

Massive Open Online Courses (MOOCs) on Climate Change and Health: Teaching a Global Audience

Sandra Barteit, Anneliese Depoux, Ali Sié, Maurice Yé
and Rainer Sauerborn

Abstract Massive open online courses (MOOCs) give the opportunity to engage and teach a global audience into the rationale and arguments of climate change and its impact on health. We want to describe the possibilities of MOOCs for climate change education on the example of three MOOCs on climate change and health that were offered on the online learning platform iversity and FUN-MOOC: one MOOC was designed for a broader audience without prior requirements in the area of climate system and climate change. The learning target was health impacts worldwide, best practices in adaptation and mitigation strategies, as well as the promotion of health co-benefits. This MOOC was subtitled in ten different languages. An executive MOOC was targeted at policy makers as part of their conference briefing for the climate conference COP21 in Paris in 2015. The key arguments of the MOOC included the development of climate policies and their fair share of the burden and benefits, as well as scientific evidence behind the four key arguments based on human health for climate policy (Sauerborn 2016a, b). The third MOOC focused again on a broader audience on climate change and health within an African context for a francophone audience. In the following, we introduce MOOCs for teaching climate change education to a global audience, also with a focus on developing countries, followed by a description of the three MOOCs on the topic of climate change and health in more detail with regards to their contents,

S. Barteit (✉) · R. Sauerborn
Institute of Public Health, Heidelberg University, Heidelberg, Germany
e-mail: barteit@uni-heidelberg.de

R. Sauerborn
e-mail: rainer.sauerborn@uni-heidelberg.de

A. Depoux
Centre Virchow-Villermé, University of Sorbonne Paris Cité, Paris, France
e-mail: anneliese.depoux@uspc.fr

A. Sié · M. Yé
Centre de Recherche en Santé de Nouna, Nouna, Burkina Faso
e-mail: sieali@crsn-nouna.bf

M. Yé
e-mail: yemaure@yahoo.fr

participant demographics, retention rate and encountered challenges. We discuss our findings with regards to all three MOOCs and will give insights into practices for employing MOOCs in climate change education, for developed and developing countries.

Keywords Climate change · Health · Climate change education
Massive open online courses · MOOC

Introduction

Climate change is in the news worldwide and captures global alertness: for the COP21, delegations from over 190 different countries met to consult on how to decrease greenhouse gas emissions to sustain global warming under 2 °C (Centre Virchow-Villermé 2016). The urgent call for climate change mitigation and the pursuit of a vision of low-carbon and climate-resilient economies and countries lead an increasing number of universities and institutions to develop courses to prepare students. Several studies identified the need for more training among health professionals, also with regards to communication and engagement towards health effects of climate change (Sayre et al. 2010; Barna et al. 2012; Nigatu et al. 2014; Wei et al. 2014; Adlong and Dietsch 2015a, b, Rudolph and Gould 2015). Especially in low- and middle-income countries (LMIC), there is an urgent need for trained healthcare workers as reported by the world health report 2013 (World Health Organization 2013) and a lack of education in the curriculum of health professionals regarding climate change (Majra and Acharya 2009; Nigatu et al. 2014). The recently growing numbers of massive open online courses (MOOCs) and their equivalent growing numbers of participants, offer possibilities to embrace climate change education (Escher et al. 2014; Chuang and Ho 2016). Already in the world health report of 2006, the WHO recommends employing regional resources and IT to moderate costs (World Health Organization 2006) of education and appeal to contribute to global health educational opportunities (Withers et al. 2016).

Health is a top priority worldwide and according to the Intergovernmental Panel on Climate change (IPCC; very high confidence), “health of human populations is sensitive to shifts in weather patterns and other aspects of climate change” (Woodward et al. 2014). Health is found to be a motivator of behavioural change of populations (Sauerborn 2016a, b) and can be the base to help raise awareness and stimulate action with regards to climate change, increasing the reach to a global level with support of technological developments in online education, such as MOOCs (Levy and Patz 2015). Thus MOOCs are possibly an enabling factor also to fulfil the Sustainable Development Goals (SDG), as outlined by the background report for the UNESCO (International Council of Open and Distance Education (ICDE) 2015).

What Are MOOCs?

MOOCs are targeted at masses (**massive**), are open to anyone anywhere given an Internet connection (**open**), its coursework is delivered entirely over the Internet (**online**) and contents are offered in a course-like-style (**courses**) (Hoy 2014). The majority of MOOCs on the most prevalent learning platforms offer xMOOCs (Adams et al. 2014) that are mainly based on the principle of knowledge replication that is transferred with video lectures, literature resources and quizzes. The open access policy of MOOCs allows students worldwide to access educational resources that otherwise may not be available to them financially and geographically (Withers et al. 2016). As an example, a MOOC that was offered on the subject of Artificial Intelligence by Stanford University in the US attracted over 160,000 students and in the end the top Stanford student was outperformed by 411 online students (Brynjolfsson and McAfee 2014). MOOCs are free of charge, learning is possible at an individual pace, everyone can sign up without restrictions, learners can support each other and build an online community, and in our case subtitles in up to ten languages are offered to lower the language barrier. Also for climate change education, MOOCs offer possibilities to engage a broad audience in climate change policies and practices, as well as they encourage the advancement towards sustainable development and climate literacy linking the debate of climate change to health. Researchers, health practitioners and institutions need to support the process of developing policies and interventions to adapt to outcome related to climate change. MOOCs could be an instrument to open access on a global level to quality education on climate change and health (Levy and Patz 2015), providing another mean to spread knowledge about a more climate friendly and healthier planet (Sauerborn 2016a, b)—especially as the technology needed to access MOOCs becomes increasingly cheaper and widespread, also in resource-low countries (Alliance for Affordable Internet 2017).

The three MOOCs on climate change and health allow participants to connect climate change and health outcomes and to give insights into adverse health effects of climate change and health co-benefits resulting from climate policies (Levy and Patz 2015; Sauerborn 2016a, b). Furthermore, the MOOCs encourage people to engage with their local political representative and actively initiate change on a local, municipal level.

