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# Gamification in MOOCs: Engagement Application Test in Energy Sustainability Courses

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**ABSTRACT** Massive open online courses (MOOCs) have triggered a sudden change in the educational scene. Its characteristics of being free, heterogeneous, multi-thematic, and fostering lifelong learning have completely changed the instructional design scene, allowing these innovations and new architectures of teaching and learning to be included. However, MOOCs have been criticized by the scientific community for their high dropout rates and low overall completion rates, which has called into question their effectiveness as a pedagogical tool. This paper analyzes how the application of gamification strategies in MOOCs on energy sustainability affects participants’ engagement and seeks to identify what types of interactive gamification media are more useful in generating interest and motivation in students. In order to do so, a mixed quasi-experimental method is used. A gamification board with challenges, badges, and leaderboards to a sample is used, and at the same time, this platform is analyzed using the integrated theoretical gamification model in e-learning environments. In the MOOCs where gamification strategies were applied, a global completion rate of 14.43% was obtained, while in those without gamification, 6.162% was obtained. Likewise, the degree of student engagement with respect to the completion rate of activities was much higher in the gamified platform (28.032%) than in the traditional design (13.252%). The results show that applying gamification strategies in MOOCs achieves a higher level of engagement and student motivation.

**INDEX TERMS** Completion rates, e-learning, engagement, gamification, MOOC.

## I. INTRODUCTION

Since their launch, Massive Open Online Courses (MOOCs) have signified a sudden change in online education, not only by democratizing access to knowledge but also because they have enabled innovation in instructional models and development in new architectures and pedagogical paradigms [1].

MOOCs refer to online courses taught through web platforms, such as edX, Udacity, Coursera, or ad hoc platforms, which seek to bring a different type of pedagogical content to a heterogeneous audience. However, they also feature lifelong learning as their main focus [2] in addition to their free access, although some institutions or interfaces may charge a fee for the issuance of certificates. In this sense, they should be viewed as a learning tool that improves, amplifies, and guides the cognitive processes of their participants [3].

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However, MOOCs have been criticized for their low completion rates [4], [5]. In fact, statistics have not changed much since the first MOOC offered by the Massachusetts Institute of Technology (MITx) “6.002x: Circuits and Electronics,” wherein only 69,221 of the 154,763 registered students completed the first assignment, with only 26,349 earning a point. Within the course’s 14 weeks, only 7,157 (4.62%) people successfully completed the activities and obtained their certificate. MOOC completion rates can vary on average from 5% to 8% [6] with respect to registered participants, although this should not necessarily be seen as a failure of the model, since both the free and flexible instructional model can be causes of the low level of student commitment. In this sense, neither should completion rates be used as the only measure of quality, nor should the dropout rate be an indicator of failure [7]–[9]. The main causes of dropout include: (1) lack of time to continue the course; (2) course level different than expected; (3) lack of motivation; (4) interest in only part of

the course; and (5) disappointment in the course (schedule, organization, etc.) [2], [10].

In contrast, the scientific literature points more to the fact that the high MOOC dropout rates are primarily because courses become very long and monotonous, since they mostly preserve the traditional paradigm of a teacher-student class through technological mediation [5], [6]. Therefore, including innovative teaching strategies that promote interaction, commitment, and ultimately, engagement is recommended [2], [11]–[13]. However, due to their own characteristics, MOOCs target multiple audiences *ergo* an enormous variety of needs, therefore the previous intentionality and expectation of value must be considered. Second, we must also understand that dropout rates can reflect certain “zapping” behavior, wherein students only select the content that interests them most or those that pique more curiosity [4].

### A. GAMIFICATION IN EDUCATION

Gamification is defined as the application of game elements in traditionally non-recreational contexts with the purpose of making an impact and solving problems [14]. Commonly, the elements used in gamification in education, according to Nah *et al.* [15], are points, badges, and leaderboards (PBL), although awards, acknowledgments, levels, and feedback are also recurrent. However, the mere use of game elements in activities does not guarantee interactivity and engagement as it will depend on their strategic use in relation to the problem, educational content, and targeted population [16].

