Digital accreditations in MOOC-based training on sustainability: Factors that influence terminal efficiency

Maria-Soledad Ramirez-Montoya
Institute for the Future of Education, Tecnologico de Monterrey, Mexico

Sandra Martínez-Pérez
Faculty of Education Sciences, Universidad de Sevilla, Spain

Guillermo Rodríguez-Abitia
Raymond A. Mason School of Business, College of William and Mary, United States of America

Edgar Lopez-Caudana
Institute for the Future of Education, Tecnologico de Monterrey, Mexico

Digital certificates in massive open online course (MOOC) learning experiences provide alternative credentials linked to lifelong learning. The Bi-National Laboratory on Smart Sustainable Energy Management and Technology Training provided the context for this research. This project was undertaken by Mexican and United States universities, businesses and governmental organisations, having granted 17,776 certifications in sustainability and 10,705 labour competence certificates. The research focused on analysing the factors that promote digital credentials, from the point of view of participant and platform characteristics, in the framework of MOOCs in energy sustainability, through the MexicoX and edX platforms. Using the ex post facto method, two validated instruments were applied to analyse motivation and self-regulation processes. A total of 4,002 useful responses were gathered from participants in 35 MOOC courses. The results account for six determinant factors for digital accreditation: perceived usefulness, self-efficacy, knowledge domain and expertise, group work disposition, achievement drive, and performance strategic thinking. We highlight implications for research on educational innovation and for educational practice in MOOCs. These data may be of interest to academics, researchers and decision-makers interested in training through distance environments.

Implications for practice or policy:

- Digital certifications in MOOCs are motivation for participants to successfully finish their courses, and this can be leveraged for education and research.
- Course leaders need to consider that effective design and implementation of new models for MOOCs may help improve terminal efficiency.
- The potential perceived benefits from training on professional performance have the greatest influence on the terminal efficiency of MOOC participants.

Keywords: MOOC, educational innovation, higher education, digital accreditations, sustainability, terminal efficiency

Introduction

In the field of educational innovation, massive open online courses (MOOCs) have provided opportunities for large scale training and the exploration of new methodologies and technologies that allow for improvements in distance learning designs. Studies such as that by Romero-Rodriguez, Ramírez-Montoya, & Aguaded (2020) found that the factor *instructional design* is decisive in the engagement of younger participants; trans-disciplinary design with creations of conceptual, theoretical and empirical structures are common between disciplines, where they can offer interesting contributions for educational innovation in MOOCs (Guajardo-Leal & Valenzuela González, 2017). Also, integrating new resources through games (Rincón-Flores et al. 2020) encourages the engagement of participants, regardless of age, gender or educational level. MOOCs have provided new possibilities for educational innovation, and some studies suggest expectancy-value and achievement goals are decisive factors for greater engagement of MOOC participants (Romero-Rodríguez, Ramírez-Montoya, & Venezuela, 2020).

Dropout rates in MOOCs have been a popular subject of analysis. Some authors have placed the dropout rate in MOOCs around 90% (Hew & Cheung, 2014; Alraimi et al., 2015). Other have placed terminal efficiency (the proportion of participants who successfully complete the course between 4.3% (Coffrin et al., 2014) and 6.5% (Jordan, 2014). Ceron et al. (2021) conducted a systematic literature review of 66 studies between 2010 and 2020, finding an emerging area of study spurred by the high dropout rate of MOOCs participants. Charani et al. (2019) agreed that in all digital courses, the dropout rate is very high, increasing skepticism about the way these courses are delivered on a digital platform and evidencing the need to focus on the analysis of the causes.

An incentive that has been registered in MOOC participants is in the possibility of obtaining alternative credentials. Alternative credentials can be diplomas, certifications or badges, depending on the conditions that are specified for the courses. Accreditations vary as well, according to the platforms, as some require a payment for certifications and others do not. In a mapping of literature on accreditations in MOOCs, in the period 2015–2021, we located 54 publications through SciVal, where the themes of open learning, professional development, university teaching and online learning models predominated. The topics identified as growing are distance education, educational technology, peer assessment, rubrics and framework (Figure 1). In the image, the size of the word indicates the number of times a topic has been addressed as a keyword in the articles. On the other hand, the colour indicates the growth of the topic's publications: green in increase, blue in decline and gray indicating no change.

