOC, mainly for students from partner institutions, but also for other interested participants, from the large target group (Table 4).

In January 2017 one dissemination event was organized at the University of Bologna, Italy. The purpose of this multiplier event was to present both the development stage of the TOX-OER MOOC and the platform design, to professionals and prospective students from different areas, who might be interested in the study of Chemistry and Toxicology.

Table 4. The opening of the TOX-OER MOOC to target groups from different fields

Initial training (students at 1st, 2nd, 3rd level)	***Vocational training***	***Continuous/ Lifelong Learning (professionals in toxicology/ related fields)***
– pharmacy – medicine, nursing, veterinary medicine – biology, biochemistry, chemistry, agronomy – environmental engineering – forensic sciences	– pharmacy assistants – nursing assistants – veterinary assistants – hygienists – lab technicians	– pharmacists – professionals in occupational medicine – forensics, police forces – supervisory bodies – authorities in energy/ environmental sector – operators at power plants/ industry/ agricultural

On the multiplier event agenda, the following activities were included:

- plenary presentations of the TOX-OER project and MOOC platform;
- parallel computer sessions, for the participants to test the MOOC platform, followed by a satisfaction survey;
- plenary discussions and conclusions.

The event was attended by 113 persons, as follows: 63 participants from the University of Bologna (professors, students, Erasmus+ students, doctoral students and post-doc fellows), providing a good cross-section of the general groups to which the project is addressed; 44 participants representing professionals from Italian institutions, outside the University of Bologna; 6 participants from international institutions, also attended the multiplier event. After the computer sessions, the participants completed some tests, and then they anonymously answered a satisfaction survey, which included questions about the event, the platform and its contents, as well as the contents of the tests.

In most cases, the participants have underlined the innovative didactic potential of this platform. For example, students perceived the gamification integrated in the TOX-OER MOOC as being very effective for the learning process. The attendees also had the invaluable opportunity to discuss in depth the strong points and the weaknesses of the MOOC platform, at that time, as they were perceived by the interested persons, no matter if they were or were not involved in the project. At the end of the impact

evaluation of the multiplier event, we concluded that the participant's satisfaction was very high.

At the end of the TOX-OER project, another type of preliminary impact assessment of the MOOC platform and developed OERs was conducted with students from UTBv, the students being the main target group and beneficiaries of the presented OERs. Two directions were envisaged during this impact evaluation:

- the knowledge acquisition – for learning evaluation, expressed as grades;
- the student's opinion about the OERs – accessibility of the scientific content, topic structure and attractiveness of the learning resources.

Following the steps inserted in Fig. 2, a number of 95 students from UTBv participated in three different workshops (wks 1, wks 2 and wks 3) where the project was presented. All of them were further accepted as users and were enrolled on the TOX-OER MOOC platform (Fig. 2, step 2).

Most of them completed the OERs (videos, texts, additional reading) and tests developed by UTBv group (Fig. 2, step 3), then completed the intermediary and final evaluation tests (Fig. 2, steps 4-6). The results obtained by the students at the evaluation tests were partially recognized in their six-month evaluation.

The total number of registered users and enrolled as students to complete the topics proposed by UTBv group are presented in Fig. 3. From all the registered students (reg) on the TOX-OER MOOC platform, by the end of the project part of them also completed (comp) the topics intermediary and final tests. Their evaluation results, expressed as grades from 5 to 10, are presented in Fig. 4.

A set of questionnaires was developed by the UTBv team in order to evaluate the student's opinion about the OERs, after they completed the topics. Students received the questionnaires, and the evaluation results are qualitatively presented in Table 5 and quantitatively in Fig. 5.