Gamification in education is presented to students in an experience that tends to be immersive, shifting from traditional paradigms to new parameters of interactive learning based on motivation [17]. Although it has been historically applied in face-to-face contexts [18], [19], it thrives in blended learning and e-learning modalities, especially due to the close link that exists between gamification and information technology [20] and with distance learning systems [21], [22].

On a similar note, Hamari *et al.* [16] consider that certain patterns incorporated in gamification, such as increased user activity, social interaction, or the quality and productivity of actions, emerge because of intrinsic motivation. A high level of motivation can be decisive; in that, a person gives meaning to the completion of a task [23], which can have a positive effect on increasing MOOC completion rates, understanding that empirical studies, such as those of Mekler *et al.* [24], have shown that applying game elements does not itself guarantee greater user engagement, but that priority must be given to the social and contextual factors of the gamification process.

Along the same lines, Kapp [25] and Simões *et al.* [26] also agree that gamification is crucial for the development of educational technology, since many elements of gamification are based on educational psychology and techniques that instructors have used for years.

In relation to the effectiveness of using gamification in MOOCs, Zichermann and Cunningham [27] demonstrated that the factors of gamified designs in this educational

modality increased social engagement by providing fun, interactive, and significant experiences for participants, resulting in more unique visitors per day and longer average connection time in activities. Rughiniş [42], who explains that applying gamification in e-learning contexts increases productive interactivity for certain types of participants, also shares this perspective. Chang and Wei [28], in contrast, identified 40 typologies of gamification mechanics in MOOCs from Coursera, Udacity, and edX, verifying that their transversal inclusion in course activities and challenges increased student immersion and commitment toward gamified content.

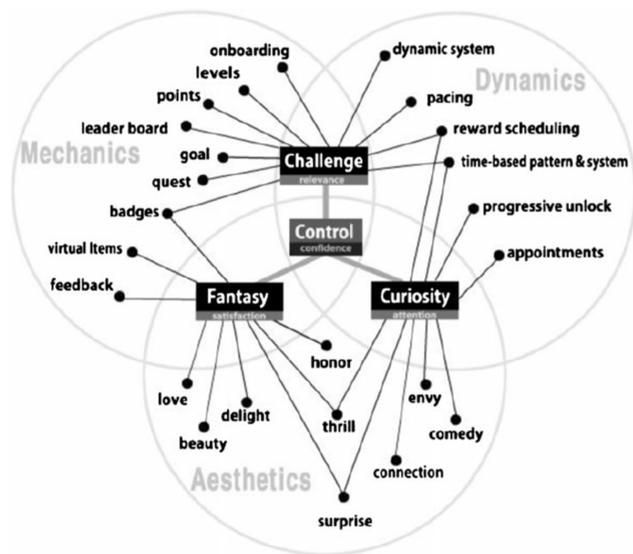
### B. EVALUATION OF GAMIFICATION IN ONLINE CONTEXTS

As can be understood from the above, although incorporating gamification in MOOCs has provided good results, it does not necessarily guarantee user engagement. As Mekler *et al.* [24] note, the mechanics, dynamics, and aesthetics of games must be strategically chosen, such as elements transversal to the instructional design, with respect to a MOOC’s social and contextual factors.

Few studies only have attempted to structure and analyze taxonomies and game components in online educational environments. In fact, a review of the state of the art completed by Dicheva *et al.* [29] extracts more than 500 publications on the use of gamification elements between 2010 and 2014 in international repositories and indexes, such as access to concepts and materials (ACM) Digital Library, IEEE Xplore, ScienceDirect, WoS, Scopus, Springer Link, ERIC, and Google Scholar, results on which Torres-Toukoumidis *et al.* [22] concur. Of these publications, at least 50 explicitly display the content of models and taxonomies for the evaluation and assessment of gamification, identifying them in another study by Dicheva *et al.* [29], which are 17 differentiated models, although coinciding in several dimensions and indicators.

