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Article

Relevancy of the Massive Open Online Course (MOOC) about Sustainable Energy for Adolescents

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Abstract: Sustainable energy is one of the biggest global challenges today. This paper discusses how we can promote adolescents' learning of sustainable energy with the help of an international massive open online course (MOOC). The aim of this case study is to understand: (i) What do the adolescents find relevant in the MOOC course about sustainable energy? and (ii) What are the opportunities and challenges of the MOOC for the adolescents to learn sustainable energy? In our study, 80 voluntary adolescents around the world, who were at least 15 year old, took part in two surveys. The themes of our MOOC course were, e.g., sustainable growth, solar power, wind power, biofuel production and smart power generation. This 38 work-hour, free of charge, online course includes an introduction video, interviews of specialists, lecture videos, reading materials of the newest research and multiple choice questions on the topics. Research data was classified by using content analysis. The study indicates that adolescents feel that both the MOOC course and sustainable energy as a subject are relevant to them. Their decision to take part in an online course was mostly influenced by individual relevance and partly influenced by both societal and vocational relevance, according to the relevancy theory used. The MOOC was experienced to be relevant for the three following reasons: (i) good content (e.g., energy production) and implementation of the course; (ii) the course makes it possible to study in a new way; and (iii) the course is personally useful. The characteristics of the MOOC, such as being available anywhere and anytime, free access, and online learning, bringing out a flexible, new way of learning and thus promoting Education for Sustainable Development (ESD) in the context of sustainable energy at school level around the world. This MOOC provided the school students with choice-based learning and expanded their learning opportunities in understanding sustainable energy. In the designing of MOOCs for studying sustainable energy, it is important to take the following things into consideration: (i) the balance between theory and practical examples; (ii) the support for interaction; and (iii) other support (e.g., technical and learning strategies) for students. Communication with other learners and getting feedback from teachers and tutors remain the vital challenges for the developers of MOOCs in the future.

Keywords: Education for Sustainable Development (ESD); sustainable energy; online learning; MOOC

1. Introduction

The promotion of Education for Sustainable Development (ESD) will be even more important in the future [1,2]. In particular, promoting the learning of sustainable energy is one of the central global contents of ESD at school levels. In addition to learning the topic, it may add to the student and his/her family's social knowledge about it and it may also help in bringing new students to the field [3].

Sustainable energy can be described as a production and using of energy that supports sustainable development. This kind of energy is renewable and is produced durably, both socially and economically. For example, solar energy, water-based production of energy, and the production of biofuels with the help of microbes are all called as renewable energies [4]. For our massive open online course (MOOC) about sustainable energy, the themes of sustainable growth, solar power, wind power, energy efficiency, energy, water and food, energy consumption, fusion energy, biofuel production, smart power generation and cities, towns and renewable energy were selected. One of the main aims was to increase the students' ability to critically follow the societal and technical discussions on sustainable energy.

In a meaningful teaching of sustainable energy, it would be important to take into consideration four strategic viewpoints: equality, flexibility, student orientability and creativity [5]. The themes about sustainable development such as sustainable energy should be dealt with holistically and in a student-oriented manner [2,5]. In particular, adolescents want to study natural science phenomena that they find interesting and socially essential, and they would like to deal with moral questions having to do with the phenomena. It has been proven that they would like it if the teaching contained more personal activity and included the effects of the professions in the fields of natural sciences and technology in solving challenges shared by the entire world [6]. Adolescents like to take into consideration also the social and ethical points of the topic in addition to the academic points [7,8]. In this research, international adolescents study sustainable energy with the help of an online course (MOOC) that has been produced communally. It has been designed exploiting previous information from earlier researches (see Section 4 for further information).

2. Promoting Sustainable Energy Learning through the MOOCs

Massive open online course (MOOC) is thought of as an innovative method both in the teaching and researching of sustainable energy [9]. According to Zhan et al. [9] MOOCs on sustainable energy can offer learning resources and opportunities for people to cultivate their awareness of global environmental protection, of a sense of sustainability, and also to learn about the ways in which universities teach sustainability-related knowledge in an open online environment. In earlier research discussions, forums and lecture videos were most frequently used as the pedagogical methods of the earlier MOOCs for university students [9].

