

Article

Innovative Education in MOOC for Sustainability: Learnings and Motivations

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Received: 2 May 2018; Accepted: 14 August 2018; Published: 23 August 2018

Abstract: This research project analyzes the motivation and learning perceived by the participants in four Massive Open Online Courses (MOOCs) that use innovative education strategies in order to train the community in Education for Sustainability. These MOOCs were delivered during 2017 and the study forms part of the subproject “Open, Interdisciplinary and Collaborative Innovation to Train in Energy Sustainability through MOOCs”, which was offered in the portal of the *Binational Laboratory for Intelligent Energy Sustainability Management and Technology Training*. The method utilized was mixed, with a triangulation design approach according to the convergence model. This method consisted of two phases: the first being quantitative, with an online survey designed by experts in a Likert type scale, and the second being qualitative, in which valuations of the users were collected through diverse instruments such as focus groups and observations. The results obtained demonstrate the advantages of designing MOOCs that make use of innovative tools, in order to engage the students as much as possible, and the collateral impact on the development of digital abilities and skills in addition to the learning acquired with respect to sustainability.

Keywords: innovative education; education for sustainability; MOOC; motivation; learning

1. Introduction

Energy sustainability is a topic of world interest, and its importance and impact extend to all areas of society, from private homes to government institutions and industry. Nevertheless, few fully understand the impact and benefits that a knowledge of sustainability can provide us with. Thus, education for sustainability must be a priority concerning all institutions today. Nevertheless, training more people in this subject remains a challenge. Energy sustainability has typically been a topic covered mainly by non-profit organizations who have protested in favor of taking better care of the environment, however, higher education institutions also need to contribute to this knowledge with an environmental culture and ideology. In response to this need, Information and Communications Technology (ICT), combined with the strategies of innovative education, can support the training of individuals in energy sustainability.

There is no doubt that the digital world has modified the way that people are learning and retrieving information; therefore any use of ICT for educational purposes must also consider itself a response to those corresponding shifts [1] (p. 18). For this reason, by considering a MOOC (Massive Open Online Course) as an appropriate ICT tool for reaching many people, the purpose of this article is first, to describe the experience of designing MOOCs with innovative education that allows more people to learn about sustainability concepts, and second, to describe the students' perceptions about their learnings and motivations.

The MOOCs were designed and supported with innovative education strategies with the objective of training the population in general in matters of energy sustainability, regardless of age, social status or the geographic location of the individual. The titles of the first four MOOCs were: (1) Energy: Past, Present, and Future; (2) The Energy Reform in Mexico and its Opportunities; (3) The New Electric Industry in Mexico; and (4) Conventional and Clean Energies and their Technology. As mentioned before, one main objective of this research was to understand the perceptions of MOOC participants with respect to their motivation and learning while being trained in the topic of energy sustainability using innovative educational strategies. Thus, this study focuses only on the people who signed up the MOOC and who finished the latter during the delivery of the first 4 MOOCs mentioned before. Variables such as learning using a Connectivist approach [2] and the motivation among enrolled students were analyzed in order to generate relevant data regarding the training of the community in general in energy sustainability.

Figure 1 shows the first four MOOCs were delivered during 2017, which were the basic ones, and it also shows the sequence of the advanced MOOCs. The basics were designed for most of people, so that anyone could take it. However, the advanced MOOCs, such as "Smart grid", required that the students followed the approved sequence in order to get to it, and of course, the latter was designed for people more prepared academically. The duration of each MOOC was five weeks and upon completion the participant had the option of presenting a knowledge test and if approved, received a certificate. In this sense, many people can study step by step, learning about sustainability concepts.

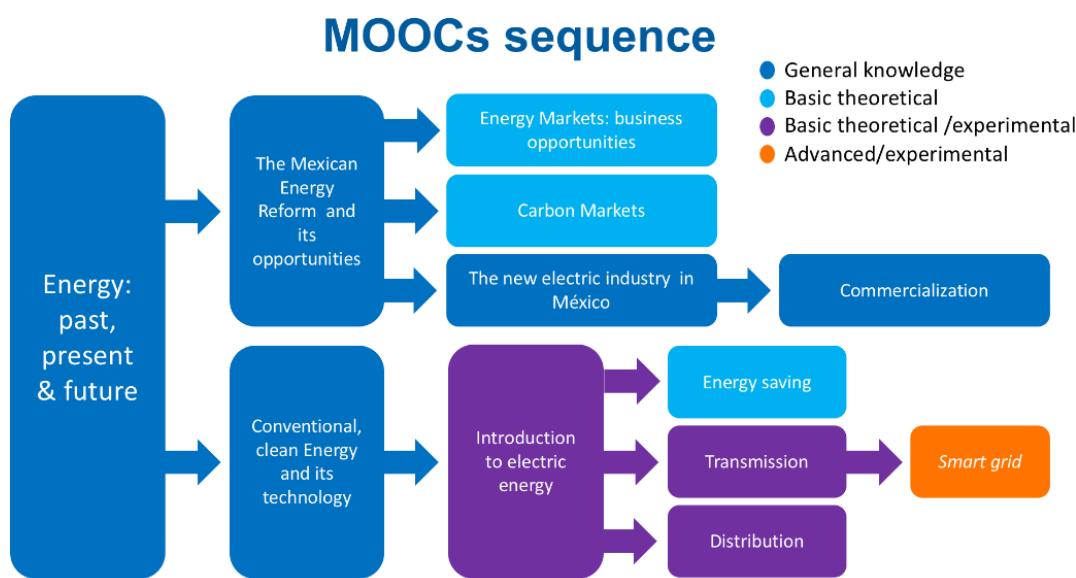


Figure 1. Massive Open Online Courses (MOOCs) sequence designed for Education in Sustainability.