However, a necessity of MOOCs is online access. Internet access has increased and is increasing globally, especially with the growth of the mobile broadband market (Alliance for Affordable Internet 2017). In 2017, more than 50% of the world will be online. Yet, the costs to access the Internet still keep low-resource countries left behind, the so-called digital divide (Alliance for Affordable Internet 2017). According to the Affordability Report 2017, Zimbabwe as an African country currently has the cheapest cost of 1 GB mobile data with 6% of average monthly income, followed by Tanzania with 8.74% (Alliance for Affordable Internet 2017). Evaluations of MOOCs show that in general they attract educated, middle-aged participants from developed countries (Escher et al. 2014; Hansen and

Reich 2015). Climate change affects populations worldwide, and the health of the poorest is often the most vulnerable. Therefore, it is important to keep the discussion and effort ongoing to close the gap of the digital divide and make climate change education as accessible as possible for everyone worldwide, targeting two Sustainable Development Goals (SDGs)¹: *goal 9*—Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation,² and *goal 13*—Take urgent action to combat climate change and its impacts.³ Overall, the demand for higher education in Africa is growing and current numbers indicate that Africa may not be able to provide the necessary infrastructure for higher education (Escher et al. 2014). MOOCs can be envisioned to act as an enabling factor (Escher et al. 2014) and an opportunity for higher education (Warusavitarana et al. 2014), also in the area of climate change and health. Current approaches to make MOOCs accessible within resource-low environments are only minor—such as decreasing the data volume of the MOOC by making lectures accessible as text downloadable files, providing audio files separately to the MOOC videos, offer low resolution videos—as they decrease the overall learning experience and deprive participants of the multimedia element of the MOOC. In order to enable people, especially in low income countries, to access the Internet and access qualitative higher learning resources, Internet access needs to be affordable. The importance of Internet access is now reflected in goal 9 of the SDG: “Significantly increase access to information and communications technology and strive to provide universal and affordable access to the Internet in least developed countries by 2020”. The 2017 Affordability Report suggests that 1 GB of data should not cost more than 2% of the average income (Alliance for Affordable Internet 2017). To bridge low-bandwidth and high mobile data prices in low-resource countries, on campuses within certain areas MOOCs could be provided centrally on a local server within a local Wi-Fi network.

MOOCs on Climate Change and Health—Educating the World

The Heidelberg Institute of Public Health (HIPH) has developed and designed three MOOCs on the topic of climate change and health together with partners from the Centre Virchow-Villermé⁴ (CVV) and Université Sorbonne Paris Cité (USPC) in Paris, France, and the Centre de Recherche en Santé de Nouna⁵ (CRSN) in Nouna, Burkina Faso. These MOOCs are offered on two different learning platforms: one

¹<https://sustainabledevelopment.un.org/sdgs>.

²<https://sustainabledevelopment.un.org/sdg9>.

³<https://sustainabledevelopment.un.org/sdg13>.

⁴<http://virchowvillerme.eu>.

⁵<http://www.crsn-nouna.bf>.

platform is the Germany-based, commercial learning platform iversity⁶—MOOCs are mainly in German and English—and on the francophone, non-commercial learning platform FUN-MOOC,⁷ supported by the French government. The main objective of the MOOC is to familiarize a broad audience as well as the specific audience of policy-makers to the rationale of climate change and health of populations. Currently, health is not prominent in the debate on climate change. To increase the accessibility and the reach of the arguments on climate change and health, the medium of MOOC was chosen as it has shown to be promising, especially in reaching a broader audience and people burdened by financial, geographical or language restrictions (Brynjolfsson and McAfee 2014; Chuang and Ho 2016).

Development and Design of the MOOCs

All three MOOCs have been designed and produced with scientific experts of the field and the MOOC factory⁸ of the CVV, who provided the technical team for the video production process.

The contents of the MOOC *Climate Change and Health (CC&H)* are based on a yearly, two-week presence short course at the HIPH that averagely had around 25 participants. The course materials were adapted and condensed to fit in video segments of 7 to a maximum of 14 min each (see Tables 2, 3 and 4). Four scientists, all authors of the health chapter in the IPCC fifth assessment report, designed and developed the MOOC *Climate Change and Health for Policy-Makers (CC&H PM)* focusing on policy-makers attending the COP21. The francophone MOOC *Changement climatique et santé dans le context Africain (CC&S)* has been collaboratively designed by experts from the HIPH and CRSN from the field of public health, climatology and meteorology who have taught the topics in presence courses, which served as a basis for the design and development of this MOOC. Multimedia such as graphs, video sequences and pictures were used to support the learning process within the MOOC segments. The English MOOCs were shot in a small video room of the CVV in Paris and on location in Burkina Faso. The video editing and course creation on the respective MOOC platforms was done by CVV. The promotion of the MOOC was through mailing lists, social media channels, word-of-mouth, conferences and through the online learning platforms.

⁶<https://iversity.org>.

⁷<https://www.fun-mooc.fr>.

⁸MOOC factory: <http://virchowvillerme.eu/the-mooc-factory/>.

MOOC Climate Change and Health (CC&H)

The MOOC *Climate Change and Health (CC&H)* offered on the learning platform iversity is targeted at a global audience and focuses on the latest evidence of the relation between climate change and health. The MOOC CC&H addresses a broad public audience, for example, health professionals, teachers, journalists, meteorologists, climate scientists and every global interested citizen without prior knowledge of climate system and climate change. In order to increase the global reach and to make the MOOC accessible to people whose first language is not English, the MOOC was subtitled in nine different languages: Arabic, Chinese (Mandarin), English, Hindi, Indonesian, French, Portuguese, Russian and Spanish. The objective of the MOOC CC&H is to familiarize students with the global effects and impacts on health, in particular for their respective home country. Throughout the course, students analysed their country as a case study, which then was published and discussed in an online forum with MOOC course participants from the same country to understand the limits and strengths of their respective home country's climate adaptation plan. Furthermore, the MOOC covers the topic of best practices for adaptation and mitigation strategies, as well as for health co-benefits. Discussion forums were setup with a focus on diseases and other target-group specific interest groups, such as climate change-related child malnutrition or health effects on the elderly. The objective was to engage students with their national and local policy makers to initiate a process to focus on health-related impacts of climate change in their respective home countries.