Figure 1. Keywords by relevance, based on 54 publications found in SciVal in 2021
Note. Colour legend for keywords: declining A A A growing

In the analysis of the articles, an area of opportunity for research was identified as the exploration of the provision of digital credentials in MOOCs, where articles that address this topic do not include digital credentials. Research opportunities were also located in the disciplinary linkage of sustainability. The studies concentrated their contributions in the discipline areas of computer science and the social sciences. Only one study (Hsieh, 2020) linked MOOCs to the sustainable development goals of social responsibility and accreditation principles (Figure 2).

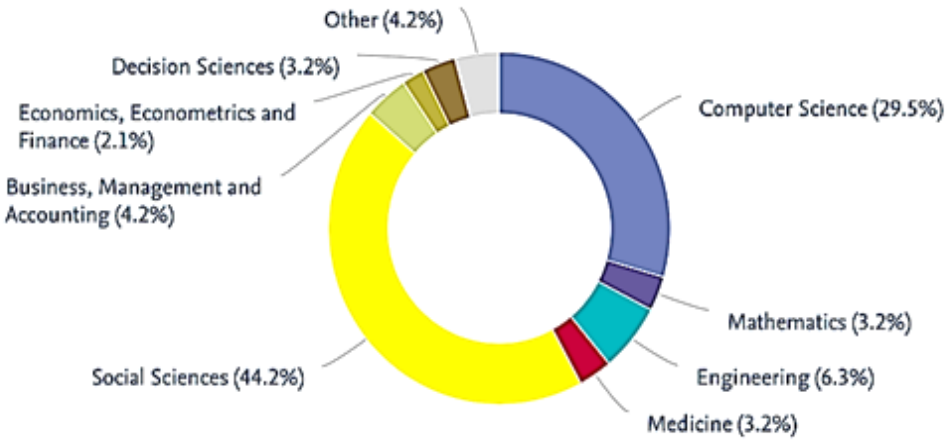

Figure 2. Keywords by relevance, based on 54 publications found in SciVal in 2021

Considering these opportunities, the research focused on analysing the factors that promote the attainment of digital credentials, from the point of view of the individual characteristics of the participants and the platforms used, analysing data from 35 MOOCs that trained in energy sustainability, through the MexicoX and edX platforms. We review a theoretical framework for MOOCs and digital credentials. Then, we introduced a case of energy sustainability MOOCs. We apply the ex post facto method, with two validated instruments that explore motivations and self-regulation. We present and discuss the results in the light of statistical data, dimensions and implications for research and educational practice. Finally, we draw conclusions for academics, researchers and decision-makers who are interested in training through distance-learning environments.

MOOCs in the framework of new models for lifelong learning

Current trends in education reveal the need to create alternative and innovative pedagogical models. Constant social, educational, technological and economic transformations have led to new ways of communicating, disseminating information, generating new resources and materials and other ways of organising and making other teaching methods visible (Tang 2017). “Open science brings with it the possibility of shared co-construction and the generation of open innovation, to contribute to the public sphere as well as private contexts” (Ramírez-Montoya & García-Peñalvo, 2018, p. 15). Thus, MOOCs:

- generate global learning opportunities (Cornelius et al., 2019), where the participation and engagement of their participants are essential
- provide access to open and shared content, emerging knowledge (Kady & Vadeboncoeur, 2013)
- have a significant impact on higher education (Watson et al., 2017)
- are a formative tool, fostering social inclusion and the internationalisation of institutions (García Aretio, 2017; Hidalgo & Abril, 2020)
- offer new options for professional development and lifelong learning (Castaño-Muñoz et al., 2017).

Moreover, these courses have the potential to contribute to the innovativeness of pedagogical strategies; transform teaching and learning processes; co-create and acquire knowledge; foster competence development, among others (Beltran & Ramírez-Montoya, 2019; Drake, 2015; Ruíz-Palmero, 2021).

Drake et al. (2015) identified five principles to keep in mind when designing and developing MOOCs: meaningful, engaging, measurable, accessible and scalable. To these five principles, they added two essential features, instructional design and attractiveness, to differentiate MOOCs from other approaches (Doherty et al., 2015). Initially, as Littenberg-Tobias and Reich (2020) pointed out, MOOC design was perceived as a solution to the demands of higher education. And most of them did not offer formal accreditation, but rather a certificate at the end of the course (Kady & Vadeboncoeur, 2013). Over time, higher education institutions, in the wake of digital transformations and the ever-changing landscape,

considered new online or blended professional credentials. Subsequent to that approach and as an immediate response, the changes are disruptive and resonate in higher education (Al-Imarah & Shields, 2019). Finally, there is the possibility of generating disruptive innovation in higher education through accredited MOOCs (Caudill, 2017; Zheng et al., 2018).