This research article was supported by a big project called the Binational Laboratory for the Intelligent Management of Energy Sustainability and Technology Training. The main issue for this collaborative binational research project is to continue enhancing educational tools aimed at broad and diverse audiences, and not only the educational experiences of a select group of people, such as the ones that have formal learning at schools. In this sense, a MOOC could be a strategy to allow accessibility to education for sustainability to most people. The call to participate in these MOOCs was offered throughout Latin America and some other Spanish-speaking countries, mainly because the MOOCs were originally made in Spanish. Participation in these MOOCs is free, but participants do need to pay a fee to receive a certificate; this means for the completion of the final activities that are at the end of each week. The cost of the certificate is not expensive, and more importantly, it is

symbolic. On the platform MexicoX, this certificate is free. On the platform EdX, the cost for the certificate is 30 dollars. Figure 2 presents the Webpage of the Binational Laboratory for the Intelligent Management of Energy Sustainability and Technology Training, where MOOCs can be located for training in energy sustainability. The name binational refers to the joint project between Mexico and the United States in which there are 13 subprojects for training in energy sustainability, of which the MOOCs project constitutes only one.

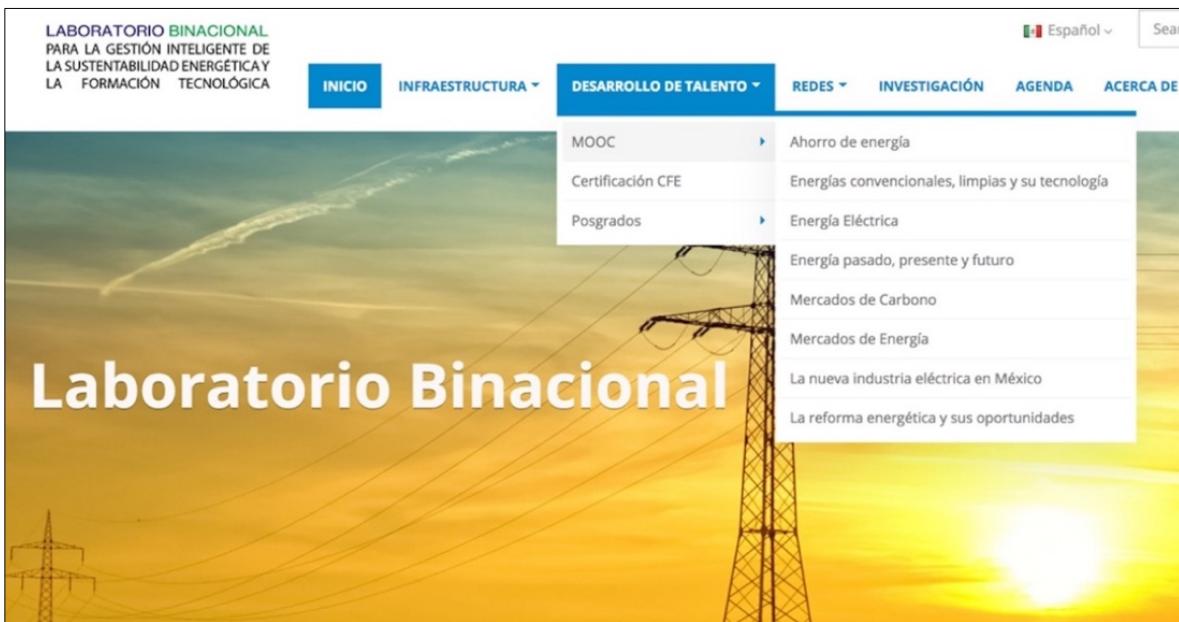


Figure 2. Webpage of the Binational Laboratory for the Intelligent Management of Energy Sustainability and Technology Training (<http://energialab.tec.mx/>).

The research question “What is the learning and the motivation perceived by the participants of the MOOCs about energy sustainability that integrate innovative education?” was the basis for the development of this article. It was designed considering the learning objectives of the MOOC courses, for which the triple entry matrix design proposed by Valenzuela, Montoya and Mena (2017) was taken. The triple entry matrix includes questions regarding the start, design, motivation and end of the courses, with which the instruments presented below were designed. Subsequently, the questions related only to the variables of motivation and learning were selected.

For the present research, only the first four MOOCs that had been generated and completed as of October 2017 will be analyzed. A number of national organizations and companies participate in the binational project, thus this paper is presented in the framework of Project 266632 “Binational Laboratory for the Management of Intelligent Energy Sustainability and Technology Education” (with funding from the Energy Sustainability Fund CONACYT-SENER, Call: S0019-2014-01) and supported by CONACYT and the Tecnológico de Monterrey.

2. Theoretical Background

Energy sustainability is currently considered one of the most important topics in recent history. Because of environmental conditions, shortage of non-renewable resources and even the economic crisis, it has become necessary to look for new less-polluting energy sources which can also be made easily available to the population in general. Jiménez [3] states that energy sustainability is considered a new ethical approach that negotiates between society and the environment with a focus on long-term permanence, in addition to the responsibility of the current generation towards itself and future generations.

The World Commission on Environment and Development (WCED), established by the United Nations (UN) on 19 December 1983, defines sustainability as a way of life that reaches from individual necessity to, in a general sense, sustainable development. It can also be usefully defined as, “development that satisfies the necessities of the present time without compromising the capability of the future generations to satisfy their own needs” [4] (p. 4). According to Willrich [4], it is important to note that energy sustainability not only benefits the environment, but is also directly related to economic factors that lead to stability and better social development, since energy sustainability is the result of direct interactions between countries. Furthermore, he notes that energy sustainability must be assumed from an interdisciplinary perspective and as a critique towards non-sustainable attitudes that we hold in society, in order to generate the discussion and conscientious action capable of guiding us towards development [5–8].