Overall, the MOOC CC&H contains 25 video lectures with an average length of 9.8 min per video lecture, arranged in the following six chapters: (1) What is climate change and how can it affect health? (2) What health effects do we expect? (3) Reducing emission—in health terms: Prevention, (4) The good news: doing something to reduce emissions is good for your health, (5) Adapting to the effects of already occurring climate change: “Therapy”, (6) Outlook: A climate friendly world is healthier, more equitable, sustainable and fun.

Furthermore, the MOOC offered a journal to students for their exercises, which covered: (1) What is climate change to you? (2) In your opinion?—Climate change policy and (3) Health as a positive leverage for climate policy—Interview someone. All students are able to access each other's journals to foster discussions.

MOOC Climate Change and Health for Policy-Makers

The MOOC *Climate Change and Health for Policy-Makers (CC&H PM)* followed the format of policy briefs as it was designed for policy-makers and negotiators, involved in climate agreements, particularly as an input for the United Nations Framework Convention on climate change—the 21st Conference COP21 in Paris, in 2016. The objective of the MOOC CC&H PM was to teach the effect of health in

climate policy as a central theme and motivator (Sauerborn 2016a, b). Four renowned scientists authored this MOOC and also the health chapter in the recent fifth assessment report of the IPCC. This MOOC has a total runtime of 3 h stretched over one week, providing evidence of health as central for climate policy: Four key climate policy arguments based on human health are presented that are integral in all climate policy negotiations (Sauerborn 2016a, b):

1. Health is a positive motivator, a driving force for citizens.
2. The huge health co-benefits must enter the risk-benefit calculations.
3. There are health limits to adaptation.
4. Decreased work productivity in hot countries.

One key argument of the course is to reflect on health as a key indicator for sustainable development and for climate policy. The course is organized in four lectures each eight minutes long and each developing the four key health arguments, that are complementary following a common storyline. Seven optional quiz questions are available, as well as a discussion forum which was central to engage participants in exchanging views and initiating discussion on course topics. Course assistants and the course lecturer participated in the forums and provided weekly feedback with videos to individual questions and email comments, on top to personal email feedback during the course.

MOOC Changement Climatique et Santé En Contexte Africain

The francophone MOOC *Changement Climatique et Santé en Contexte Africain (CC&S)* was targeted at a francophone audience, in particular focusing on West Africa, including students and professionals in the field of public health and environmental sciences interested in the interdisciplinary issue of the health impacts of climate change. The MOOC CC&S defines climate change and its health impacts in Africa and provides an environment for reflection on how to best adapt and prevent risks for health and to work collaboratively on climate change and its health impacts. Experts in public health, climatology and meteorology from CRSN and HIPH were involved in the design and production of this MOOC to describe, explain and analyse climate change and introduce course participants to the concepts of prevention, mitigation and adaptation. The course was spanned over five weeks covering the topics of: (1) Basic physics of climate change, (2) links between climate change and human health, (3) responses to mitigation, surveillance and prevention, (4) responses to adaptation, (5) policy responses.

Looking Behind the Curtain

We have analysed all three MOOCs. Overall, the three MOOCs on Climate Change and Health (Climate Change and Health, Climate change and Health for Policy-Makers, Changement Climatique et Santé en Contexte Africain) attracted almost 7,000 participants globally. The retention rate—how many participants have earned certificates—varies for the three MOOCs between 1% for CC&H, 20% CC&H PM and 9% for CC&S. For the MOOCs on CC&H and CC&H PM most participants progressed less than 5% of the total course contents. The retention decreases for the course progress span of 5–20% (CC&H: 12%, CC&H PM: 15%) and 20–80% (CC&H: 5%, CC&H PM: 7%). However, for having progressed more than 80% of course contents, there is a slight increase in participant retention of the CC&H (6%) and a steeper increase of participant retention of the CC&H PM (19%) (see also Table 1).

People participated from all over the world in all three courses, most participants were from high income countries, especially from Germany (iversity) and France (FUN-MOOC). However, half of the participants are from lower middle-income countries, and for the MOOC CC&H PM there were even more people participating from lower middle-income countries than from high income countries (see Figs. 1 and 2).

The strongest represented age group in all three MOOCs is from 31 to 40 years, followed by the age group 26–30 years, and then 41 years of age and older.

The MOOCs CC&H and CC&H PM were translated into 9 (Arabic, Chinese—Mandarin, English, Hindi, Indonesian, French, Portuguese, Russian, Spanish) and 7 languages (Arabic, Chinese—Mandarin, Hindi, Indonesian, Portuguese, Russian, Spanish) via the open-source translation website Amara.⁹ Native speakers of the HIPH—doctoral and Master course students—translated subtitles for the MOOC, who previously have attended the presence course in Climate Change and Health in Heidelberg and were familiar with the domain language of climate change and health (Fig. 3).

Discussion

The analysis of the demographic data of the three MOOCs confirmed the findings of other MOOCs: mostly students from high income countries between 25 and 40 years of age are making use of this educational resource. Depending on the origin of the learning platform, the nationality of the participants is reflected: On the German iversity platform predominantly participants from Germany registered, on the French FUN-MOOC platform mostly French participants registered. Both platforms are available in English and offer MOOCs in English, but also MOOCs in German (iversity) or French (FUN-MOOC). The French MOOC CC&S has

⁹<http://amara.org/en/>.