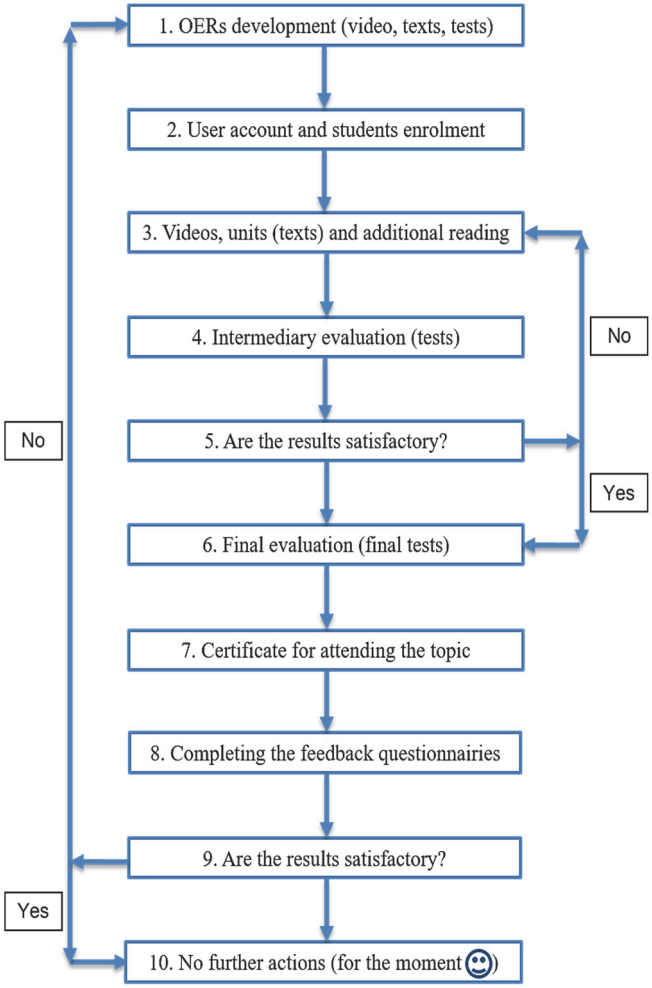


Fig. 2. Actions cycle for the OERs impact evaluation: from the OERs development to the completion of the feedback questionnaires and OERs improvement