Based on this understanding of sustainability and its role in the future of contemporary society, this piece of research looked for ways to measure how motivation and learning happen within the MOOCs, with a view to providing energy sustainability education designed to include innovative teaching strategies such as the flipped classroom, challenge-based learning, and gamification. Furthermore, it must be emphasized that MOOCs are considered, in themselves, to form part of the field of innovative education because they integrate cutting-edge technology to generate self-learning and self-regulation within the participants [9] (p. 9).

2.1. Innovative Education in the Design of the MOOCs for Training in Energy Sustainability

The type of Educational innovation that is sought in this article is the one defined by the electronic information space known as the Observatory. Thus, the disruptive innovation in education, that is what the authors are trying to do in this article, is define as: “proposal that has the potential to impact the entire educational context. Its impact allows the linear evolution of a teaching-learning method, technique or a teaching-learning process that changes drastically altering the linear evolution of the educational context, permanently modifying the way in which the actors of the context, the media and the environment itself are related” [10] (p. 1) (<https://observatorio.itesm.mx/edu-news/innovacion-educativa>).

Innovation, according to Drucker [11], innovation is the action of knowing instead of doing. According to Carbonell [12], innovation is, “a series of interventions, decisions, and processes, with a certain degree of intentionality and systematization”. The definition of innovative education is complex because it encompasses these ideas of creation, modification, discovery, intervention, intentionality and systematization, and integrates them with the problems of education: technology, teaching approaches, pedagogical processes, and people.

United Nations Educational, Scientific and Cultural Organization (UNESCO) [10] offers a definition of innovative education as a deliberate and planned activity for the solution of problems whose objective is to achieve better quality in the learning process of students by overcoming traditional paradigms. It implies, therefore, transcending the teacher’s knowledge and shifting from passive learning to a model where education is an interaction, and it is built by everybody. According to López and Heredia [13], innovative education implies the implementation of a significative change in the teaching-learning process. Within this transformation process, education is vital in the generation of a culture of innovation, where the principal goal is to transform innovation itself into a cultural approach to problem solving, not a fashion.

Innovation in developmental processes implies the elevation of the students’ minds to a superior level which will allow them to become critical in their own learning and their own context. Because of this, it is understood that innovative education not only facilitates the teaching-learning processes, but also forms individuals capable of answering global demands [13–17]. Thus, training in energy sustainability at all levels of society has become necessary for our present and future as humans, and as part of this process of transformation, the MOOCs were designed to train for energy sustainability.

2.2. Innovative Tools in the Sustainable Energy MOOCs

The innovative education strategies used in the MOOCs for sustainable energy were the flipped classroom, challenge-based learning, and gamification. A brief explanation of the three follows.

2.2.1. Flipped Classroom (FC)

The flipped classroom is a pedagogical model that makes use of technological advances to improve existing teaching–learning processes and respond to the global demand for accelerated change. The flipped classroom is presented as a Blended Learning model that represents the need to transfer part of the teaching and learning process outside the classroom, with the purpose of utilizing class time for the development of more complex cognitive processes in order to favor significative learning.

Two of its precursors, Bergmann and Sams [18], straightforwardly define this idea as referring to a model in which what is traditionally accomplished in the classroom is now done at home, and the tasks that were previously assigned to be completed at home, are now worked on in class. Gerstein [19], defines the flipped classroom concept (which is the same as inverted classroom concept) as an impulse towards a constructive learning theory that offers an affective learning environment as an added benefit, where the professors must be able to use technology to involve their students in the learning process. According to what Huber [20] has demonstrated, these methods are framed as inductive learning, which is characterized by achieving an active, self-regulated, constructive, situated, and social learning.

Within the studied MOOCs, the flipped classroom model is applied in the form of short videos that students can review in their homes prior to class, and then comment upon in the forums with their peers, the videos provide the basis to carry out the activities that correspond to each topic and for the students' interactions with the teacher and their peers [21]. For example, in the topic of conventional and clean energies, they are asked to review short videos (less than 5 min) and then discuss the topics in the forums and classify the analyzed technologies reflecting on their advantages and disadvantages. Subsequently, they respond to a questionnaire. The learning begins with a video that must be analyzed later when answering a questionnaire in which the answers appear with the explanation in order to deepen the students' learning and understanding of the topics. The videos allow the student to visualize what the solar cells are like, how they are installed, how they work, instead of only describing the concept in writing, as might have been done traditionally.

2.2.2. Challenge-Based Learning (CBL)

Challenge-Based Learning is a pedagogical approach that actively involves the student in a real and relevant context in order to resolve a problematic situation that they understand and that is linked to their actual surroundings; the model requires the definition of a challenge and the implementation of a solution. This approach has its roots in Experiential Learning, the fundamental principle of which is that students learn better when they participate actively in open learning experiences than when they engage passively in structured activities. In this sense, Experiential Learning offers students opportunities to apply what they learn in real situations where they face problems, discover and try out solutions by themselves, and interact with other students within a determined context [22].

The challenge-based learning approach was implemented in the studied MOOCs as a project completed collaboratively by students during the five-week period the course lasted, supported by the discussion forums [23]. For example, in the MOOC called: "*Energy: Past, Present, and Future*", students organized by teams of 5, had to design strategies that would impact the use of alternative energies or reduce the use of electric power from their homes. The objective of the challenges was that, throughout the course, the students would apply what they learned. For example, for a project intending to save energy in the home and reduce the electricity bill, the student would have to apply their knowledge of the management of unit systems, energy concepts and sustainability concepts. This approach is unlike Problem Based Learning or Project Oriented Learning since, in the former, the problems are shorter, and the objective is not defined, while in the latter, the project has a specific objective, but is not necessarily a challenge. This strategy was applied because it is necessary to

motivate and involve the MOOC participants in things which are tangible for them, so that they can become aware of the importance of energy sustainability and how it affects all people.