Of those 17 evaluation models, six are applied specifically to online educational environments. They include the following: (1) Nolan and McBride [30]; (2) Schoech *et al.* [31]; (3) Metler and Pinto [32]; (4) Hamzah *et al.* [33]; (5) Kim and Lee [34]; and (6) Tomé *et al.* [35]. However, out of these, the latter two have received the most attention from the academic community through number of citations, immediacy, and applications.

Kim and Lee [34] proposed the Dynamical Model for Gamification of Learning (DGML) for which they adapt to the traditional macro-model MDA to two theoretical models about digital games, coding and correlating the dimensions and theoretical indicators of the game coming from diverse theories in a map of common elements of gamification (see Figure 1). On the other hand, Tomé *et al.* [35] generate, from the macro-model MDC, their Conceptual Model of Gamification in E-Learning Environments. The objective of this model is to identify the elements and motivations that intervene in the gamified teaching-learning process in digital platforms and is also composed of 4 dimensions, in the form of questions.



**FIGURE 1.** Fundamentals and dimensions of the primary factors of the Dynamical Model for Gamification of Learning. Source: Kim and Lee [34, p. 84488].

**II. E-MIGA: INTEGRATED THEORETICAL GAMIFICATION MODEL IN E-LEARNING ENVIRONMENTS**

In response to the models analyzed in the previous section, Dicheva et al. [29] propose an Integrated Theoretical Gamification Model in e-Learning Environments (E-MIGA), in which the criteria, dimensions, and indicators of gamification in online educational environments, including MOOCs, are unified, drawing from models by Kim and Lee [34], and Tomé et al. [35]. The objective of this taxonomy is to categorize the dimensions and indicators to establish a reliable order of interaction between the gamification variables and to operationalize their categorization.

First, the model by Tomé et al. [35], created from the dimensions operationalized by Werbach and Hunter [36], establishes four dimensions in the form of questions: (1) Who?—the people involved in the process, (2) Why?—explaining if the gamification context is suitable for the application, (3) How?—the way in which the game elements should be used to encourage certain users and to motivate interaction, and (4) What?—the didactic structure and instructional design.

For its part, Kim and Lee’s taxonomy [34] called “Dynamical Model for Gamification of Learning” (DMGL) is derived from the mechanics, dynamics, and aesthetics (MDA) macro model by Hunnicke et al. [37]. However, they adapt theories on digital gameplay to this macro model in a map of common elements of gamification, such as challenge, control, curiosity, and fantasy, as shown in Fig. 1.

Although the model presented by Kim and Lee [34] is more focused on the central concept of gamification, such as elements of the game at the technical level, the taxonomy by Tomé et al. [35] is more specific to game-based learning contexts. This implies that both models coincide in many aspects

on the mechanics and dynamics, but the third component is reviewed by one model as “components” [35], while in the other as “aesthetics” [34], as can be seen in Fig. 1.

In this sense, the E-MIGA by Dicheva [29] chooses to unify both models by using elements that are empirically verifiable through participant observation, which implies that creating and maintaining expectations will be based on analyzing rewards in the position charts, medals, and points, the classical triad applied and familiar in gamification systems, as shown in Table 1.