Table 1 MOOC participants and overview

	Climate change and health	Climate change and health for policy-makers	Changement climatique et santé en contexte Africain
Number of participants	2735	1782	2451
Total number of participants certified	24	349	213
% Participants certified	1%	20%	9%
<i>Course progress</i>			
<5% (total/%)	2111/77%	1167/65%	
5–20% (total/%)	335/12%	174/15%	
20–80% (total/%)	143/5%	126/7%	
>80% (total/%)	167/6%	342/19%	
Total min. runtime videos	244	41	198
Number of videos	25	4	23
Avg. min per video	9.8	10.25	8.6
MOOC runtime (weeks)	6	1	5
Subtitles	9 (Arabic, Chinese—Mandarin, English, Hindi, Indonesian, French, Portuguese, Russian and Spanish)	7 (Arabic, Chinese—Mandarin, Hindi, Indonesian, Portuguese, Russian and Spanish)	

attracted quite high numbers of participants from francophone, low income countries, which can be attributed to the MOOC being offered in French also attracting a francophone West-African audience. The MOOC CC&S focuses on climate change within an African context and was co-developed by experts from Burkina Faso. For the targeted audience of a MOOC, the respective learning platform has to be taken into account. As our analysis showed, the francophone MOOC had high participation from French-speaking countries, such as France and West-African countries. The reach of the francophone MOOC CC&S to a West-African audience on the French learning platform FUN-MOOC was much higher than that of the CC&H and CC&H PM MOOC on the German iversity learning platform. Figure 2 shows the country of origin per learning platform: German participants make up the majority on the MOOCs on the German-based iversity platform (15% CC&H and 12.3% CC&H PM) and on the FUN-MOOC platform French participants make up the majority with 33.2% of all participants of CC&S. Also, the country of origin differs vastly between the iversity MOOCs and the MOOC on FUN-MOOC: iversity attracts participants from countries with dominantly English-speaking communities (India, Pakistan, Philippines, Italy, UK, Nigeria, Canada, Bangladesh,

Fig. 1 Economic status of home country of MOOC participants (*LIC* low income country, *LMIC* lower middle income country, *UMIC* upper middle income country, *HIC* high income country as defined by Worldbank)

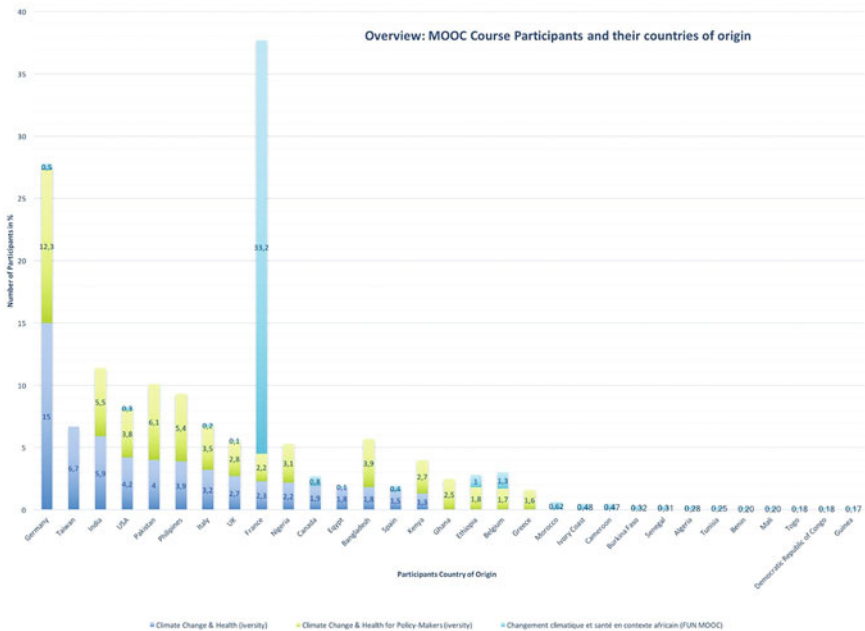
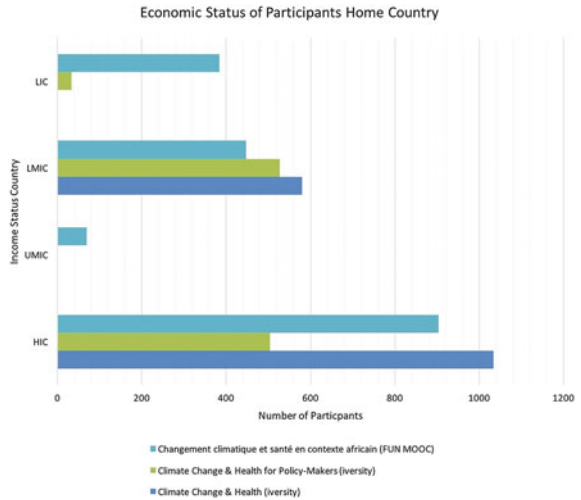


Fig. 2 Overview of the MOOC course participants’ country of origin

Kenya, Ghana, Greece), whereas the MOOC on FUN-MOOC has course participants from countries with dominantly French-speaking communities (Canada, Morocco, Belgium, Burkina Faso, Senegal, Algeria, Tunisia, Mali, Togo, Democratic Republic of Congo, Guinea) (see Fig. 2). Resultantly to these

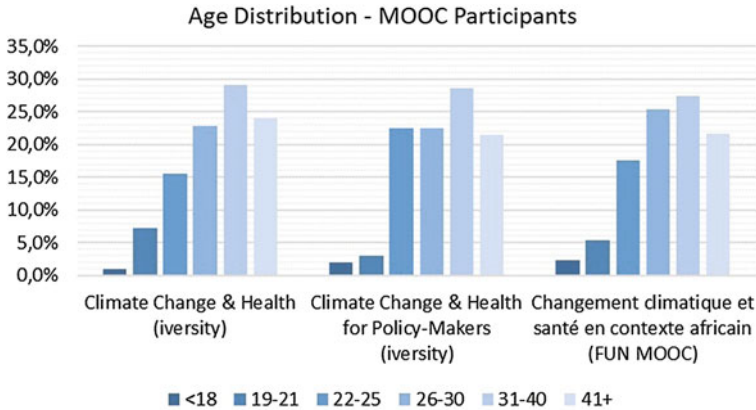


Fig. 3 Age distribution of participants of all three MOOCs on climate change and health

observations, dominant language communities of the targeted countries, cultural barriers and current extent of reach of the learning platform employed should be kept in mind when designing and producing a MOOC.

A major challenge for low and lower-middle income countries is the high cost for Internet access. In general, broadband networks are not expanding as fast as mobile data networks do and are less affordable in low and lower-middle income countries (Alliance for Affordable Internet 2017). The gap of affordable Internet access is decreasing, if at an uneven pace for certain groups such as low-income countries and the group of women. Still, a growing number of people worldwide are able to access MOOCs which makes it a valuable medium for increasing access to climate change education, especially to people that previously have been out of reach of other educational endeavours.