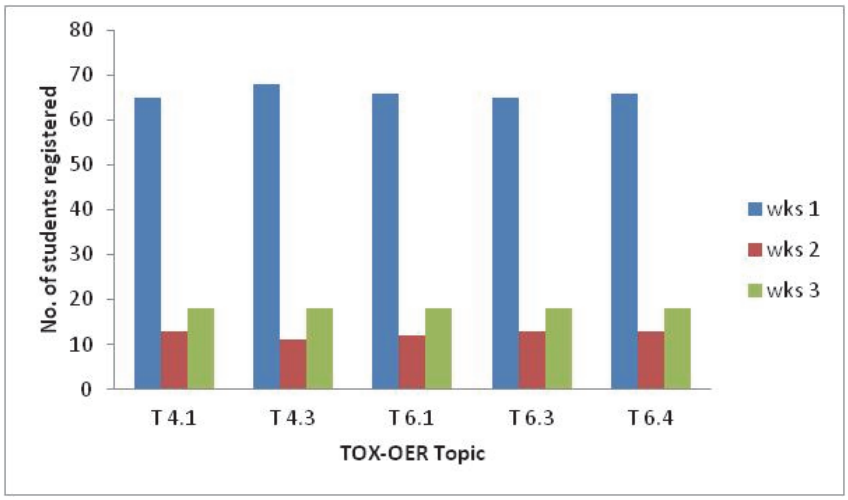
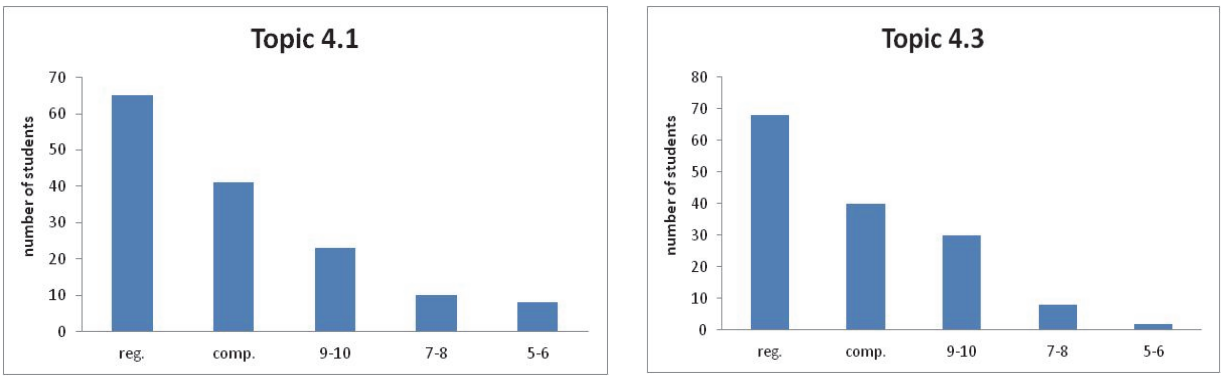
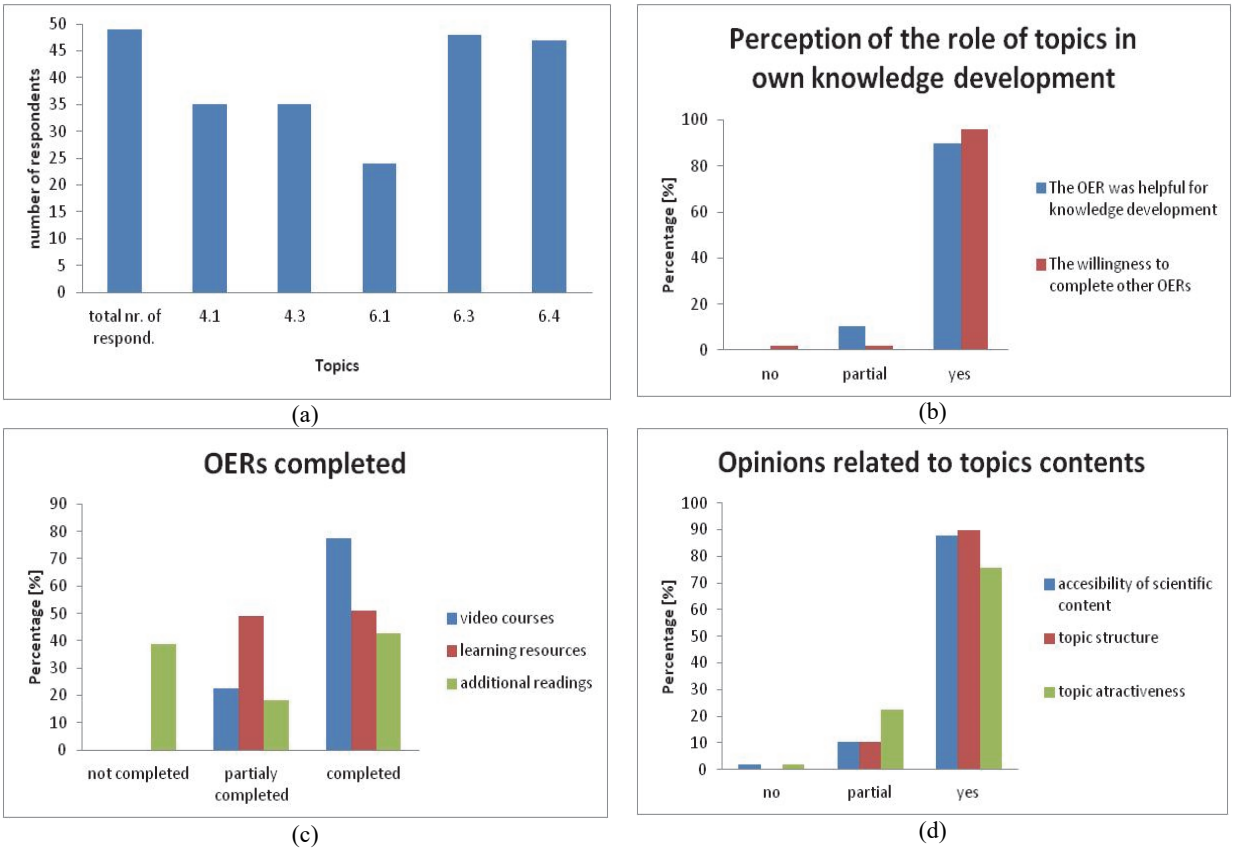