**TABLE 1.** Taxonomy of the integrated theoretical gamification model in e-learning environments (E-MIGA).

Dimension	Indicators
Typology of actors (TA)	<ul style="list-style-type: none"> <li>- CSB: Characteristics of the student body (target).</li> <li>- SR: Student roles.</li> <li>- TR: Teacher roles.</li> <li>- OA: Other actors in the process.</li> </ul>
Motivation for learning (ML)	<ul style="list-style-type: none"> <li>- ACM: Access to concepts and materials.</li> <li>- LS: Learning schedule.</li> <li>- CTE: Completing tasks and exercises.</li> <li>- GID: Gradual increase in the degree of difficulty of the lessons.</li> <li>- TA: Measuring time to complete the activity.</li> <li>- IS: Interaction systems.</li> <li>- LBE: Learning based on pragmatic experiences and exemplifications.</li> </ul>
Creating and maintaining expectations (CE)	<ul style="list-style-type: none"> <li>- SDC: Type of stimulation of didactic components.</li> <li>- GE: Gameplay elements: levels, challenges, goals, etc.</li> <li>- PBL: Reward systems: points, badges, and leaderboards.</li> <li>- FI: Feedback on interactions.</li> <li>- NS: Narrative and storytelling.</li> <li>- PC: Promoting competition and cooperation.</li> </ul>
User Control (UC)	<ul style="list-style-type: none"> <li>- AMA: Ability of the main actor (user) to determine the course of the story.</li> <li>- P: Personalization.</li> </ul>

The designations of the E-MIGA model converge with the results of the European Report on Information and Communication Technologies [38], considering aspects related to motivation, competences, and lifelong learning, especially in relation to interaction and collaborative work. Furthermore, this tool was transformed into a quantitative assessment system through expert opinion of e-learning and gamification by Torres-Toukoumidis et al. [39], obtaining the results shown in Table 2.

As can be seen in Table 2, the “motivation for learning” (ML) dimension obtains the highest score with 28 points under the sum of its indicators. The “creating and maintaining expectations” (CE) dimension follows in second place with 21 points. “Typology of actors” (TA) takes third place with 10 points in expert opinion and finally

**TABLE 2. Evaluative conversion of E-MIGA indicators.**

Dimension	Indicator	Statistical average ( $\bar{x}$ )	Standard deviation ( $\sigma$ )	Score
(TA)	CSB	3.15	,738	2
	SR	3.85	,675	4
	TR	3.25	,646	3
(ML)	OA	2.35	,823	1
	ACM	3.35	,738	4
	LS	3.66	,523	5
	CTE	3.70	,319	6
	GID	3.80	,316	7
	TA	3.25	,949	3
	IS	2.90	1,054	1
(CE)	LBE	3.30	,789	2
	SDC	3.25	,766	2
	GE	3.60	,315	6
	PBL	3.65	,538	4
	FI	3.70	,565	3
(UC)	NS	3.45	1,101	1
	PC	3.55	,398	5
	AMA	2.70	,637	1
	P	3.65	,422	2

“user control” (UC) has a sum of three points. In this regard, panel experts agree with the trend presented by most of the research on the use of gamification in e-learning environments, believing that the motivation strategies for learning and CE are ideal to incorporate elements of gamification in online educational contexts—especially in MOOCs. This means, for example, that encouraging competition and cooperation (IS-PC) to complete a task, accompanied by a reward system (PBL) for finishing tasks and exercises (CTE), will theoretically achieve a greater impact than a control component such as aesthetic personalization (P) or managing the course of the story (AMA).

**III. APPLICATION CONTEXT: ENERGY SUSTAINABILITY MOOCs**

In 2015, Mexico’s National Council of Science and Technology (CONACYT, for its Spanish acronym), together with the Secretary of Energy (SENER, for its Spanish acronym) and Tecnológico de Monterrey created a strategic energy initiative to develop proposals for energy reform, bringing together various sectors of society such as academics, businesspeople, and communities. This project would later focus on the “Binational Laboratory for the Intelligent Management of Energy Sustainability and Technological Training” (<https://energiyalab.tec.mx/>).