The total participant numbers of the MOOCs are also resultant of the overall registered users on the particular learning platforms. The German MOOC platform iversity has over 600,000 registered users, the French FUN-MOOC platform has over 900,000 registered users—in comparison to the currently largest MOOC platform Coursera¹⁰ which has over 24 million (Coursera) and the second largest platform edX¹¹ which has over 11 million registered users (edX). MOOCs clearly outperform presence courses in their reach of students, yet, MOOCs have to be thoroughly evaluated in terms of system quality, perceived usefulness, net benefits, development costs, participant’s attitude, intention of usage and ease of use. The development of a MOOC requires investments as experts in the field are needed, as well as technical support in the production of the video materials and setting up of

¹⁰<https://www.coursera.org>.

¹¹<https://www.edx.org>.

the MOOC. The time to develop a MOOC from concept to a fully-fledged course takes at least 12 months.

The low completion rate (acquired certificates) of the three MOOCs (1% for CC&H, 20% CC&H PM, 9% CC&S) is in line with other MOOCs, as not all participants aspire for certificates and may benefit from the MOOC despite not finishing the full course. The median certification rate of 236 courses of MIT and Harvard was 7.7% for 4.05 million participants, with certification rates as low as 0.2% and as high as 34% (Chuang and Ho 2016). Observing the participation in the MOOC forum, it is clear that there is a small fraction of participants who actively participated in the activities and participant exchanges, pursuant to completion rates. Reasons for not completing a MOOC may be no official accreditation which may decrease motivation. Other reasons may be the employed course pedagogy or assessment types (Jordan 2014).

In order to make the MOOCs as inclusive as possible for non-native English speakers, we translated two of the MOOCs with the support of native speakers from the HIPH into 9 different languages. The open-source online platform Amara was providing the base for the subtitle translations and was found by the translators to be quite fit for the purpose—most of the translators needed only very little guidance in working with the open-source translation platform. Prior we tried to engage MOOC participants to translate the MOOC segments, however, only minor translations were accomplished. Averagely, one minute of a video lecture takes about 12 min to translate, so a ten-minute MOOC lecture is around 2 h' translation work. This kind of time commitment can be not expected of course participants and another downside of crowd-translation efforts is the level of quality, as the level of language proficiency is unknown and the level of familiarity with the domain language (Beaven et al. 2013). The subtitles were added to the MOOCs in 2016, after the start of the course.

After this first analysis of the MOOCs, further questions remain to be answered. To better understand the motivation and expectations of participants, an online survey is conducted retrospectively which covers further demographics, motivation, course expectations, user satisfaction, information quality, service quality, course use, cultural barriers and perceived benefits. It is advisable for future MOOC courses to employ an evaluation before the start of the MOOC covering mainly motivation and course expectations. Also, it would be advisable to employ a pre- and post-test to evaluate knowledge gain of the MOOC. Furthermore, for the next MOOC we want to keep track of invested efforts into the MOOC production to provide insights into cost and effect of a MOOC.

Conclusion

Effects of climate change are already taking their toll globally: a rise in sea levels and global temperatures, warming and acidification of oceans, shrinking ice sheets, declining Arctic sea ice and glaciers, as well as an overall increase in extreme

weather events (Louis and Phalkey 2016). “Climate-sensitive diseases are among the largest global killers. Diarrhoea, malaria and protein-energy malnutrition alone caused more than 3 million deaths globally in 2004, with over one third of these deaths occurring in Africa.” (World Health Organization 2017). There is a dire need to include health impacts in the debate of climate change on a global level. MOOCs offer a great potential as they are getting more and more popular (Chuang and Ho 2016) and could therefore be an enabler for teaching and engaging a bigger global population within the topic of climate change and health. Alongside those lines, three MOOCs have been published that focus on climate change and health for different audiences: at Anglo- and francophone general audiences and at policy-makers. The country of origin of the learning platform has shown to define the range of MOOC participants: although the MOOCs attracted an international crowd in general, for the German iversity platform, there were predominantly German and English-speaking participants, and for the French FUN-MOOC platform there were predominantly participants from French-speaking communities, including West-African countries. The MOOCs have been translated into 9 different languages to increase the reach to people not sufficiently familiar with English. It still has to be evaluated if subtitle efforts positively influence participants’ retention and motivation and how MOOCs transfer knowledge and foster learning, especially for a global audience. There is a global demand for MOOCs, and as a recent survey from Coursera shows that learners from developing countries were even more likely to report benefits (Levin 2017).

Although there is a need to fully understand the impact of MOOCs, it is obvious that the reach of participants of the three MOOCs out passes the reach of presence courses. For the three MOOCs in total almost 7,000 students as compared to a two-week presence-course with a potential reach of 25 students per course. The design and production of the MOOC involves a commitment in terms of time, finances and professional expertise.

The advantages are at hand: MOOCs offer an extensive participant reach on a global level which can be a driver for climate change education, enabling a greater accessibility into the rationale between climate change and health available to people that have been outside the reach of other teaching endeavours, such as presence courses. With the expansion of mobile data networks and decrease in prices for these mobile services, also low and lower-middle income countries are able to access quality resources such as MOOCs. The francophone MOOC designed for an African context had a greater participation of participants from low-resource countries as compared to the other two MOOCs on the German learning platform iversity. Although MOOCs are made for a global audience, our results show that there is need to define target audiences and adapt the MOOC according to participants and their cultural context. Further evaluations into MOOCs are necessary to tailor future MOOCs better to the targeted participant needs, which may be challenging keeping in mind the diversity of a global audience. Research underlines the popularity of MOOCs (Chuang and Ho 2016), which

as we have found with the three MOOCS on climate change and health is a chance for opening climate change education and making arguments and state-of-the-art knowledge available to a diverse global audience, fostering discussions and change in terms of adaptation and mitigation of climate change especially with a focus on health.

Addendum

See Figs. 4, 5, 6 and Tables 2, 3, 4.