2.2.3. Gamification

Kapp [24] defines gamification as the utilization of aesthetics, the mechanisms of games, and recreational thinking to attract people, motivate actions, promote learning, and solve problems. Based on this definition, for the objective of this report, gamification is defined as the application of a game process and the corresponding mechanisms of resolving problems in order to obtain a reward. It can be applied to any problem that can be solved through the motivation and active engagement of the individual. According to Zichermann and Tixes [25,26], it is necessary to understand the difference between the game and play. The game implies having an explicit system of rules that guides users towards discreet goals and results and is therefore somewhat closed and structured. The game is found inside a circle separated from the real world. The objective of gamification is to try to draw the subject into such a circle by involving him or her in the game process by making the activities that are included in the process attractive and dynamic. The individual is moved by a reward to acquire new knowledge to resolve the game's problems. This strategy is effective for people that like to play games and like to win, since they will continue learning as long as they are acquiring points in the game.

Gamification is presented in different activities through the MOOCs in this study, with the purpose of engaging the student's attention in the learning of a given topic. Examples of gamification in the MOOCs were incorporated into activities of the inverted (or flipped) classroom, that is, once the learning of some concepts ended, the game followed, with MOOC students participating in activities that required them to play correctly using their knowledge of all the characteristics of a given technology, such as solar cells. If they succeeded, they earned points which could be considered in their final course score and this, in turn, helped them to obtain their MOOCs diploma. These games were designed on the platform to be entertaining, mimicking standard game features, such as applause sounds when they won, among others.

2.3. Learning and Motivation in the MOOC

Learning and motivation are inherent factors in the life of any individual with each being fundamental in leading people to search for a more extensive knowledge of the world that surrounds them, personal improvement and a better quality of life. Each person experiences learning and motivation differently, however, and, in the MOOCs studied, a diverse range of people of all ages and from different economic, social and academic levels were enrolled. A key challenge of such an educational context is to maintain students' attention during the training process to prevent students abandoning the course and to ensure that they fully understand the course content. For these reasons, it is crucial to analyze how participants perceived that their motivation and learning were impacted by the use of innovative educational strategies during the course.

Colvin and Rutland [27] define the Connectivist approach as the process of acquisition of dexterities and abilities and point out that learning takes place through links between nodes inside networks. Motivation is the impulse that human beings have to fulfill themselves in life and is related to needs of a physiological type which drive an individual toward self-realization. According to Maslow and Santrock [28,29], motivation is thus viewed as a group of internal or external factors that partially determine the actions of a person. Therefore, the MOOCs training students in energy sustainability have integrated tools that potentialize educational technologies to create an innovative learning environment which is attractive to students.

Advantages and Limitations of the MOOCs

Some of the advantages of MOOCs found in the literature were the following:

- They can reach a significant quantity of users from 1000 to 120,000 students [30].
- They are designed by areas of knowledge [31].

- Most of the MOOCs are free [32].
- The number of people that benefit from this type of courses is more significant than the number of people who take on-site courses [33].
- The user is the self-regulator of his/her learning [2,9].
- Some deliver the certification free for those who take the course (Tamez, 2014).
- It allows people who have previously not been able for economic reasons to continue a traditional type education [34].
- It facilitates, in principle, that formation and knowledge get to a higher number of possible recipients [35].
- It is based on the Connectivist theory of learning [2].
- Several types of MOOCs exist according to the audience to which they are directed [36].
- There is no established schedule to carry out the activities or exams, thus the courses adapt to the family or work situations of the students [32].
- Questions are resolved by employing the collaborative learning of the discussion forums [2].
- They fully use the tools that ICT offers with the purpose of potentializing the learning of the students [37].

Among some of the limitations in the literature review about MOOCs, we found the following:

- That access can only be obtained by people who have Internet and a computer [38].
- The student should have basic knowledge in the use and handling of the ICT [36].
- Some MOOCs have a cost and a registration limit [33].
- There is a significant dropout rate in these courses [33].
- The duration could depend on the user in the case of the free access and no-cost courses [33].
- Some MOOCs charge for the expedition of the certificate once the course is concluded, because of the prestige of the institution that offers such a course [33].
- The maintenance of the MOOCs is expensive for the organization that offers them [39].

3. Materials and Methods

In this piece of research, the mixed methodology has been used, with a triangulation design approach according to the convergent model, comprised of three stages: quantitative, qualitative and convergent. This is described by Hernández, Fernández and Baptista as follows, “the data collection and obtaining results of qualitative and quantitative analysis procedures are developed in parallel and, finally, are compared and contrasted in a convergent stage, in which the results are interpreted to reach conclusions based on both stages” [40] (p. 63). The goal of mixed research is not to replace quantitative research or qualitative research, but rather, to use the strengths of both types of inquiry by combining them and trying to minimize their potential weaknesses. In this way, Figure 3 presents the methodology used by the present investigation.