Originally the term MOOC, coined by Dave Cormier, was used to represent the phenomenon of their course called "Connectivism and Connective Knowledge (CCK08)", which was facilitated by S. Downes and G. Siemens in 2008. The MOOC has been described as an online course with the option of free and open registration, a publicly-shared curriculum, and open-ended outcomes [10]. They characterized the MOOC as integrating social networking and as being an accessible online resource. The MOOCs were facilitated by leading practitioners in the fields of study, and significantly, they were built on the engagement of learners who self-organize their participation according to learning goals, prior knowledge and skills, and common interests [10]. In general, these kinds of MOOCs are based on connectivism and the social construction of knowledge. Therefore, they are called cMOOCs (Connectivist MOOCs).

Although the first MOOC was carried out in 2008, the interest in MOOCs at that time was quite limited among researchers and mainstream media [11,12]. In 2011, Stanford launched three MOOCs, including the "Introduction to Artificial Intelligence" ('CS221') course, for which about 160,000 learners were registered. In the beginning of 2012, the MOOC models made by companies Coursera, Udacity and edX, were launched by Stanford, MIT and Harvard. MOOC was hyped up as the revolution of high education by the media and, 2012 was named "The year of MOOC" [13]. Different to the original MOOC led by S. Downes and G. Siemens, the pedagogy of Stanford's MOOC was more instructivist and behaviorist [12,14]. In this kind of a MOOC, there were weekly recorded video lectures and quizzes with immediate feedback. Some courses consisted of assignments that were peer-reviewed. All of the courses had discussion forums that students could use for their own purposes, and in some courses, instructors directly encouraged students to use these forums, though none of the instructors had a strong presence on the forums [15]. These kinds of MOOCs were labeled xMOOCs, as used in this study.

From 2012 onwards, the number of MOOCs has increased rapidly. But the concept of the MOOC remains relatively poorly defined. Matthew Plourde's diagram illustrates that every letter in MOOC is negotiable. In this paper, we use the definition of MOOC developed by OpenupEd [16], in which MOOCs are "online courses designed for large numbers of participants, that can be accessed by anyone anywhere as long as they have an internet connection, are open to everyone without entry qualifications, and offer a full/complete course experience online for free". This definition is shared by many European partners and has some empirical data to support [17].

Although MOOCs, especially xMOOCs, have not led to the disruptive innovation of education portrayed by the media, it is a valuable low-cost supplement to formal education [18,19]. A survey from Duck University suggested that learners under the age of 18, learners over the age of 65, and learners who reported a lack of access to the course contents indicated that the MOOCs provided expanded opportunities to their current formal education and their present and future career experiences [20]. MOOCs can help in meeting the increasing demand for on-the-job continuous professional development as employment patterns and lifelong learning change [13,18]. For developing countries, MOOCs help to improve the information literacy of people [21]. In Finland, MOOCs have been found useful for learning programming at school level [22].

However, MOOCs also have to face many challenges in their teaching because of the massive amount of participants in one course. The completion rate of MOOCs is usually very low [18,23]. The motivational, emotional and intellectual commitments, and the skill profiles of MOOC learners, affect the development and use of MOOCs [24]. The assessment of the higher levels of learning remains a challenge for MOOCs [18].

3. The Relevancy of the MOOC Course about Sustainable Energy

In this case study, we are interested in how relevant the course participants experience a MOOC course on sustainable energy. The results of this MOOC course are examined from the point of view of relevance theory [25].

"Relevance" is a concept that is often used when talking about the teaching of natural sciences. Teaching should be relevant, but the concept does not have a specific meaning and it therefore has been used in many different ways across time and from speaker to speaker. In the beginning of the 20th century, teaching of natural sciences was relevant when it served the purposes of the state and companies, and it was meaningful from the point of view of the functioning of society. Later on, the general education in natural sciences and their meaning in daily life became important [25,26].

As a concept, relevance has been used in order to illustrate a student's interests [27,28], and to illustrate how meaningfully the phenomena of daily life appear from the point of view of individuals and society, for example: applying science and technology to social, economic, environment, and political questions through sustainable development [29,30]. Relevance has also been used to explain how well the students are able to perceive the significance of using daily life contexts in teaching [31–34]. And it has been used as a synonym for importance, usefulness and correspondence of needs [35,36].