Within the framework of this macro-project, 12 MOOCs were created, with content ranging from generalist topics such as energy saving, to more complex topics such as Smart Grids. These academic activities were offered both on the MexicoX platform (<http://www.mexicox.gob.mx/>) and on edX (<https://www.edx.org/school/tecnologico-de-monterrey>) from January 16, 2017 to September 21, 2018. During that time, 123,124 participants enrolled, with 16,887 successfully completing it, achieving an overall completion rate of

13.715% (Table 3), which is a much higher rate than the common denominator of 5–8% noted by Osuna-Acedo *et al.* [6].

**TABLE 3. Energy sustainability-related MOOCs subject of the study.**

MOOC	<i>n</i> (e)	<i>n</i> (f)	C <sub>R</sub>
Energy saving	12929	2019	15.616%
Distribution of electrical energy	5549	639	11.515%
Smart Grid: Electrical networks of the future	6608	821	12.424%
Smart Grid: Technical fundamentals	5498	743	13.514%
Electric power transmission	5961	1074	18.017%
Conventional, clean energy, and its technology	18693	2770	14.818%
Electric power: Concepts and principles	15978	1807	11.309%
Energy: Past, present, and future	13224	2106	15.925%
Carbon markets	6710	910	13.561%
Energy markets	10255	846	8.249%
The new electricity industry in Mexico	8975	1224	13.637%
Energy reform and its opportunities	12744	1928	15.128%
<b>TOTAL</b>	<b>123124</b>	<b>16887</b>	<b>13.715%</b>

*n* (e) = Number of enrollments / *n* (f) = Number of finished / C<sub>R</sub> = Completion Rates.

These MOOCs follow the traditional instructional design of xMOOCs, which is very similar to traditional e-learning courses, wherein the content is presented in a structured manner; they have start and end dates and their evaluations focus on multiple choice tests or co-evaluation exercises [40], [41].

The 12 energy sustainability-related MOOCs that were the subject of the present study are shown in Table 3.

**A. GAMIFICATION IN ENERGY SUSTAINABILITY-RELATED MOOCs**

These MOOCs have integrated gamification dynamics throughout their content, especially the dynamics of challenges, leaderboards, and badges. The principles established by Llorens-Largo *et al.* [43] were considered in designing the gamified strategies of the aforementioned MOOCs:

1. **Simplicity:** Achievable and stimulating goals that progressively increase in complexity.
2. **Feedback:** The system provides immediate feedback on participant interactions.
3. **Real time:** Both interactions and feedback occur in real time, so there is no lag between activities and corrections.
4. **Progress:** Activities progressively increase in difficulty and the system generates the sense of progress and challenge necessary for stimulation.
5. **Autonomy:** The system provides the opportunity to make decisions and complete exercises at the participant’s own pace of learning, adjusting to some deadlines established at the beginning of the course.
6. **Individual responsibility:** The participants maintain control over their learning rhythms.

7. Treatment of errors: Errors are allowed without penalty, allowing participants to complete the exercises until they reach their goal.

In this sense, the gamification system used was a panel or board linked to a question that was related to the central topic of each teaching unit. The question was multiple choice with four options and the badge or emblem was linked to the number of times it took the user to correctly answer the question: a gold trophy for those who answered correctly on the first attempt, silver for those who did it on the second attempt, and bronze on the third. Those who answered correctly on the fourth attempt did not get any badge (Figure 2). Based on the design of the badges, we would expect students who did not answer correctly in the first attempt to try again rather than giving up so that they can get either a silver or bronze badge. Therefore, it was expected that students in the gamified MOOCs will have higher average number of attempts in the quizzes.

USER	RESPONSE TIME	NUMBER OF ATTEMPTS	BADGE
USER_1	00:01:23	1	
USER_2	00:02:01	2	
USER_3	00:12:45	3	

FIGURE 2. Gamification board incorporated in the MOOC with leaderboard and badges.

Similarly, the board was presented as a leaderboard, in which those who took less time to answer the question correctly were listed first (Figure 2).

