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Veröffentlichungsversion / Published Version
Zeitschriftenartikel / journal article

Empfohlene Zitierung / Suggested Citation:
Tsaple, V., & Tzionas, P. (2019). Qualitative system dynamics models to assess the effect of MOOCs on the system of tertiary education. *Journal of Contemporary Education, Theory & Research*, *3*(1), 3-8. https://doi.org/10.5281/zenodo.3598665

Qualitative system dynamics models to assess the effect of MOOCs on the system of tertiary education

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Abstract: *Massive Online Open Courses (MOOCs) are an innovation in higher education that cause disruptions in the traditional operation of universities. For this reason it is important to understand what their effect may be in the tertiary level of education. The purpose of this paper is to study this effect under a Systems Thinking perspective. For that reason, several Causal Loop Diagrams (CLDs) were developed with the variables derived from a literature review and interviews with students and teachers. These CLDs showed that communication and collaboration among students and with teachers, cost and language are elements that determine the behavior of the system of tertiary education and the MOOCs integration. Furthermore, they can be seen as an important tool for academic advancement and a means for participation in innovative research. However, higher education is a complex system and there is the need for more advanced and/or quantitative research to fully comprehend the effect of MOOCs on it.*

Keywords: *Massive Online Open Courses; Systems Thinking; System Dynamics, Causal Loop Diagrams; tertiary education*

JEL Classification: *I20, I23, I29*

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1 INTRODUCTION

The rapid development of technology has invaded almost every aspect of people's lives. Similarly, in higher education, technology offers alternative ways of education, different from the traditional, cheaper and easier, making a lot of universities to feel threatened (Finkle & Masters, 2014).E-learning made its appearance many years ago. Since the 1990s a lot of universities have offered their lectures electronically and asynchronously. Entering the new millennium, the development of simultaneous electronic contact, has helped the universities to develop real time communication. In the same way, the opportunity was offered to attend lectures live, without preventing many teachers from sharing their educational material with the students by using the asynchronous e-learning (Finkle & Masters, 2014).

In 2002 MIT started an innovative open global educational movement through Open Educational Resources (OER) (Vardi, 2012). In this way MIT has invited many universities around the world to create open libraries, in order to improve Higher Education and lower their costs. This educational movement helped a lot of people to acquire knowledge either to complete their degree or to promote their career, while burdened by professional or family obligations.

Even nowadays, higher education has been very difficult for millions of people around the world. An important tool to fight this, are Massive Open Online Courses (MOOCs) which are not only offering access to quality education but also, with the help of NGOs, can contribute to addressing social problems such as poverty and gender inequality (Patru &

ISSN: 2654-0274. UDC: 658.8+338.48+339.1+640(05)
http://doi.org/10.5281/zenodo.3598665
Published online: 19 April 2019

Balaji, 2016). This kind of education may not change university radically, but it can certainly be very useful (Pope, 2014).

The core of MOOCs is about free, online learning experience, accessible to all (Patru & Balaji, 2016). These courses are offered through electronic, profit-making or non- profit platforms, such as Coursera or edX to anyone who wants to attempt them and registration in each lesson can be done without any criteria and without a fee (Friedman, 2013). The broad appeal of MOOCs has forced a lot of universities to create their own electronic platforms in order to offer their lessons (Billsberry, 2013).

Even though MOOCs describe the full range of these online courses, most scholars specialize them by dividing them into two groups according to the teaching method applied (Billsberry, 2013). Specifically, there are xMOOCs, in which the traditional frontal teaching method is used through a video lecture (Billsberry, 2013) and cMOOCs in which a completely different teaching method is used; students themselves create the knowledge and communicate with each other with the teacher in the leading role (Billsberry, 2013); (Admiraal, Huisman, & Pilli, 2015).

MOOCs have caused a variety of reactions as they have a lot of advantages and disadvantages (Billsberry, 2013). Some suggestions have already been made to improve some of these such as how to evaluate and obtain certification (Reich, 2015). Additionally, it is certain that MOOCs, as an educational innovation with an increasing impact, will be a pole of attraction for many researchers (Billsberry, 2013). Whether their use is increased or not, it is certain that new teaching methods are being used in order to offer knowledge to anyone (Billsberry, 2013).

After the literature review, it has been found that there is no research that focuses on how MOOCs could affect the entire system of tertiary education. Moreover, there has not been an extensive research on what are the elements that may affect and be affected by MOOCs. In conclusion, there has not been a formal systemic study of the role and place of MOOCs in higher education.