Even though people have not always agreed on the meaning of the concept of relevance, the relevance in science learning has been studied quite a lot. The most well-known research project dealing with the relevance of scientific education has been the international ROSE (The Relevance of Science Education) project. In the ROSE project, the concept of relevance was thought of mostly as a synonym for motivation and interest, but the organizers of this research were given the possibility to define relevance in the way they preferred [37].

Because there was not a previous similar model for relevance, Stuckey et al. [25] have aimed at creating a similar model for the relevance of teaching natural sciences, which considers the previous notions. According to this model, the relevance of teaching can be evaluated in three different dimensions: individual, societal and vocational relevance. The usefulness of this model is also supported by the fact that also Van Aalsvoort [38] has previously described the concept of relevance similarly. In addition to these above-mentioned three dimensions, intrinsic and extrinsic relevance is often talked about, as well as whether or not learning is relevant right at this moment or only later in the future.

Stuckey et al. [25] presents a model in their article for evaluating the relevance of learning natural sciences. This model can be tangibly exploited in addition to research in planning teaching. Here we can observe that, as a concept, relevance is more comprehensive than just interest or significance. The principle of the model can be observed in Figure 1, below.

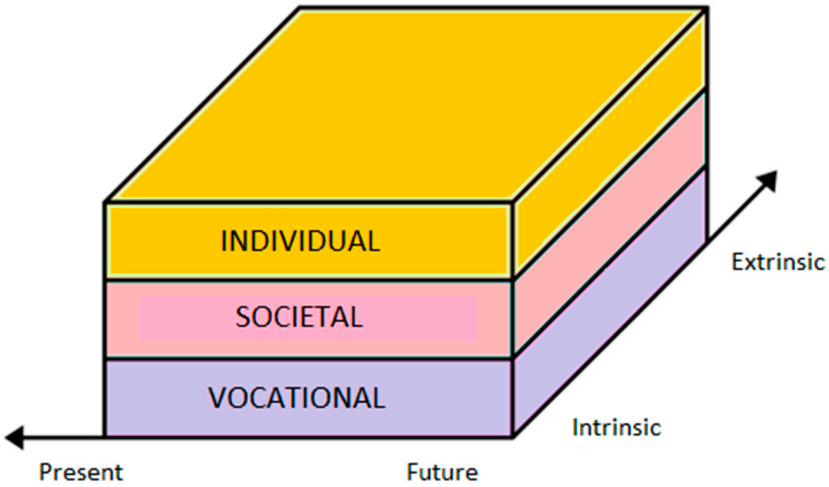

Figure 1. The dimensions of relevance [25].

In this model, individual relevance consists of, for example, subject matters that increase the student's interest or help the student to be successful in school and daily life. Things that can be considered to fit under societal relevance are, for example, those that help the learner act as a responsible member of society, to better understand the society around them and to be active in helping to develop the society. Vocational relevance consists of knowledge and skills that for example give a person the qualifications for a certain field or that bring support to the possible future profession. The present–future dimension in the model of relevance means that the thing being dealt with may be relevant to the learner either in the same exact moment or far in the future. Intrinsic relevance supports the student's interests and motivation, whereas extrinsic relevance is caused by the demands arranged by the surroundings.

It is briefly stated by Stuckey et al. [25] that the teaching of natural sciences becomes relevant training when teaching has positive effects on a student's life. Relevance, as a concept, should be available to the teachers and people who make the core curriculum, so that they can evaluate the relevancy of their lesson plans [39]. A model created on the basis of Stuckey et al.'s research has been created in order for the teachers to be able to actively analyze their lesson plans and perhaps edit these plans, so that teaching would be as relevant as possible from the students' point of view [25].

Stuckey et al. [25] have themselves used this model, created by them, in teacher training, where it has been used as a helping tool for reflecting on the aims for relevant education in natural sciences and as a tool for evaluating different teaching methods. Using this model in analyzing core curriculums makes it possible to find strengths and weaknesses, as well as the different levels of relevance in teaching [25].

4. The Aim and Content of the MOOC Course "Sustainable Energy"

A MOOC course, arranged for the first time, was organized by the University of Helsinki and in cooperation with the Aalto University and Technology Academy Finland (TAF). This course was held in autumn 2015. It was especially meant for over 15-year-olds all over the world who were interested in the subject. It was free of charge.