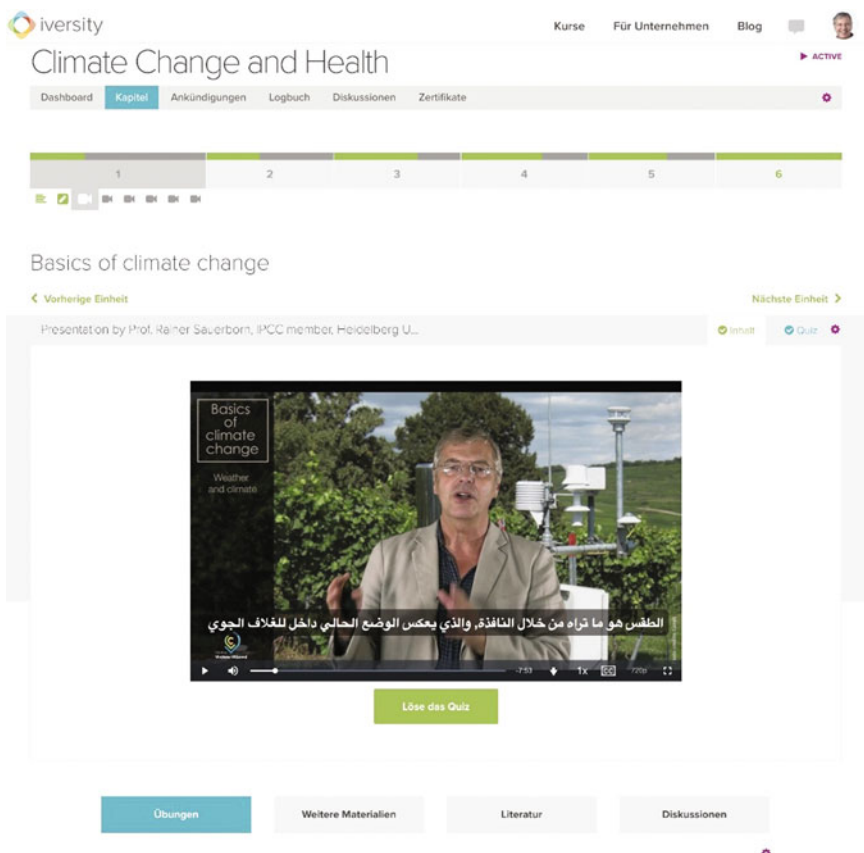


Fig. 4 iversity learning platform with MOOC climate change and health, showing subtitle in Arabic

The screenshot displays the iversity learning platform interface. At the top, the iversity logo is on the left, and navigation links for 'Kurse', 'Für Unternehmen', and 'Blog' are on the right. The course title 'Climate Change & Health for Policy-Makers' is prominently displayed. Below the title, a navigation bar includes 'Dashboard', 'Kapitel', 'Ankündigungen', 'Diskussionen', and 'Zertifikate'. A progress bar shows six chapters, with the first chapter selected. The main content area features a video player titled 'Argument 1. Health as a motivator'. The video shows Prof. Rainer Sauerborn, an IPCC expert from Heidelberg University, speaking. Chinese subtitles at the bottom of the video read: '欢迎大家聆听MOOC“卫生政策制定者”的第一讲。'. Below the video player, there are four tabs: 'Übungen', 'Weitere Materialien', 'Literatur', and 'Diskussionen'. A citation for Sauerborn et al. (2009) is visible at the bottom of the page.

Fig. 5 iversity learning platform with MOOC climate change and health for policy-makers, showing subtitles in Chinese (Mandarin)

The screenshot displays the Fun-Mooc interface for the course 'MOOC USPC Changement climatique et santé en contexte africain'. The top navigation bar includes the course title and a search function. Below this, a secondary bar shows 'View this course as: Staff'. The main content area is divided into a left sidebar and a right main panel. The sidebar contains a 'Courseware' menu with options like 'Course Info', 'Discussion', 'Wiki', 'Progress', and 'Instructor'. It lists course units: 'Semaine 1 : Bases physiques du changement climatique - Comprendre le changement climatique', 'Présentation de la semaine', 'Unité 1 : L'effet de serre', 'Unité 2 : Climat et météorologie en Afrique', 'Unité 3 : Phénomènes climatiques/géographiques (ENSO)', and 'Unité 4 : Événements climatiques extrêmes'. The main panel features a video player titled 'L'EFFET DE SERRE' showing a woman at a desk with a globe in the background. Below the video are download options and a 'QUIZZ (1 point possible)' section with the question 'L'effet de serre est ... (plusieurs réponses possibles)'. Five multiple-choice options are provided, each with a radio button.

Fig. 6 Fun-Mooc learning platform with MOOC Changement climatique et santé en context Africain

Table 2 Course structure MOOC: climate change and health

Chapter name	Total runtime (in min)	Contents
What is climate change and how can it affect health?	72	<ol style="list-style-type: none"> 1. <i>Interaction forum</i>: present yourself and your motivations to follow this course 2. <i>Interaction journal assignment</i>: climate change to you 3. Basics of climate change 4. Historical trends and future projections 5. Climate change is long-term and irreversible 6. Pathways from climate change to disease and health 7. Ethics, justice, equity, development: policy implications 8. How to find out about the impact of climate change on health?
What health effects do we cover?	70	<ol style="list-style-type: none"> 1. Childhood malnutrition is the largest negative effect 2. Non-communicable diseases 3. Climate change and infectious diseases: the example of dengue 4. Climate change and Malaria 5. Vector-borne diseases and interannual climate changes: El Niño/La Niña 6. Health impact of other extreme weather events 7. <i>Interaction journal assignment: in your opinion?</i>
Reducing emission—in health terms: prevention	28	<ol style="list-style-type: none"> 1. Health as a positive leverage for climate policy 2. What can we do to reduce emissions? 3. What can the health sector do to reduce emissions?
The good news: doing something to reduce emissions is good for your health	57	<ol style="list-style-type: none"> 1. What are co-benefits and why they are important for climate policy? (part 1) 2. What are co-benefits and why they are important for climate policy? (part 2) 3. Health and climate benefits from reducing indoor air pollution 4. Child spacing is good for child and maternal health and for the climate 5. Riding your bike or walking is good for climate and your health

(continued)

Table 2 (continued)