Both the gamified board and the challenge dynamics are part of an open source project developed by Tecnológico de Monterrey, available for download at: <https://goo.gl/MMJZ62>

#### IV. GAMIFICATION AND ENGAGEMENT IN MOOCs

First, the general objective of this research study is to determine if the use of gamification in MOOCs positively affects engagement and completion rates. Second, we attempt to correlate the gamification strategies used in MOOCs with the value conversion of the E-MIGA model by Torres-Toukourmidis *et al.* [39] (Table 2) to determine the most useful indicators of the model mentioned in the gamification of MOOCs.

To execute the first objective, we turn to the mixed quasi-experimental model. With the objective of being able to compare the incidence of applying gamification in engagement and completion rates, only the gamification panel or board was applied in the MOOCs taught on the MexicoX platform (<http://www.mexicox.gob.mx/>), whereas on edX, no gamified experience was applied (Table 4).

TABLE 4. Differences in completion rates by platform.

Platform	$n(e)$	$n(f)$	$C_R$
edX (without gamification)	10629	655	6.162%
MexicoX (with gamification)	112495	16232	14.429%
<b>TOTAL</b>	<b>123124</b>	<b>16887</b>	<b>DIF: 7.217</b>

$n(e)$  = Number of enrollments /  $n(f)$  = Number of finished /  $C_R$  = Completion Rates.

As shown in Table 4, although the  $n(e)$  on edX is 10 times less than on MexicoX, the completion rates ( $C_R$ ) vary by 7.217%, which means that MexicoX had twice the completion rate (in percentage) of edX.

Another indicator that conveys greater engagement with the course is the completion rate of the MOOC’s activities (homework). Considering, in general, that there were four homework assignments per course, the MexicoX courses reported a 28.032% average completion rate of the exercises, although in descending order that went from 53.55% for the first exercise to 14.29% for the last.

In contrast, the courses implemented on edX reported an average of 13.252% completion rates of the exercises (14.78% less than those on MexicoX). These were also in descending order, ranging from 23.33% in the first exercise to 6.16% in the last (Figure 3).

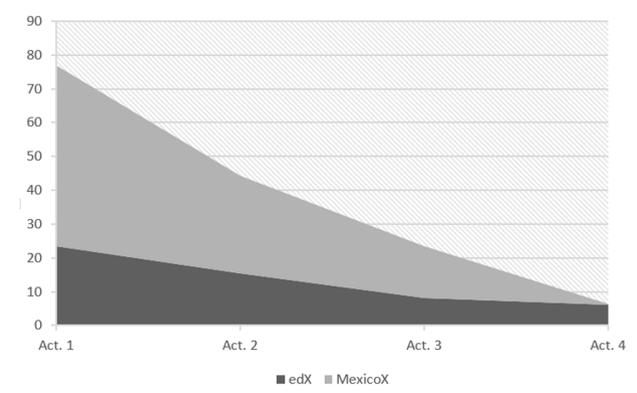


FIGURE 3. General completion rates of MOOC activities.

Both results—the differences in the completion rates as well as the completion rates of the exercises—allow us to understand the following:

1. In all the courses analyzed, the tendency to finish exercises was in descending order, although in those where gamification was applied, the average completion rate of exercises was higher than where it was not applied.
2. On the platform where gamification (MexicoX) was used, the completion rates were double compared to those in which it was not applied.
3. The gamification dynamics applied (challenges, badges, and leaderboards) managed to create competition among MOOC participants in a particular way. This could influence the creation of learning communities.

The second research objective is to analyze the gamified platform of the energy sustainability-related MOOCs outlined, in relation to the E-MIGA model by Dicheva *et al.* [29], under the indicator value conversion scheme by Torres-Toukoumidis *et al.* [39] (Table 2).

On the one hand, this will allow us to validate the use of this quantitative assessment model in MOOCs, and on the other, it will let us review what other gamification strategies according to the aforementioned model can be used to obtain a higher level of engagement, and consequently, completion rates.