In order to get such a view of the tertiary system of education, it is necessary to employ a methodology that allows a systemic, top-down approach, where elements of the system can be seen as individual variables and more importantly, causal relationships are essential for its study. Systems Thinking and its operational form - System Dynamics- is such a method. It is based on differential equations that are used to simulate systems and their behavior over time (Sterman, 2000); (Senge, 2014); (Pruyt, 2013). Systems Dynamics are fundamentally interdisciplinary and the importance is the discovery and presentation of feedback loops that in combination with stock and flow structures, time delays, non -linearity, determine the structure of a system (Forrester, 1970).

The objective of the present paper is to study the structure of the higher education system with the presence of MOOCs and to investigate the behaviour that may occur in time, using System Dynamics. The rest of the paper is structured as follows: In the next section, the research methodology is presented, with a literature review and a small explanation of System Dynamics and Causal Loop Diagrams. Further, the structures of the various models that have been developed are presented with explanations on their results. Conclusions and future research directions are presented in the last section of the paper.

2 THEORETICAL FRAMEFORK

Although MOOCs are online courses in general, they have some differences between them, depending on how teaching and learning are achieved (Billsberry, 2013). Most scholars categorize them into xMOOCs and cMOOCs (Billsberry, 2013). Firstly, xMOOCs are lessons based on the traditional frontal teaching method. The course is videotaped and entails questions and/or quizzes. It shares a similarity with the traditional, class courses and the instructor prepares the training material, and the direction of the learning process (Admiraal, Huisman and Pilli, 2015; Baturay, 2015). On the other hand cMOOCs are lessons which employ a completely different pedagogical method, in which students lie at the center of knowledge creation by forming and articulating opinions (connectivism) (Billsberry, 2013). In this kind of lessons, the instruction has the role of a mentor who helps students to discover the way of studying (Admiraal, Huisman, & Pilli, 2015).

Finally, beyond these two most prevalent categories of MOOCs, some scholars believe that there is a third one called sMOOCs in which a holistic approach is used based on cultural elements such as language (Patru & Balaji, 2016). In this type of MOOCs the instructor plays the role of guiding the students to discover their individual studying process. It is based on discussions, reflections and constant communication among students and/or instructors (Kaplan & Haenlein, 2016).

Many of the world's largest and best known universities offer their courses with MOOCs, through online platforms that already exist or are created from the beginning. The most well-known are Coursera(www.coursera.org), EdX(www.edx.org) and Udemy(www.udemy.com).

Like all new subjects that appear in the front line of research, the use of MOOCs has caused a variety of reactions (Billsberry, 2013).

MOOCs were not the first attempt of the universities to offer their educational material to anyone (OpenCourseWare or OpenLearn). These programs had a lot of problems though. Even though students had access to lectures and educational notes, they did not have a complete educational experience and the communication was not existent. Thus, it was very easy for them to quit. MOOCs addressed these problems by providing courses which are open to everyone and are designed in such a way that can support an unlimited number of participants. In addition to attending the lectures, the enrolled students are allowed to participate in forums where they can communicate either with their teacher or with peers. A lot of universities also, provide the opportunity to obtain certification to anyone who wishes, by paying a certain fee (Billsberry, 2013).

Another important aspect of MOOCs is that through these courses knowledge can be accessed by everyone, regardless of their location or their financial situation. They only need internet access (Billsberry, 2013) without being limited by the need for simultaneous communication, since they are

offered asynchronously, giving students the opportunity to attend classes in their own time and space (Kaplan & Haenlein, 2016). The importance of this feature of MOOCs is really big especially for people with mobility problems (Friedman, 2013).

Except from the opportunities that MOOCs offer to pupils, they offer advantages to teachers and university institutions as well. MOOCs are a way to achieve fame, and attract students other than the traditional approaches (Kaplan & Haenlein, 2016).

On the other hand, there are a lot of researchers that disagree with the creation and use of these lessons (Billsberry, 2013). First of all, they believe that a lot of universities are providing MOOCs in order to achieve some of their policy goals. Either to promote their best projects or to promote themselves as institutions that actively participate in educational innovations. If so, it is certain that MOOCs will not last for long since the real reason for creating and using them is totally different (Billsberry, 2013). It is also a great concern for universities the fact that they could lose many foreign students on whom they rely for much of their income, since MOOCs offer the opportunity to gain a degree from a distance and at a lower cost (Billsberry, 2013).

Although MOOCs promote equality and free education, their market penetration has not been extremely high because so far only educated people with internet access and the technological skills have participated. Access is not easy for anyone, especially in developing and underdeveloped countries (Patru & Balaji, 2016). Furthermore, completion percentages have never been high and it is considered that MOOCs suffer from the lack of personal contact between an instructor and a teacher (Pope, 2014; Brahimi & Sarirete, 2015; Kaplan & Haenlein, 2016) . This issue is especially important, since according to the research by (Gameel, 2017; Qayyum, 2017), interaction with instructors plays a major role for students.