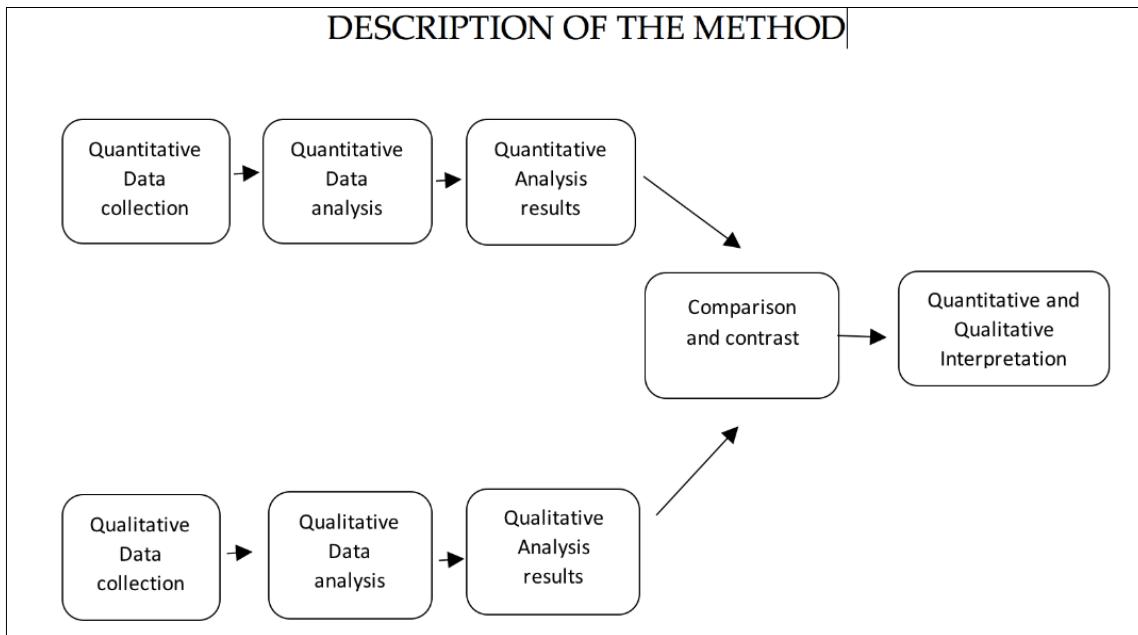


Figure 3. Schema of the mixed research method with a convergent triangulation design approach.

Some of the advantages of the triangulation approach are that the methods provide more reliability and validity in the results, more creativity in the development of the study, and flexibility to interpret the results. In addition, mixed research methods represent the systematic integration of quantitative and qualitative methods in a single study in order to obtain a more complete “picture” of the phenomenon [41]. Hernández (2010) suggests that this type of instrument provides an advantage in the crossed validity although the challenge resides in that it can sometimes be complicated to compare results between studies. Therefore, the mentioned author states that “this model is probably the most popular and used when the investigator seeks to confirm or to corroborate results and to make crossed validation between quantitative and qualitative data” [40]. The data are commented, according to Creswell [42] from “side to side”. This means that the statistical results of each variable and/or quantitative hypothesis are included, followed by categories and qualitative segments, as well as the based theory that confirms or not the quantitative discoveries. Also, the design can embrace the whole investigative process or only the collection, analysis, and interpretation phases [20].

In the present investigation, some focus groups were formed with some of the participants to enrich the qualitative section of this research. The observation technique was also applied in one of the interaction forums, and finally, the triangulation technique was added to lend more significant credibility to the results. The surveys, the focus group, and the observation (see Table 1) are instruments that were designed to strengthen mixed model research because the triangulation design approach, according to the convergence model, requires the use of several instruments for its validation [41] (p. 570).

Table 1. Instruments for data collection.

Quantitative	Qualitative
Survey by questionnaire in Likert Scale	Focus group Observations

3.1. Instruments

This study is based on using a mixed method approach, and therefore, a survey by questionnaire of the Likert type was applied parallel to the focus groups and observations, with the latter specifically applied to the case of forums in MOOCs. The questionnaire made use of an online application, the Google Forms tool, which allows for and facilitates the processing of the information

obtained. From the above, it can be said that the data will obtain double value and meaning for the understanding of the problem, that is, both qualitatively and quantitatively (Moreno, M., 2000). Although the survey by questionnaire in Likert Scale was designed with many questions for many research purposes, in this article the authors only selected the questions that refer to learnings and motivations, those are presented in the graphs of the results section. Most of the questions in this instrument are the same for the initial questionnaire that was applied to the students, and for the final one.

The following table shows the data collection instruments that were used for each research method.

3.2. Validation and Reliability of the Quantitative Instrument

The validation of the quantitative instrument (survey with Likert scale that was applied to the participants in the MOOC) is described in the following paragraphs according to the process that Valdivia [23] developed for the MOOCs that are studied in this piece of research. The process of content validation was summed up in four stages: the conception of the purpose and structure of the instrument, the design of questions, the application, and the revision. The final version of the survey was liberated for application in January of 2017, the date when the two MOOCs: "Energy: Past, Present and Future" and "The Energy Reform of Mexico and its Opportunities" were liberated on the platform Mexico X. These two MOOCs were designed for the first phase of the Project of the *Binational Laboratory for Intelligent Energy Sustainability Management and Technology Training*. The collection of information using this instrument has continued in later courses. The index of reliability was determined by calculating the alpha coefficient of Cronbach, which had a value of 0.89, which indicates that the results of the survey are very stable [23].

3.3. Participants of the Energy Sustainability MOOCs

There could be a great diversity of participants in these MOOCs, almost everybody can have signed up for these basic MOOCs about Sustainability, with an age range from 13 to 70 years, different academic levels, and varying professional and geographical contexts. The key principle behind implementing MOOCs to provide training in energy sustainability is to reach the highest number possible of people with this knowledge [42,43]. However, due to the fact that the authors have no control of the people who signed up for these MOOCs, it was necessary to resort to convenience sampling for this study using the data from the people who had signed up. Thus, the sample used for this study was the people who signed up, and the demographic analysis of the participants in this study is been described in the results section.

3.4. Procedures

For the purposes of this research, a series of steps have been designed for scientific rigor in the process of construction of new knowledge:

1. The research topic was chosen, taking into account the study environment of the research.
2. A review of several materials about the phenomenon was carried out, in order to elaborate the approach to the research problem and its contextualization, which was enunciated in the form of a question.
3. The objectives are written aims to achieve in the research and comprise the justification for the research.
4. The delimitation, or limitations, were raised.
5. A review of the literature on research approaches was carried out, the mixed approach was selected.
6. We proceeded to the selection of the study population, in this sense the participants of the four first MOOCs.
7. The questions of the instruments were integrated according to the research question that was intended to be answered, the observation in the participation forums and the results of the

- Likert-type surveys.
8. The analysis and interpretation were done with bar-type graphs using Tableau.