The goals of this MOOC course about sustainable energy are to:

- give a versatile glimpse into one of the biggest global challenges of today, sustainable energy;
- strengthen the students' skills on sustainable energy and its production based on the latest research and technology innovations;
- help to understand energy production in the future as a multidimensional entity;
- increase the students' ability to evaluate the choices connected to sustainable development in the daily life;
- promote Finnish knowledge of energy and future study possibilities, as well as the Millennium Technology Prize;
- inspire learning about mathematical subjects, natural sciences and branches of technology.

The teachers of this course were top-level researchers from a wide range of fields: there were lecturers from professors to doctoral students and from representatives from branches of science to representatives from commercial fields. Also, the themes chosen for this course dealt widely with sustainable development: from solar energy to nuclear energy (see details in Introduction). The themes dealt with the effects of renewable energy on the electrical network in the future and with increasing the effectiveness of using energy. This course aimed to bring forth both advantages and possible disadvantages for students. A more specific description of this course can be found here in the webpage: https://www.lumate.fi/event/millennium-youth-course-sustainable-energy/.

In order to be able to pass this course, the students would have to familiarize themselves with the specialists' interviews (videos), lecture videos (20 minutes each) and articles (the topics: Smart Power Generation and Cities, Towns and Renewable Energy) and then answer multiple-choice questions designed mostly by specialists. This course, implemented in the *Moodle* learning environment, was a 38 work-hour high school course, suitable for independent study, because it unifies the natural science entity in schools. Against a course diploma, a student could apply for a course performance from their school, a student could apply for a one study point marking of performance from the University of Helsinki, or they could apply for a study point also from our Open university. The subject of this course followed the new Finnish National Core Curriculum's (for high schools) theme: the necessity of a sustainable lifestyle.

An international MOOC course "Sustainable Energy in Education", a further training course for teachers, was implemented in the spring of 2016 on the basis of the research study of Sustainable Energy course.

5. Research Methods

There are two research questions in this case study:

(1) What do the adolescents find relevant in the MOOC course about sustainable energy?
(2) What are the opportunities and challenges of the MOOC for the adolescents to learn sustainable energy?

In this case study, 80 adolescents took part in research. Data for the first research question was collected in the beginning of this online course (the first task). A research form was compiled communally on the basis of relevance theory. Data for the second research question was collected at the end of the online course. In total there were two open questions about possibilities and challenges related to the second research question.

Data from the first research question was classified with the help of theory based content analysis [40]. All answers were divided into three classes: (i) individual relevance; (ii) societal relevance; and (iii) vocational relevance, according to the relevancy theory explained in Section 3. In addition, frequency of the answers for each class was calculated (see Table 1).

Table 1. The Relevancy of the Course.

Relevance Theory	The Answers of the Students	Frequency
Individual	• An interesting topic (26) • Wants to learn more about sustainable energy (24) • Interested in energy production (11) • Interested in natural sciences (11) • Course is in English (10) • Interested in sustainable energy (10) • Wants a coursemark (7) • An important topic (5) • Online course (5) • MOOC is cool • Useful information for the future • Might be helpful in the matriculation examination • Course was suggested by a teacher • To improve grade in physics • A challenging course • A flexible course • Wants to know about implementing courses in Finland • Wants to gain experience about the university life • Interested in learning in general	117
Societal	• Wants to make the world a better place • People should know more about sustainable energy	11
Vocational	• Wants to work with sustainable energy in the future • Wants to be a better teacher	4

Data from the second research question was classified using inductive content analysis [41]. Subclasses were formed first from the answers and then the upper classes were formed on the basis of the subclasses. First, all opportunities of the MOOC were coded and 12 codes were formed by a researcher, for example: (i) flexible learning (34 answers; e.g., an adolescent's answer: "could study anywhere and anytime"); (ii) interesting topic (25 answers; e.g., an adolescent's answer: "course topic was interesting"); (iii) good lectures (18 answers; e.g., "lectures were clear and well organized"). Then, they were classified into three categories by another researcher (see Table 2) and compared with earlier research.

Table 2. The opportunities of the MOOC during the course.