To address the issues, universities attempt to hire people whose sole responsibility is to teach and interact with MOOCs students. Furthermore, the platforms that host these courses are enriched with new innovative features that promote communication (Pappano, 2012). However, these costs increase the overall cost of establishing and operating MOOCs.

Finally, impersonation and plagiarism are also important problems that need to be solved soon. The identity of participants cannot be easily verified either on attending or participating on projects and forums, but also in evaluating and acquiring certification (Sigala & Christou, 2009; Reich, 2015). These problems are aggravate by the fact that several learning fields require exams and not being able to understand who took the exams renders it hard to put a just and fair mark (Billington & Fronmueller, 2013 ; Dolan, 2014).

As a result, the quality of the courses (Vardi, 2012), communication and assessment of the whole learning process (Guàrdia, Maina, & Sangrà, 2013) are elements that could contribute to the success or not of integrating MOOCs in the system of tertiary education.

Despite the many disadvantages and concerns raised, for some students, especially adults who want more training, even failure in a free MOOC is more profitable than the traditional way of attending a classroom for several hours in at a time (Pope, 2014). Research concludes that more and more universities will resort to offering at least part of their curriculum via MOOCs (Finkle and Masters, 2014).

What is certain is that more effort are necessary to fully comprehend them and their effects, in order to remedy the handicaps that, like any other innovation MOOCs face (Patru & Balaji, 2016). One approach could be to regard the system of MOOCs as part of the whole tertiary education system. To do so, it is essential to employ a methodology that embraces the systemic perception.

Systems Thinking and System Dynamics

Systems Thinking (Senge, 2014) was developed with the purpose of providing a formal frame of reference to treat the world as a complex system in which everything is connected and interacting (Sterman, 2000). The operational branch of Systems Thinking is the System Dynamics methodology; inherently interdisciplinary, they rely on the importance of feedback loops that along with the stock and flow structures, time delays and non-linearity, determine the behavior of the system under study (Forrester, 1970).

In System Dynamics, various tools are used to interpret the structure of the system, and one of them is Causal Loop Diagrams (CLD). CLDs are qualitative models that map the elements/variables of the system and show the causal relationships that are formed among them. Furthermore, it is an easy way to clearly observe feedback loops that can give rise to complex behavior (Myrovali, Tsaples, Morfoulaki, Aifadopoulou, & Papathanasiou, 2018; Tsaples & Armenia, 2016) . There are two types of feedback loops, the positive and the negative ones. Positive loops tend to reinforce whatever happens in the system. Negatives on the other hand, oppose and react to change and describe the processes that tend to be self-limiting and seek balance (Ford, 1999).

It must be stated that CLDs do not predict what is going to happen to a system, but they represent the structure of it and how it could behave in time under certain circumstances. Additionally, an increase in a variable does not necessarily mean that the result will also increase and this is because a variable often has more than one input. In order to determine what is really happening, the way to change the inputs must be disclosed (Sterman, 2000), in other words translate the CLD into a quantitative model.

As a result, CLDs may have disadvantages but they can be a first step to understand a system and its behavior. Furthermore, from the study of the literature it was not found (to the best of our knowledge) any attempt to address MOOCs from a systemic point of view. Hence, this is the first effort to study MOOCs with System Dynamics and Causal Loop Diagrams

3 METHODOLOGY

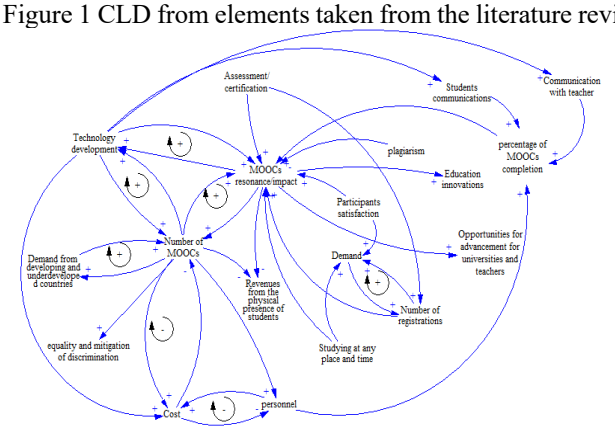
As it was mentioned above, to the best of our knowledge there has not been a systematic effort to comprehend how MOOCs fit into the whole system of tertiary education and how it can affect it in time. To achieve the objective of addressing the gap, the present paper will employ two different methods: First, a literature review was conducted.