3.5. Data Analysis

Based on a triangulation design, it was necessary to define if the same individuals would be analyzed to obtain both quantitative and qualitative data, and achieve convergence, confirmation and/or correspondence or not, of both methods. The emphasis of the analysis is on the contrast of both types of data and information. In the case of this project, the same population was used as an object of study and a mixed method was used, as justified above. For quality purposes, Microsoft Excel 2016 computer software was used for the accuracy of the data and then presented in statistical graphs [44].

4. Results

The results were analyzed according to on the theoretical framework described above and in accordance with the research question: "What is the learning and the motivation perceived by the participants of the MOOCs about energy sustainability that integrate innovative education?".

4.1. Basic Data from the Participants

In the four MOOCs that were analyzed for this study, a total of 17,210 participants from different countries were enrolled. Only the responses of 5713 participants who answered the initial survey (quantitative instrument) and 1519 who answered the final survey (quantitative instrument) were analyzed.

The information retrieved from the 5713 participants that answered the initial survey was the sample for this study. The analysis of this sample showed that: 38.6% were female and 61.4% were male, 95% were from Mexico and 5% from other Latin American countries distributed in 12 countries. The maximum level of the participants' studies was: 26.6% from High School, 9.2% technical studies, 47.3% with a bachelor degree, 11.7% with a master degree, 1.2% with a Ph. D. and 4.1% from others (the latter means from secondary school and people that have no formal education). The disciplines that have the participants that reached formal education are: engineering 39%, Natural Sciences 12.4%, Social Sciences 6.6%, Humanities 2.4% and the rest from others. Also 5% of the participants were unemployed at the time they took the MOOC. The previous experience from all the participants with a MOOC was that 48.6% did take it for the first time.

4.2. Results of Quantitative Instruments

4.2.1. Initial Survey to Measure Insterests and Motivation to Study the MOOCs

In order to understand the initial motivation of the participants that enrolled the MOOC, Figure 4 presents the statements that were included in the initial survey and that was applied to them. In this category, a survey was applied based on a Likert scale format closed question questionnaire where the perception of the students at the beginning of the course was analyzed. This questionnaire was sent to the 17,544 students who enrolled in the four MOOCs, from which, only 5713 participants answered this initial survey. It can be observed in Figure 4 that between 40% and 60% responded with "strongly agree" that, when registering in the MOOC, they would obtain a better educational formation, as well as helping them in their professional development, getting work and business opportunities, and finally they considered themselves to have the required ICT abilities to conclude the course. Nearly 6% "did not answer", and around 4% "disagree" on that this course could improve their work and business opportunities. Also, around 4% "disagree" on that this course could facilitate the establishment of professional relationships.

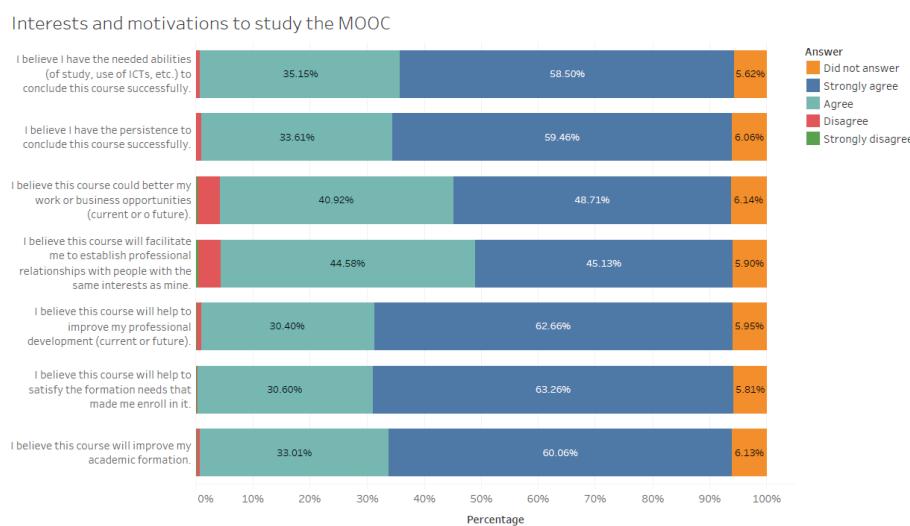


Figure 4. Interests and motivations to study the MOOCs.

4.2.2. Final Survey to Measure Teaching-Learnings Strategies with the MOOC

At the end of the MOOCs analyzed, Figure 5 shows that from 1519 participants that answered the final survey, 55.56% of the respondents consider that they "strongly agree" that they learned from

others by the discussion forums. However, some observations from the forums show small collaboration between participants; this issue will be commented on in more detail below. Also, students seem to like evaluation by pairs, 55.56% answered “agree” and 44.44% considered that they “strongly agree”. Most of the students agree that the games motivated their learning, only 11.1% “disagree” on that the design of activities with games are innovative, and that the games motivate the students to solve the exercises.