The Opportunities	An Example of the Answers	Frequency
Course design	- Course topic was interesting (24) - Lectures were clear and well organized (18) - Lecturers were great (11) - Videos were clear and re-watchable (9) - Quiz system was clear (8)	70
Providing a new way of learning: flexible learning and new learning strategies	- Could study anywhere and anytime (34) - Course was free and online (3)	37
Personal benefit: Learned lots of new things, learned English, encouraged towards learning about science and Finnish research	- Learned lots of new things (11) - Learned English (4) - Encourages children towards learning science (student teachers) (2) - Learn about Finnish research (2)	19

Secondly, all challenges of the MOOC were classified and nine codes were formed by a researcher, for example: (i) not enough interaction (16 answers; e.g., an adolescent's answer: "There was not enough interaction between students"); (ii) problems with technology (14 answers; e.g., an adolescent's answer: "there were some technical difficulties") and (iii) lecturers' skills in English (7 answers; e.g., an adolescent's answer: "lecturers should learn to speak English"). Then, they were classified into three categories by another researcher (see Table 3) and compared with earlier research.

Table 3. The challenges of the MOOC during the course.

Challenges	An Example of the Students' Answers	Frequency
Course design	- Lecturers should learn to speak better English (7) - Instructions were unclear (6) - Something other than questionnaires (5) - Wanted more practical examples (5) - Didn't like the reading tasks, they were too long (4)	27
Interaction	- There was not enough interaction between students - Would like to have feedback after every chapter	18
Learning support	- There were some technical difficulties - Would like to have some deadlines	17

The results of the case study have been confirmed by three researchers according to the research method [40,41]. The classifications of both data were checked, on the basis of the examples, by all the three researchers (two from the same research group and one from another research group), and the classification was accepted. Two researchers are specialists in sustainable development education (EDS) and in research of relevancy theory, and the third researcher is a specialist in research of online learning (MOOCs). The results of the qualitative case study are directional.

6. Research Results

In the following part, the results are analyzed according to the main research questions (see Section 5).

6.1. The Relevancy of the MOOC Course

The students thought that both the course and its theme were relevant (see Table 1 above). Students chose this course in particular because of the reasons of the principle of individual relevance. The three most popular reasons for taking part in this course were: (i) finding the theme of the course interesting; (ii) wanting to learn more about sustainable energy, and (iii) a general interest in production of energy. All in all, there were 80 participants in this research. According to the answers, there were 132 different "points" in accordance with the relevance theory, from which 61 answers belonged to these first three categories mentioned above.

The fourth most popular reason, according to the students, was general interest in the natural sciences; a large part of the other answers can also be counted to belong under individual relevance. All in all, individual relevance could be seen in 117 answers out of a possible 132.

In five of the answers, the student wanted to make the world a better place, five students thought that the theme of the course was generally important, and one student thought that people should know more about sustainable energy. These three answers all represent societal relevance. In total, the societal relevance in taking part in the course could be seen only in 11 out of 132 answers.

Vocational relevance was even less popular than societal relevance. The vocational viewpoint had been taken into consideration in only four answers.

6.2. The Opportunities and Challenges of the MOOC

According to the survey, the course participants reported that this MOOC provided them with a good learning experience in the three following areas (Table 2): (i) Course design (70 answers altogether); (ii) Providing a new way of learning (37 answers); and (iii) Personal benefit (19 answers). The course materials were well-prepared and easy to use (course design). Twenty-four answers claimed that the topic of the course was quite interesting for them. Thirty learners deemed that the lectures were clear and well organized and that they were also great. Seventeen answers commended the good quality of videos and quiz system for their clarity and reusability. Firstly, this course was a new way of learning for the participants. Thirty-seven answers mentioned that the characteristics of the MOOC, such as being available anywhere and anytime, free access, and online learning, and bringing out a flexible, new way of learning. Thirdly, the course participants got personal benefit from this course study. Some learners claimed that they had learned lots of new things, others felt it interesting to see what kind of research is done in Finland. Some teacher trainees thought that this MOOC would encourage kids towards studying natural sciences. Not only had the students' knowledge of energy increased, some Finnish learners reported that their English had been improved.

There are some challenges that this MOOC has to face, concerning: (i) course design; (ii) interaction; and (iii) learning support. At first, the design of the course needs to be improved. The survey showed that learners needed clearer instructions to leading study, and they wanted more practical examples to help them understand the learning content. Some learners thought that the reading materials were too long for them to read. Others thought that there should be more different forms of assignments and that they should be more varied. As an online course, open to the world, some learners suggested that the lecturers should speak better English in their lectures. Lack of interaction between teachers and students, and between students, was another problem in this xMOOC. Eighteen answers mentioned that there was not enough interaction among students and that the teachers did not give enough feedback. Learners also reported that they needed some technical help and learning support to assist their online study.