Chapter name	Total runtime (in min)	Contents
		6. Improving diets in the global South and North lowers GHG emissions substantially 7. <i>Interaction group discussion and additional reading</i> : doing something to reduce emissions: what do you think?
Adapting to the effects of already occurring climate change: “Therapy”	29	1. Indian climate adaption plan in light of COP21 2. The limits of adaptation for work outside and in non-air-conditioned factories 3. The health basis for absolute limits of adaptation efforts: keep the 2 °C goal! 4. <i>Interaction group discussion and additional reading</i> : adapting to the effects of already occurring climate change: what do you think?
Outlook: a climate friendly world is healthier, more equitable, sustainable and fun	10	1. A climate friendly world is healthier, more equitable, sustainable and fun

Table 3 Course structure MOOC: climate change and health for policy-makers

Chapter title	Total runtime (in min)	Contents
Argument 1. Health as a motivator for taking action against climate change	8	<i>Interaction—assignment</i> : please answer the following questions (survey) Presentation by Prof. Rainer Sauerborn, IPCC member, Heidelberg University (Germany)
Argument 2. There are huge health co-benefits of climate-protecting policies and behaviour	15	Presentation by Prof. Sir Andy Haines, IPCC member, London School of Hygiene and Tropical Medicine
Argument 3. There are physiological limits to human capacity to adapt to climate change	8	Presentation by Prof. Rainer Sauerborn, IPCC member, Heidelberg University (Germany)
Argument 4. In poor countries, work productivity will decrease in a warmer world	10	Presentation by Prof. Tord Kjellstrom, IPCC member, Australian National University <i>Interaction—assignment</i> : end of the MOOC quiz
Readings for the whole MOOC	30	Core readings
Help us translate the videos in your own language!		

Table 4 MOOC course structure: changement climatique et santé en contexte Africain

Chapter title	Total runtime (in min)	Contents
Bienvenue dans ce MOOC	2:31	<ol style="list-style-type: none"> 1. Organisation et premiers pas <ol style="list-style-type: none"> 1.1 Teaser (Video) 1.2 Comment organiser ma semaine sur ce MOOC? (text) 1.3 Methode d'évaluation (text) 1.4 Présentons-nous les uns aux autres! (text) 1.5 Groupe Facebook (text)
Semaine 1: Bases physiques du changement climatique—Comprendre le changement climatique	15	<ol style="list-style-type: none"> 1. Présentation de la semaine Objectifs & déroulé de la semaine <ol style="list-style-type: none"> 1.1 Interaction discussion forum: discussion à propos de la semaine 1 2. L'effet de serre (video) <ol style="list-style-type: none"> 2.1 Quizz (5 MCQ) 3. Climat et météorologie (video) <ol style="list-style-type: none"> 3.1 Quizz (4 MCQ) 4. Phénomènes Climatiques/ Géographiques (ENSO) (video) <ol style="list-style-type: none"> 4.1 Quizz (5 MCQ) 5. Changement Climatique et évènements climatiques extremes (video) <ol style="list-style-type: none"> 5.1 Quizz (3 MCQ) 6. À vos claviers <ol style="list-style-type: none"> 6.1 Interaction discussion forum: discussion: changements remarquables 6.2 Interaction group work: Travaillons ensemble 6.3 Additional reading: Liens utiles et lectures complémentaires
Semaine 2: Liens entre changement climatique et santé humaine	8	<ol style="list-style-type: none"> 1. Présentation de la semaine <ol style="list-style-type: none"> 1.1 Objectifs & déroulé de la semaine 1.2 Interaction discussion forum: discussion à propos de la semaine 2

(continued)

Table 4 (continued)

Chapter title	Total runtime (in min)	Contents
		2. Changement climatique et santé humaine (video) 3. Maladies hydriques et malnutrition (video) 3.1 Quizz (4 MCQ) 4. Maladie liées à la température et à la chaleur (video) 4.1 Quizz (3 MCQ) 5. Maladies à transmission vectorielle – L'exemple du paludisme (video) 5.1 Quizz (5 MCQ) 6. À vos claviers 6.1 <i>Discussion</i> : plus grande menace 6.2 <i>Additional resources</i> : Liens utiles 6.3 Pages wiki
Semaine 3: Les réponses en matière d'atténuation, surveillance et prévention	10	1. Présentation de la semaine 1.1 Objectifs & déroulé de la semaine 1.2 <i>Interaction discussion forum</i> : discussion à propos de la semaine 3 2. Stratégies d'atténuation et d'adapation (video) 3. Rôle des zones humides dans l'atténuation des effets du changement climatique (video) 3.1 Quizz (5 MCQ) 4. Surveillance des maladies (video) 4.1 Quizz (4 MCQ) 5. Épidémiologie des maladies infectieuses et lien avec l'environnement (video) 5.1 Quizz (4 MCQ) 6. Analyse de l'association climat-moralité, analyse de series temporelles (video)
Semaine 4: Les réponses en matière d'adapation	30	1. Présentation de la semaine 1.1 Objectifs & déroulé de la semaine 1.2 <i>Interaction discussion forum</i> : discussion à propos de la semaine 4

(continued)

Table 4 (continued)

Chapter title	Total runtime (in min)	Contents
		2. Stratégies d'adaption – Gestion des systems de santé (video) Quizz (4 MCQ) 3. Limites de l'adaption physiologique à la chaleur (video) Quizz (4 MCQ) 4. Méthodes et outils – Télédétection (video) Quizz (3 MCQ) 5. Évaluation environnementale, étude d'impact (video) 6. À vos claviers 6.1 <i>Discussion</i> : adaptation dans votre environnement 6.2 <i>Additional resources</i> : Liens utiles et lectures complémentaires 6.3 Pages wiki
Semaine 5: Les réponses politique	43	1. Présentation de la semaine 1.1 Objectifs & déroulé de la semaine 1.2 <i>Interaction discussion forum</i> : discussion à propos de la semaine 5 2. Politiques globales sur le climat (video) 2.1 Quizz (4 MCQ) 3. Politiques nationales d'adaption – L'Afrique de l'ouest (video) 3.1 Quizz (3 MCQ) 4. Impacts sur les secteurs de development (video) 4.1 Quizz (6 MCQ) 5. Droit environnemental (video) 5.1 Quizz (5 MCQ) 6. Introduction au Plan d'Action National d'Adaption (PANA) (video) 6.1 Quizz (6 MCQ) 7. À vos claviers 7.1 <i>Discussion</i> : réponse politique 7.2 <i>Additional resources</i> : Liens utiles et lectures complémentaires 7.3 Pages wiki 7.4 Text Rendu exercice final