Databases were accessed using the keywords: "MOOC", "Online Courses", "University", "System Dynamics and MOOCs". The literature review offered glimpses on how the academic world views the various issues regarding MOOCs. The main findings of the review were translated into systemic variables that were used for the development of Causal Loop Diagrams (the qualitative branch of System Dynamics). This part offered a top-down view on the system of tertiary education according to research. However, an attempt was made to incorporate more perceptions, hence interviews were conducted with university teachers in Greece and people who have attended MOOCs. For each of the four interviews, a different Causal Loop Diagram was developed and their analysis revealed the common elements, the differences and potential behaviours of the different perceptions.
The following paragraphs describe in detail the research process and the results of the current paper.

4 MODEL STRUCTURE AND RESULTS

CLDs are usually developed from observations, interviews and discussions with experts. However, in general they tend to represent only one perception of the system under study- the one that all participants agree/compromise on. A different approach was followed on the present paper: It was assumed that MOOCs and higher education can be perceived differently by people. Students understand differently than teachers and researchers/academics attribute significance to different elements than students.
As a result, for the present paper, five different CLDs were constructed. One with information from the literature and four from interviews with people who have knowledge and/or actively participate -with different capacities- in MOOCs. In more detail, two of the interviews were with university professors who have actively taught in MOOCs and two with students.
The purpose of the development of five CLDs is to investigate how MOOCs are comprehended by different people with different perceptions, what are the main differences and what are the common elements from which generalizations could be inferred.
Taking elements from the literature review of the previous section, the first CLD was constructed and can be seen in the figure (Figure 1) below.

Figure 1 CLD from elements taken from the literature review



At a first glance it emerges that the higher education system with MOOCs is very complex, indeed even more complex than originally hinted at the literature, and a simple theoretical analysis may not be enough to study the issue and draw safe conclusions. Furthermore, several small feedback loops are formed between sets of two variables, positive in their majority.
The most important variables appear to be Number of MOOCs and MOOCs resonance/impact. Their importance is measure by the number of causal relationships that originate from them and those that end in them. As a result, it can be concluded that so far in their evolution, MOOCs seem to depend on their "fame" across the world and the variety in which the universities offer them. Thus, the CLD illustrates that the reasoning of many universities as a means to attract students can act cumulatively; the better the fame, the higher the number of students that are willing to attend.
Furthermore, elements like communication (either among students or with teachers) appear to play an important role in the development of MOOCs, since they could have an increased impact (through proxy causal relations) to the number of MOOCs and their impact. Moreover, these elements appear in a number of positive feedback loops in the diagram, which constitute the majority of the loops. These reinforcing loops entail an inherent danger: as long as they act positively (behavior is desired) they can reinforce the positive evolution. However, if the direction of change for some reason is negative (undesired behavior) then an exponential deterioration of the values of the variables can be observed.
Finally, the equilibrium loops in the CLD (negative loops) involve the variable of Cost. As a result, their number may be smaller compared to the reinforcing loops, nonetheless their significance/effect on the system more important, since cost is considered in the literature one of the most important factors that will determine the evolution of MOOCs in higher education.
Consequently, the CLD with variables from the literature has demonstrated the struggle between the desire to have MOOCs as part of the curriculum and the cost associated with such an infrastructure. The nature of the diagram however, does not allow to determine which of the loops will prevail in the long-term; cost may participate in only one loop, but its strength could be such that overcomes all the positive aspects of the system.
The first two interviews were conducted with people that have attended MOOCs. The figure (Figure 2) below illustrates the CLD that was developed from one of the interviews. The first difference to notice is that the CLD of the students are in general simpler than the one constructed with elements from the literature review. Thus, students have not thought about MOOCs and higher education in its entirety, bur focused only on those elements that can have an immediate impact on them.

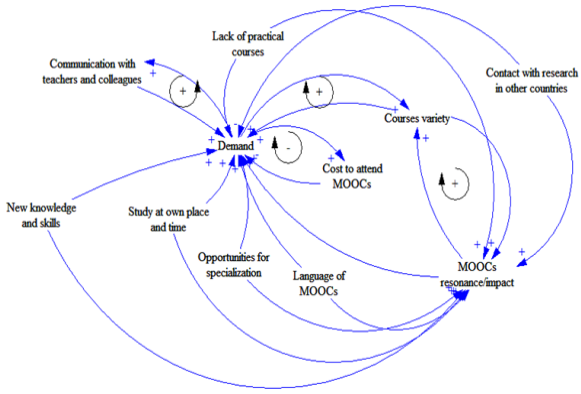


Figure 2 CLD from the interview of one of the students

Furthermore, it becomes evident that acquiring new skills and knowledge is very important for people that think about attending MOOCs. Similarly, the opportunity to study at their own pace is one of the most important elements of their perception and the demand for those courses.