With regard to the “typology of actors” (TA) dimension, xMOOCs have predefined the roles of students and teaching staff (SR and TR). Unlike cMOOCs, which place emphasis on knowledge created by students, creativity, autonomy, and social and collaborative learning, xMOOCs emphasize traditional learning focused on watching videos and completing small test-like exercises. In this sense, the energy sustainability-related MOOCs analyzed does not allow students to play an active role in knowledge creation or pre-defining tasks. Meanwhile, the characteristics of the student body (CSB) are people interested in the issues addressed (free registration), while there are no other actors involved in the process (OA).

In relation to the ML dimension, all the indicators proposed by Dicheva *et al.* [29] are met in terms of ACM, learning schedule (LS), completing tasks and exercises (CTE), gradual increase in the degree of difficulty of the lessons (GID), interaction systems (IS), including MOOC participation forums, and learning based on pragmatic experiences and exemplifications (LBE).

Regarding the CE dimension, in which gamification strategies are included, there are types of stimulation of didactic components (SDC), gameplay elements (GE) on the gamified board (challenges), and reward systems (PBL), including badges and leaderboards, and promoting competition and cooperation (PC). Although the dynamics of the proposed xMOOCs have narratives and storytelling (NS) in some way, the video lessons cannot be modified based on the levels demonstrated by the participants, which means that this indicator is not achieved.

Concerning the last dimension, UC, the main actor’s (user’s) ability to determine the course of the story (AMA) or the ability to personalize learning components (P) was not verified.

Although the E-MIGA model is a theoretical taxonomy of gamification in e-learning environments and does not intend to establish the effectiveness of the courses in terms of completion rates and engagement through scores, it establishes general guidelines for keeping users’ attention and motivating them to achieve pedagogical goals. The values represented are the result of those awarded by expert opinions in the study by Torres-Toukoumidis *et al.* [39], while the MOOC assessment is binary, implying that if the existence of the indicator is identified, the maximum score is awarded (Table 5).

**TABLE 5.** Value conversion of E-MIGA indicators in relation to the MOOCs analyzed.

Dimension	Indicator	Maximum score	MOOC score
(TA)	CSB	2	2
	SR	4	0
	TR	3	0
	OA	1	0
(ML)	ACM	4	4
	LS	5	5
	CTE	6	6
	GID	7	7
	TA	3	3
	IS	1	1
	LBE	2	2
(CE)	SDC	2	2
	GE	6	6
	PBL	4	4
	FI	3	3
	NS	1	0
	PC	5	5
(UC)	AMA	1	0
	P	2	0
<b>TOTAL</b>		<b>62</b>	<b>50</b>

As is clearly evident, the greatest weaknesses of the MOOCs analyzed are in the TA dimension; specifically those related to the passive roles that students (SR) and teachers (TR) have in xMOOCs. Likewise, the absence of other actors (OA), such as tutors or learning intermediaries, could reduce students’ engagement with the courses, as there is no human interaction in the learning processes.

However, a value of 0 also appears for NS because the xMOOC instructional design is not interactive—the videos do not vary according to learning level. Moreover, this situation affects the indicator for the ability of the main actor (user) to determine the course of the story (AMA) and the ability to personalize (P).

Applying the E-MIGA model resulted in the following findings:

1. The traditional models of xMOOCs, which keep users as passive actors in learning, do not achieve greater student engagement. This is also verifiable in the comparison between the platform that used gamification and the one that did not (Table 4).
2. The absence of human actors in educational intermediation (TR and OA) can affect student engagement in finishing activities.
3. Considering the heterogeneous profiles of MOOC participants and their different levels of knowledge, the use of an NS system that varies depending on learning level will allow the student to determine the course of the story (AMA) and personalize the learning experience (P).

In this sense, the E-MIGA theoretical model perceives that although important aspects of gamification are included in MOOCs from MexicoX, using an interactive platform to measure learning, linked to new levels opening in the course

(activities, exercises, and topics), could significantly increase user engagement and, therefore, completion rates.