References

- Adams, C., Yin, Y., Vargas Madriz, L. F., & Mullen, C. S. (2014). A phenomenology of learning large: The tutorial sphere of xMOOC video lectures. *Distance Education, 35*(2), 202–216.
- Adlong, W., & Dietsch, E. (2015a). Environmental education and the health professions: Framing climate change as a health issue. *Environmental Education Research, 21*(5), 687–709.
- Adlong, W., & Dietsch, E. (2015b). Nursing and climate change: An emerging connection. *Collegian, 22*(1), 19–24.
- Alliance for Affordable Internet. (2017). Affordability report. A. f. A. Internet.
- Barna, S., Goodman, B., & Mortimer, F. (2012). The health effects of climate change: What does a nurse need to know? *Nurse Education Today, 32*(7), 765–771.
- Beaven, T., Comas-Quinn, A., Hauck, M., de los Arcos, B., & Lewis, T. (2013). The open translation MOOC: Creating online communities to transcend linguistic barriers. *Journal of Interactive Media in Education, 3*.
- Brynjolfsson, E., & McAfee, A. (2014). *The second machine age: Work, progress, and prosperity in a time of brilliant technologies*. WW Norton & Company.
- Centre Virchow-Villermé. (2016, January 21). *Climate change & health*. Retrieved May 31, 2017, from <http://virchowvillermé.eu/course/climate-change-health/>.
- Chuang, I., & Ho, A. D. (2016). HarvardX and MITx: Four years of open online courses—Fall 2012–Summer 2016.
- Coursera. (2017). *About*. Retrieved May 18, 2017, from <https://about.coursera.org/>.
- edX. (2017). *Media kit*. https://www.edx.org/sites/default/files/mediakit/file/edx_-_mediakit_-_may_2017.pdf.
- Escher, G., Noukakis, D., & Aebischer, P. (2014). Boosting higher education in Africa through shared massive open online courses (MOOCs). *Education, Learning, Training: Critical Issues for Development, 195*.
- Hansen, J. D., & Reich, J. (2015). Democratizing education? Examining access and usage patterns in massive open online courses. *Science, 350*(6265), 1245–1248.
- Hoy, M. B. (2014). MOOCs 101: An introduction to massive open online courses. *Medical Reference Services Quarterly, 33*(1), 85–91.
- International Council of Open and Distance Education (ICDE). (2015). Online, open, and flexible higher education for the future we want: policy challenges. In A Background Report Prepared by the International Council of Open and Distance Education (ICDE) for the United Nations Educational, Scientific and Cultural Organization (UNESCO). ICDE.
- Jordan, K. (2014). Initial trends in enrolment and completion of massive open online courses. *The International Review of Research in Open and Distributed Learning, 15*(1).
- Levin, R. (2017). *How are people globally benefiting from online learning?* <https://blog.coursera.org/online-learners-around-world-report-benefits-ranging-advancing-careers-discovering-field-study-gaining-confidence/2017>.
- Levy, B., & Patz, J. (2015). *Climate change and public health*. Oxford University Press.
- Louis, V. R., & Phalkey, R. K. (2016). Health impacts in a changing climate—An overview. *The European Physical Journal Special Topics, 225*(3), 429–441.
- Majra, J. P., & Acharya, D. (2009). Protecting health from climate change: Preparedness of medical interns. *Indian Journal of Community Medicine, 34*(4), 317.
- Nigatu, A. S., Asamoah, B. O., & Kloos, H. (2014). Knowledge and perceptions about the health impact of climate change among health sciences students in Ethiopia: A cross-sectional study. *BMC Public Health, 14*(1), 587.
- Rudolph, L., & Gould, S. (2015). Climate change and health inequities: A framework for action. *Annals of Global Health, 81*(3), 432–444.
- Sauerborn, R. (2016a). *About this course—Climate change & health for policy-makers*. Retrieved May 31, 2017, from <https://iversity.org/en/courses/climate-change-health-for-policy-makers>.
- Sauerborn, R. (2016b). Why should health be a central argument in climate negotiations? Can a MOOC help to bring the message across? *Public Health Reviews, 37*(1), 18.

- Sayre, L., Rhazi, N., Carpenter, H., & Hughes, N. L. (2010). Climate change and human health: The role of nurses in confronting the issue. *Nursing Administration Quarterly*, 34(4), 334–342.
- Warusavitarana, P. A., Lokuge Dona, K., Piyathilake, H. C., Epitawela, D. D., & Edirisinghe, M. U. (2014). MOOC: A higher education game changer in developing countries. *Rhetoric and Reality: Critical Perspectives on Educational Technology. Proceedings Ascilite Dunedin*, 359–366.
- Wei, J., Hansen, A., Zhang, Y., Li, H., Liu, Q., Sun, Y., et al. (2014). Perception, attitude and behavior in relation to climate change: A survey among CDC health professionals in Shanxi province, China. *Environmental Research*, 134, 301–308.
- Withers, M., Press, D., Wipfli, H., McCool, J., Chan, C.-C., Jimba, M., et al. (2016). Training the next generation of global health experts: Experiences and recommendations from Pacific Rim universities. *Globalization and Health*, 12(1), 34.
- Woodward, A., Smith, K. R., Campbell-Lendrum, D., Chadee, D. D., Honda, Y., Liu, Q., Olwoch, J., Revich, B., Sauerborn, R., Chafe, Z., Confalonieri, U., & Haines, A. (2014). Climate change and health: On the latest IPCC report. *The Lancet*, 383(9924), 1185–1189.
- World Health Organization. (2006). The world health report: 2006: Working together for health.
- World Health Organization. (2013). Research for universal health coverage: World health report 2013 (p. 168). World Health Organization.
- World Health Organization. (2017). *10 facts on climate change and health*. Retrieved May 18, 2017, from http://www.who.int/features/factfiles/climate_change/facts/en.