7. Discussion

7.1. The Relevancy of The Course

The adolescents experienced the course as individually relevant. Personal interest belongs to the front and upper corners in the left-hand side in the model of relevance theory [25] and it represents individual, present and intrinsic relevance. The desire to learn new things belongs to the front and upper corners on the right-hand side, so it belongs also to the individual and intrinsic relevance, but instead of present, belongs to the future. In addition to individual relevance, also societal and vocational relevance had an effect on the students' decisions whether or not taking part in the course, even though in noticeably lesser proportions. The societal viewpoint is most likely going to strengthen over time, when the awareness of the world strengthens through globalization. This will possibly also have an effect on the students' decisions about which courses to choose, and this might be an interesting subject of research in the future.

The answers that represent vocational relevance were those in which the responder wants to work with sustainable energy in the future or the responder wants to become a better teacher. From the basis of these results, it would be wise to ponder whether or not the students are able to think about their working lives in the future, or whether personal interests are just simply so much more important that the vocational viewpoint cannot be fitted into a small description about why the student has especially chosen this course? In the further revision of this course it would be wise to take this viewpoint better into consideration.

7.2. The Opportunities and Challenges of The MOOC

MOOCs, especially xMOOCs, are characterized as delivering high quality content from the world's best universities for free to anyone anywhere with a computer and an internet connection, and supporting choice-based learning [18,42]. Students in primary and secondary schools, have the opportunities to take MOOCs in topics not taught in their schools and to explore different disciplines in helping to weigh their academic and career choices [20]. In our MOOC practice, most of the learners chose this course because of their interest in the natural sciences and sustainable energy/sustainable development. This MOOC provided them with choice-based learning and expanded their learning opportunities.

MOOCs were respected to give rise to innovation on the existing education system. Although current critiques of MOOCs in the mainstream media are general and mostly focused on the failed "revolution in education" [12], our survey showed that MOOC did bring new learning strategies, including learning online, global learning, learning with media, self-paced learning, etc., to the learners and made a change on the individual level.

Ossiannilsson et al. [43] did a system literature review in order to identify factors affecting the quality of MOOCs. They concluded that the present research study identifies learning design and learning environment as key factors affecting experience and quality [43]. This research highlights some elements that affect the design of the MOOC, including the relevance of content to the learners, the design of instruction and guidance, the length and complexity level of the reading materials, the forms of assignments, etc. This will be helpful in the designing of online courses in the future.

How to support learners participating in a MOOC is an important issue. With the massive amount of participants taking part in a MOOC, it is not possible to provide tailored individual support [44]. Our findings showed that learners need support both in technical skills and learning strategies. In cMOOCs, the common method was to encourage participants to create their own PLE (Personal Learning Environment) consisting of tools and peers to support their learning [44], but in xMOOCs, it is still a problem that needs to be explored. Interaction between teachers and students is another key issue in the more individually focused, didactic MOOCs. Although e-assessment and peer review have been introduced to support learning, communication with other learners and getting feedback from teachers and tutors remain vital challenges for the developers of MOOCs.

7.3. Conclusions

The aim of the course was to give the students' more information about sustainable energy and its production through the help of the newest research and technology innovations, and to give an understanding of energy production in the future as a multidimensional entity. The MOOC course was personally relevant for the students on the basis of this case study. It gave adolescents a new holistic approach to learning about sustainable energy on the basis of the newest research. The theme of the course was also thought to be relevant. In particular, energy production was considered as one of the most useful topics. If we want to increase the societal and vocational relevance of the topic [4], then they should be more visible in the planning and carrying out of a course.

The characteristics of the MOOC, such as being available anywhere and anytime, free access, and online learning, bring a great opportunity to supporting learning about sustainable energy on the basis of the newest research [9], especially at school level, around the world, and thus promoting Education for Sustainable Development (ESD). Next time it would be useful to think about whether or not an xMOOC-shaped course is the best option. An online course that consists of videos, articles and multiple choice questions does not seem to support the students' interaction and learning enough; the students requested this for future courses. The xMOOC shape would seem to be better for independent studying of the theme. In the future, the cMOOC-shaped online course, which supports communal learning, could be used and studied. This would make it possible to include useful reflections and discussions pointed out in this study.

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