Fig. 3. Students from Transilvania University of Brasov registered on TOX-OER MOOC platform for different topics developed by the university group of authors



(a) (b)

Fig. 4. Students from Transilvania University of Brasov registered on TOX-OER MOOC platform that completed topics 4.1 (a) and 4.3 (b), and their evaluation results



(a) (b)

(c) (d)

Fig. 5. Evaluation results from of the questionnaires completed by students participating in the workshop organized on 9 January 2018

Table 5. Example of questions and comments received from the students

Items	***Comments***
I followed the videos related to the units	Everything is presented clearly and explicitly.
I followed the texts (units)	I found in the texts the required information.
I followed the additional reading materials	No, I did not, it was not necessary.
The OERs helped me acquire knowledge in the environmental protection domain	The OERs presented and explained to me a lot of new and interesting information.
The scientific content was accessible	It was easy to follow.
The materials were well structured	The materials were well structured and the scientific information was interesting.
Presentation of content was attractive	Very attractive, it is useful to learn this way.
I would like to follow such OERs again	From my point of view, it is a pleasure to learn and be evaluated this way.
Additional comments	After following these modules/ topics, I am proud of my studies and my future work.

As presented in Table 5, the students are satisfied with this new approach to learning, using both traditional texts with the newly developed video lessons.

A number of 49 questionnaires were filled in by the students from UTBv, which differently completed to various degree the topics on the TOX-OER MOOC platform (Fig. 5a). 90% of the respondents declared that the OERs were helpful in their process of acquiring knowledge and 96% would like to complete more OERs, which emphasizes their willingness to learn more OERs based (Fig. 5b). Most of the students completed the video courses (78%), only half of them also followed the learning resources (supplementary texts) and only 43% admitted that they also followed the additional readings (Fig. 5c). Related to the topic contents, 88% of the students responded that the scientific content was accessible for them, 90% appreciated the structure of the topic presentation, and 75% evaluated the topic as being also attractive (Fig. 5d).

The feedback obtained from the questionnaires' evaluation gave the authors preliminary information for further developments, as on-going and dynamic process for OERs improvement.

4. Conclusions

The TOX-OER project created the conditions for the recognition and certification (ECTS) of learning achievements, at least between partners. The partners involved in the educational tasks managed a virtual space (server) within which the MOOC platform was installed, and where all the Open Educational Resources are now available. An appropriate Open Source MOOC platform in terms of an open source multi-language platform based on Moodle educational system was implemented. The TOX-OER MOOC platform is under continuous development, being improved based on the feedback provided by groups of students from each partner country that tested the platform's usability.

The data collected from the questionnaires, will allow the OERs authors to better evaluate the level of understanding among their students. The students are the main beneficiaries of the project outcomes, but other target groups are also envisaged. The impact that the OERs have on the learning, will constitute the basis for continuous improvements of the topics, both in terms of content and presentation.

Acknowledgements

Project "Learning Toxicology through Open Educational Resources" (TOX-OER), with financial support from the European Erasmus+ Programme, key action KA2, Strategic Partnership, project code 2015-1-ES01-KA203-015957.

References

Anderson A., Huttenlocher D., Kleinberg J., Leskovec J., (2014), *Engaging with Massive Online Courses*, Proc. 23rd Int. Conf. on World wide web, Seoul, Korea, 687-698.

Bernstein J., Alexis N., Bacchus H., Bernstein I.L., Friz P., Horner E., Li N., Mason S., Nel A., Oullette J., Reijula K., Reponen T., Selzer J., Smith A., Tarlo S., (2008), The health effects on nonindustrial indoor air pollution, *The Journal of Allergy and Clinical Immunology*, **121**, 585-591.

Betianu C., Gavrilescu M., (2006), Persistent organic pollutants in environment: inventory procedures and management in the context of the Stockholm Convention, *Environmental Engineering and Management Journal*, **5**, 1011-1028.