However, the CLDs present also common elements. These focus mostly on the communication with the teachers and their colleagues. Similarly, cost and language are two important variables in the system. Finally, it should be noted that once again positive loops still are the majority, however, cost is still central in a negative loop. Thus, it is necessary to continue research by developing a quantitative model and examining what is the impact of cost.

The other two interviews were conducted with university professors/academics that participated in the conduction of MOOCs. The figure (Figure 3) below illustrate the CLD that was developed from one of those interviews (the CLD from the other interview is similar).

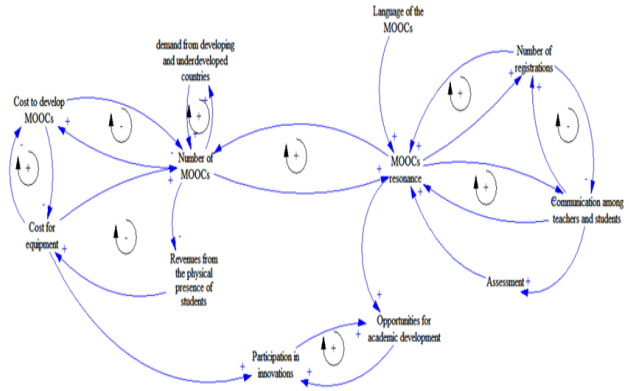


Figure 3 CLD from the interview with one of the teachers

It can easily observed that the CLD shares a lot of the variables with the one from the literature review, despite it being less complex. Furthermore, it has common variables with the CLD of the students, like communication. As a result, it is an element that appeared in all the CLDs, which indicates that it is one aspect of MOOCs that needs further investigation in order to assess its importance.

Furthermore, new variables are introduced in the diagram that are focused on academic development and participation in innovative research. It appears that these variables are of extreme importance for academics and in that direction, MOOCs are seen as an important element for fame, revenues and an opportunity to buy equipment that can be further used for research.

Finally, the economic/cost aspect of MOOCs is considered in more detail and is of special interest for the academics. The number of negative/equilibrium loops is higher than the other diagrams. As a result, it can be concluded that, especially with the literature review, different academics consider that the various elements of the tertiary level of education are causally connected with a different manner. Consequently, for MOOCs to be truly an innovation in education there is the need to investigate deeper the various elements of the system and considered different dimensions that could contribute to the success of the MOOCs.

5 CONCLUSIONS

The purpose of the paper was to investigate the effect of MOOCs in the tertiary level of education under a systemic perspective. To achieve the objective, System Dynamics was used and its tool of Causal Loop Diagrams. To understand the important elements of the system and how MOOCs can affect and be affected by them, different CLDs were developed: One from information gathered in the literature review, along with CLDs from interviews with academics and students that were involved in one way or another with some aspect of MOOCs.

The various CLDs revealed great and diverse insights into the system. Firstly, communication between teachers and students is an important dimension that all the involved parties recognize it as such. Furthermore, the language of the courses can be a hindrance on how many students will enroll, since the vast majority of MOOCs is in English and not in the various local languages.

Moreover, cost is a variable that appears in all the CLDs either the cost to enroll (for students) or the cost to make a MOOC (academics and literature review). However, to fully comprehend the effect of cost, more research is necessary especially with quantitative methods. Finally, the CLD from the literature review illustrates in a clear way the complexity of the system. Since MOOCs are an innovative approach to education in its early stages, it is not easy to understand their long term effect, due to that complexity of the system.

The qualitative models that were developed have limitations. First, they are fully qualitative, thus it is difficult to fully investigate the behavior that emerges without numerical data. Furthermore, the pool of people that were interviewed is limited (two teachers and two students) and more interviews could reveal more perceptions. Finally, the CLDs are limited to the tertiary education, but could be expanded to the sector of vocational training since many MOOCs are offered to train employees in new skills.

As a result, future directions of the research include the development of CLDs from a more diverse pool of people with the purpose of revealing aspects that may not have appeared in the CLDs above and investigate those elements that are common. Furthermore, the development of quantitative model will increase the value of the research since it will provide the opportunity to see a more precise effect of the most important elements. In that direction, the

employment of a diverse range of methods could enhance the confidence in the results

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SUBMITTED: NOVEMBER 2018
REVISION SUBMITTED: JANUARY 2019
ACCEPTED: FEBRUARY 2019
REFEREED ANONYMOUSLY

PUBLISHED ONLINE: 19 APRIL 2019