## V. CONCLUSION

MOOCs have signified an important revolution in online education, first by allowing free and open access to knowledge for many people, and second, because they have provided a testing laboratory to innovate in pedagogical models and develop new teaching architectures.

However, MOOCs have also been the subject of much criticism in the scientific community for their low completion rates [4], [5], which normally vary between 5% and 8% [6] with respect to registered participants, although we caution that neither should completion rates be used as the only measure of quality, nor should the dropout rate be an indicator of failure [7]–[9]. For its part, the scientific literature points more to the fact that MOOC dropouts are highly correlated with the fact that the courses become long and monotonous, since they mostly preserve the traditional paradigm of a teacher–student class through technological mediation [5], [6]. Therefore, including innovative teaching strategies that promote interaction, commitment, and ultimately, engagement is recommended [2], [11]–[13].

In this regard, Tecnológico de Monterrey (Mexico), together with the National Council of Science and Technology (CONACYT) and the Secretary of Energy (SENER) created and implemented 12 MOOCs on energy sustainability, which although still follow the traditional instructional design of xMOOCs, they include a panel or gamification board, following the instructions established by Llorens-Largo *et al.* [43]. The courses taught from January 16, 2017 to September 21, 2018 on two different platforms (MexicoX and edX) had a total of 123,124 participants, with 16,887 successfully completing the course, resulting in a global completion rate of 13.715%, which is much higher than the common denominator of 5% to 8% [6].

To differentiate the effect that applying gamification has on MOOCs, we used a mixed quasi-experimental model to apply a gamification board to one of the two MOOC platforms (MexicoX) in which an overall completion rate (of the 12 MOOCs) of 14.429% was obtained, while in the MOOCs taught on edX (without gamification), an overall completion rate of 6.162% was obtained (Table 4).

Furthermore, the degree of student engagement in MOOCs was demonstrated in the rate of completion of activities (Figure 3), wherein gamified MexicoX courses obtained an average exercise completion of 28.032%, while those on edX (non-gamified) obtained an average of 13.252%. However, it is necessary to indicate that in both platforms, exercise completion rates trended downward, which reflected the dropout rates.

The gamification board's design with challenges, badges, and leaderboards manages to create competition among MOOC participants in a particular manner, which can influence the creation of learning communities. These results coincide with those reviewed by Hamari *et al.* [16], and we

can verify that incorporating gamification increases social interaction through intrinsic motivation (competition). Likewise, the results obtained aligned with those presented by Zichermann and Cunningham [27] and Rughiniş [42] on the effectiveness of using gamification in MOOCs, in particular on the increased social engagement through immersion and competitiveness in the courses.

Regarding the second research objective, we sought to demonstrate which elements of gamification could improve social engagement in e-learning environments, especially in the MOOCs analyzed. From the E-MIGA by Dicheva *et al.* [29], and based on the assessment scale proposed by Torres-Toukouridis *et al.* [39], we observe that traditional xMOOC models, keeping users as passive learning entities can be monotonous and decrease users' attention, essentially because their role nothing besides watching videos and answering test-like exercises.

Likewise, since there is no human intermediation between users and platforms—the absence of faculty and OA (such as tutors)—it can affect students' engagement in the culmination of activities because no element of interactivity that links them to the course exists.

Another problem that arises with the xMOOCs is that users with very heterogeneous profiles and levels enroll; therefore, if these courses are completed by high school students, they may be too difficult, while for users with engineering degrees, they can be too basic. In this regard, the E-MIGA model recommends that MOOC platforms have narrative and storytelling that allows evaluation and personalization of levels by users through certain exercises, which would somehow even out the different enrollment profiles. This recommendation is also in line with that stated by Borrás Gené *et al.* [2] and by Zapata-Ros [10], in that two of the main causes of MOOC dropouts are that the course level was different than expected and an interest was only in a part of the course.

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