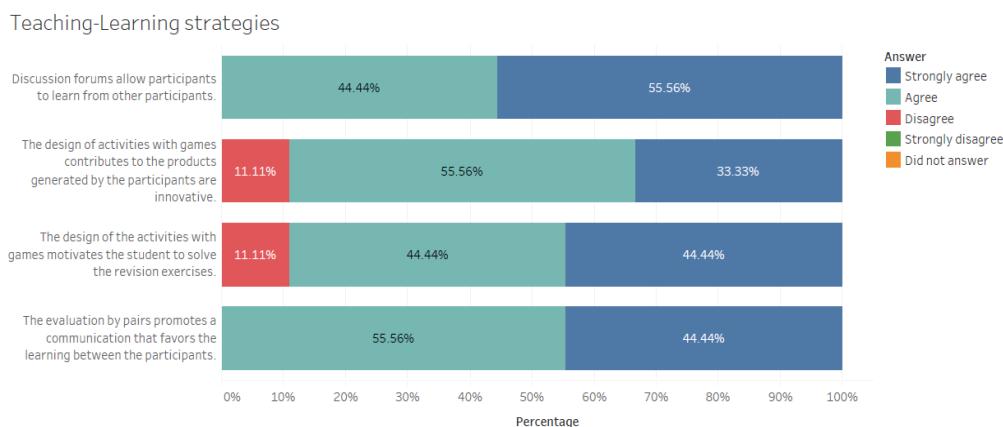


Figure 5. Teaching–learning strategies.

4.2.3. Final Survey to Measure Interests and Motivations after Having Studied the MOOC

The objective of the final questionnaire was to gather information about the learning experience from the students that concluded the courses. Again, this final survey was answered by only 1519 participants (10% of the original enrolled people). Figure 5 shows the results obtained regarding interests and motivations when applying the final survey; only the questions related directly to the studied variables are integrated. It is important to highlight in Figure 6, on the positive side, that more than 60% of the students perceived as “strongly agreed” that this course satisfied the education promised that made the student enrolled in this course. On the negative side, 12.9% “disagree” that this course facilitates the student’s ability to establish professional relationships.

Figure 6 shows that the students who took the MOOCs were “in agreement” that the courses met their initial expectations and that they improved their academic form due to the content that was covered. Other instruments, besides the survey applied in the Likert scale, were designed to analyze in detail the results of the qualitative method; these were: forum observation and the focus group.

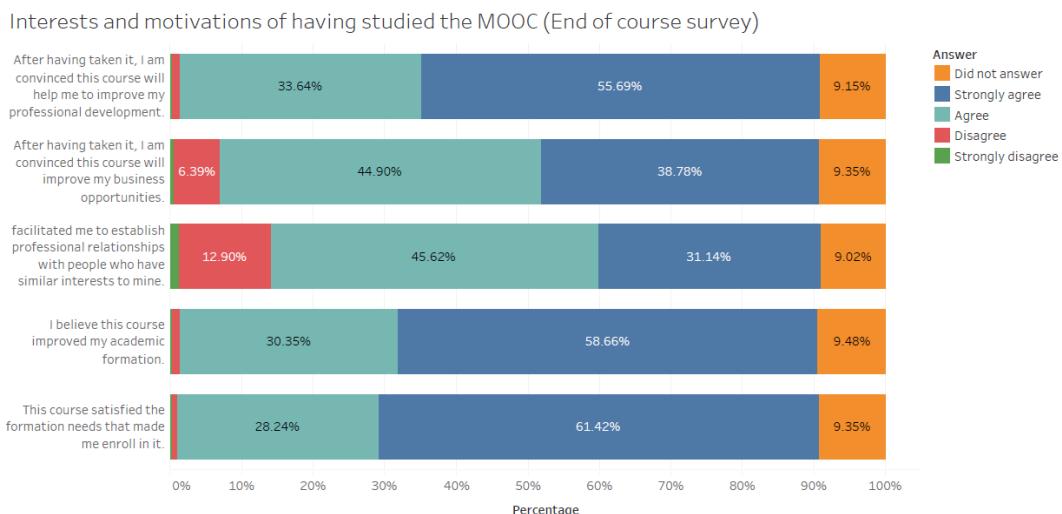


Figure 6. Interests and motivations of having studied the MOOC.

4.3. Results of Qualitative Instruments

4.3.1. Observations of the Researcher with Respect to Focus Group

Focus groups is a kind of group interview, which consist of meetings of small or medium groups (three to 10 people), in which the participants talk about one or several topics in a relaxed and informal environment, under the guidance of a specialist in group dynamics. Beyond asking the same question to several participants, its objective is to generate and analyze the interaction between participants [39] (p. 425).

To select the participants of the focus group, emails were sent to 10 of the participants of the MOOC courses. These participants were chosen based on their proximity, to be able to interview them in the scheduled sessions. However, due to the size of the MOOC participants that was analyzed, this focus group was repeated 3 times with a different and random choosen sample in order to corroborate the information provided. Table 2 summarizes the most relevant ideas related to the objective of the research.

4.3.2. Observations of the Researcher with Respect to Participation in the Forums

In the forums of each MOOC, little interaction was observed among the students. Even though they had the opportunity to get feedback from peers, the tendency was to do their comments and interventions in an isolated way. This means that the students used the forums mainly to see other students' participation, to read other comments, and not really to answer the others comments. In other words, the observations to the forums made by the researchers, at least twice a week, show that the students did not want to collaborate with others through the forums. Probably, they were inhibited by the large number of participants.

On the other hand, it was evidenced that the participants lent more interest to the activities and projects (practices) that the courses requested. A factor that could likely have harmed this interaction was the automated feedbacks from the experts and teachers.

Table 2 presents the questions asked during the focus group, in addition to the answers with only the key phrases that the researcher is interested in and which the participants expressed.

Table 2. Perception of the students who coursed the MOOCs about energy sustainability (focus group).

ITEM	What motivated you to enroll in the MOOC?	Describe your perception regarding the learning objectives of the course.	Which would you mention was your principal interest to decide to study the MOOC?	How do you consider was your performance in the course?	Would you consider that the interaction in the forums potentialized your learning? Explain...	Did the course satisfy your formation necessities?	Other comments
PERCEPTION	We decided to enroll in these courses because the professor that imparted a subject of the Master's in Educational Technology invited us to have contact with the experience of online courses.	We considered that the objectives were clear, defined in energy sustainability topics and related to the projects to be performed.	In the first instance, learning and knowing the topic about energy sustainability as well as understanding the instructional design of the MOOC intimately.	We believe it was very good. We passed the courses in which we enrolled.	We consider they help a little to the interaction because the lines of conversation do not allow all participants to follow them.	In a certain way, we can say yes, because we were interested in learning about energy sustainability, which represented a challenge because of our lack of knowledge about the topic.	We believe the dynamic was pretty enriching because, in some cases, it was our first experience with a MOOC related to this topic.