Boor B.E., Spilak M.P., Laverge J., Novoselak A., Xu Y., (2017), Human exposure to indoor air pollutants in sleep microenvironments: a literature review, *Building and Environment*, **125**, 528-555.

Burge J., (2015), *Insights into Teaching and Learning: Reflections on MOOC Experiences*, Proc. 46th ACM Technical Symposium on Computer Science Education (SIGCSE '15), New York, 600-603.

Camilleri A.F., (2012), *Portability and Transparency: The OER test Guidelines*, In: *Open Learning Recognition: Taking Open Educational Resources a Step Further,* Camilleri, A.F., Tannhäuser A.-C., (Eds), European Foundation for Quality in e-Learning (EFQUEL), Brussels, 38-55.

Chiappe-Laverde A., Hine N., Martínez-Silva J.A., (2015), Literature and Practice: A Critical Review of MOOCs, *Comunicare, Media Education Research Journal*, **44**, 9-17.

Dobrinas S., Soceanu A., Birghila S., Popescu V., Matei M., Coatu V., (2004), Content of organic pollutants (PAHs and POPs) in surface waters from Danube Delta and Plitvice Lakes**,** *Environmental Engineering and Management Journal*, **3**, 355-362.

Guerra L., Ferrari L., (2018), *MOOC Pedagogy*, In: *Challenges in Open Education Resources. The Case of TOX-OER MOOC*, Morales Martin A.I., (Ed), Amarante, Salamanca, Spain, 33-45.

Jansen D., Konings L., (2017), MOOC Strategies of European Institutions. Status Report Based on a Mapping Survey Conducted in November 2016 – February 2017, European Association of Distance Teaching Universities (EADTU), On line at: http://eadtu.eu/documents/Publications/OEenM/MOOC_Strategies_of_European_Institutions.pdf

Remiao F, Makela M., (2018), *Learning Recognition*, In: *Challenges in Open Education Resources. The Case of TOX-OER MOOC*, Morales Martin A.I., (Ed), Amarante, Salamanca, Spain, 123-134.

Salthammer T., Udhe E., Schripp T., Schieweck A., Morawska L., Mazaheri M., Clifford S., He C., Buonanno G., Querol X., Viana M., Kumar P., (2016), Children's well-being at schools: Impact of climatic conditions and air pollution, *Environmental International*, **94**, 196-210.

Smaranda C., Gavrilescu M., (2008), Migration and fate of persistent organic pollutants in the atmosphere - a modelling approach, *Environmental Engineering and Management Journal*, **7**, 743-761.

Uchidiuno J., Ogan A., Yarzebinski E., Hammer J., (2016), *Understanding ESL Students' Motivations to Increase MOOC Accessibility*, Proc. 3rd ACM Conference on Learning @ Scale, Edinburgh, 169-172.

Vassura I., Ventruini E., Bernardi E., Passarini F., Settimo G., (2015), Assessment of indoor pollution in a school environment through both passive and continuous sampling, *Environmental Engineering and Management Journal*, **14**, 1761-1770.

Web sites:

https://clintox.cop.ufl.edu/programs/courses

https://www.toxicology.org/education/ce/onlineCourses.asp

(https://phmtox.msu.edu/education/online-ms-programs/ms-pharmacology-toxicology/

https://www.hotcoursesabroad.com/study/training-degrees/uk/distance-online/toxicology-courses/loc/210/smode/3/cgory/rh.465-4/sin/ct/programs.html

www.mooc-maker.org/?dl_id=30countries in Europe in 2015 https://elearninginfographics.com/european-moocs-scoreboard-infographic/

https://toxoer.com/

http://moodle.toxoer.com/course/index.php?categoryid=6

https://www.eea.europa.eu/publications/air-quality-in-europe-2017

http://www.euro.who.int/__data/assets/pdf_file/0006/298482/Health-risk-assessment-air-pollution-General-principles-en.pdf?ua=1)

https://www.wipo.int/edocs/trtdocs/en/unep-pop/trt_unep_pop_2.pdf.