5. Discussion and Conclusions

The principal conclusions that can be reached from this study are analyzed in response to the research question: "What is the learning and the motivation perceived by the participants of the MOOCs about energy sustainability that integrate innovative education?".

First of all, analyzing the demographic data from the participants that signed up for the four first basic MOOCs and did answer the survey; it can be observed that many people were interested in this kind of knowledge, 26.6% were from High School, and 4.1% was people from secondary school and people that has no formal education. Therefore, there is motivation from young people (age from 13–18) to learn topics about Sustainability, and the MOOCs that were designed could be an efficient strategy to deliver this knowledge. This is the reason why the people that designed the MOOCs wanted to add activities with innovation such as gamification or challenge-based learning, to engage more people. In this way, the MOOCs could have more variety of activities and elements: projects, videos, games, etc. Also, 5% of the whole sample of participants were unemployed at the time they participated in these MOOCs, meaning that this could also be a motivation for learning while you are not working.

The topic of energy sustainability was of interest to the majority of the participants from the beginning, and it was suggested that it is also a topic that is useful in their professional development. Some mentioned benefits about getting better work and business opportunities due to this knowledge because it permitted them, among other things, to broaden their contacts and collaboration networks (this information was obtained from the focus group).

The primary motivation for the students, that is reflected among the answers from the diverse instruments applied in this study, is that when they learn about topics relating to energy sustainability, they have a more significant opportunity to grow in their jobs, in their professional development and, in some of the comments, they even acquire a greater awareness of their environment.

Another observation related to the motivation in this study was the restlessness among the students about the way in which the forums of the MOOCs were administered. Since they were uncertain about whether their participation would be given feedback by the advisor, or they were uncertain because the answers were given in an impersonal tone and replicated in a short time, which gave the impression of their being automated. This could have caused the students to experience the feeling of being alone in the learning process and caused a lack of participation, both student to student and teacher to student. In contrast to the authors of [2] who ensure that questions are resolved through forums through collaborative learning in the discussion forums, in this case, the forums with a large number of students (as in a MOOC) did not work as effectively as it could with a small number of students (meaning 30–40 students as in a regular class). However, in the projects applied with Challenge-based Learning, that are mentioned in Section 2.2.2, the students did participate in small teams (of 5 each), and that worked well. In the end, the initial motivation was the driving force for the students to finish the course, that is, the learning of sustainable energy.

Regarding teaching content, according to the quantitative results, more than 60% of the students "strongly agreed" that this course satisfied the promised education that made the student enrol in the course; the results from the qualitative section confirms this statement. However, 11.1% "disagree" on that the design of activities with games are innovative, and that the games motivate the students to solve the exercises. In the focus groups, some of the comments related to the question "others" were because this was the first experience with MOOC, and they believed this dynamic (activities) was enriching. As a conclusion about the content at the end of the course, it could be said that, because between 30–60% answered that they "strongly agreed" in questions related to their learning, the main purpose of the MOOC design was achieved. This design included some educational innovations. More students agreed than disagreed in the sense that they did learn what was expected since the beginning of the course. Some of the advantages of designing MOOCs that make use of innovative activities is to engage the students as much as possible, and the collateral impact on the development of digital abilities and skills in addition to the learning acquired with respect to sustainability.

The education for sustainability through MOOCs, with innovative strategies such as gamification, challenged based learning and flipped classroom, allows the participants to learn the concepts from different perspectives. It is not just reading and writing, nor presenting some exams. It helps to keep the learners engaged, which could include people from a very young age to older ones. It also allows for a large number of people to sign up, and to learn from basic to more complex concepts about sustainability. Also, the Webpage itself, where the MOOC is, provides more information about the topics. Furthermore, it is important to note there was some content that was not readily accessible to students, except for those who had previous knowledge of the subject or who belonged in some way to the field of knowledge. One of the benefits of MOOCs is precisely that they can be thematic; but this time they were directed to the general public. Therefore, it would be important to consider either adapting the content using more accessible language or clarifying more precisely the target audience. The topic of energy sustainability is vital for our planet because it envisions a better cultural attitude towards our environment and the possibility of building a better present and future for our society. In this sense, the MOOCs significance is in their potential to recruit many people around the world to learn about energy and sustainability and participate in this vision.

Author Contributions: D.R.H contributed to the writing of the Introduction, conclusions and the finalizing the paper, J.C. wrote Theoretical Background, D.R.H, and J.C. wrote the Material and Methods, analyzed the data and wrote the results.

Acknowledgments: This paper is presented in the framework of the Project 266,632 “Binational Laboratory for the Management of Intelligent Energy Sustainability and Technology Education” with funding from the Energy Sustainability Fund CONACYT (Consejo Nacional de Ciencia y Tecnología). SENER (Secretaría de Energía de Mexico), Call: S0019-2014-01. The support of CONACYT and Tecnológico de Monterrey is acknowledged and deeply appreciated.

Funding: This research was funded by CONACYT-SENER grant number Call: S0019-2014-01.

Conflicts of Interest: The authors declare no conflict of interest.

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Por favor referenciar este artículo como:

Carrera, J. and Ramírez-Hernández, D. (2018) Innovative Education in MOOC for Sustainability: Learnings and Motivations. *Sustainability*. Special issue Teaching and Learning for Sustainability, *10*(9), pp 1–27. <https://doi.org/10.3390/su10092990>.