These new disruptions and innovations through MOOCs not only accredit the acquisition of knowledge but also verify labor and social competencies, from a more participatory and personalised point of view. In this way, a relationship is established between technologies (MOOCs) and the acquisition of competencies (Berestova et al., 2021). Some of the personal skills that MOOCs enhance are self-knowledge (self-awareness and self-evaluation), self-regulation (self-efficacy, innovation, adaptability, self-control) and self-motivation (commitment, achievements). They also favour the acquisition of professional competencies and efficiency, such as adaptability, creativity, responsibility, social intelligence, communication and collaboration, teamwork, proactivity, decision-making, achievement success; and leadership (Bandura, 1997; Cheng, 2020; Ma et al, 2017: Pinho & Soares, 2011; Soonhee, 2002; Stark et al., 2007; Van Knippenberg, 2000; Yi et al., 2006).

Digital accreditations in MOOCs

A person could acquire a series of competences or skills and obtain results not related to holding a degree or professional qualification, but rather through specific courses, for example, MOOCs. These courses allow them to be proactive in the choice of the skills and knowledge they want to validate, defining their own pace (García-Bullé, 2019). This kind of accreditation is known as alternative credentials. There is currently no agreed definition and classification of the concept. Nonetheless, they are based on assessment and in accordance with the efforts invested (Fong et al., 2016).

The use of alternative credentials has been growing in recent years in response to social, economic and political changes. This type of accreditation offers new, more accessible, affordable and effective ways for individuals to demonstrate their knowledge and skills to potential employers (Tecnológico de Monterrey, 2019). Validation and recognition are key elements in the accreditation of acquired competences. Validation is obtained when a person has achieved learning outcomes. It consists of four phases: identification, documentation, assessment and certification. Recognition, on the other hand, implies the accreditation of these learning outcomes by an institution or employer. Both credentialling and recognition are related to the certification of a validation process (Witthaus et al., 2016).

MOOCs generally offer certificates of either participation and/or completion of the course, or those that verify the identity of the learner and the learning outcomes (Kopp & Ebner, 2017). The possibility of obtaining a non-university or alternative credential in exchange for a fee started in 2014. Examples of such programmes are micromasters, nanodegrees and professional certificates. Coursera offers hundreds of courses and specialisations from organisations around the world (Hollands & Kazi, 2019), with alternative credentials. These are programmes designed to train people in specific skills and can be of three types: certificate programmes (less than 2 years by career technical institutions); on-the-job training (corporate training, training and internships offered by companies); and skills-based short courses (specific skills for employment) (Brown & Kurzweil, 2017; Tecnológico de Monterrey, 2019).

The terms of alternative credentials or recognition from MOOC certifications is a topic that requires different approaches. Studies of MOOCs have covered several aspects to study the likelihood of MOOC completion. Recent studies have included the prediction of completion linked to likely English proficiency (Duru et al., 2021); others have reviewed how user engagement correlates with certification rates in courses, regardless of specific content (Wintermute et al., 2021); and others have performed an analysis of the behavioral differences between learners (those who obtain the certificate) and explorers, leading to their different learning outcomes (Liu et al. 2021). Furthermore, other studies have found that the use of innovative strategies such as gamification seems to contribute to increases in user participation as well as in course completion (De Notaris et al. 2021). Şahin (2021) used an adaptive neuro-fuzzy inference system to predict dropout rates in MOOCs. Guerrero et al. (2021) studied MOOC-based intrapreneurial capabilities with a direct role in achieving university outcomes, as well as an indirect role by mediating the positive effect of ordinary university capabilities on university outcomes. These studies have attempted to understand the relationship between participants in MOOCs and the attainment of credentials or credits earned.

MOOC-based training on sustainability

The Bi-National Laboratory on Smart Sustainable Energy Management and Technology Training was developed in Mexico. It is an initiative from the Energy Ministry, the Science and Technology National Council and Tecnologico de Monterrey, in collaboration with many higher education institutions (public and private, national and international), a platform that generates technology and knowledge around the energy, looking to place Mexico at the level of the most advanced in the fields of training, research and infrastructure (Ramírez-Montoya, 2018). The Bi-National Laboratory contributes to sustainable lifestyle awareness mainly through its open training strategy with its MOOCs (Figure 3), linking:

- industry: Federal Electricity Commission
- government: National Council of Science and Technology and Secretary of Energy of Mexico
- academy:
    - Mexican institutions: Tecnologico de Monterrey, Tecnológico Nacional de México, National Institute of Electricity and Clean Energies
    - International institutions: Arizona State University and University of California at Berkeley
- networks: research groups of climate change and educational innovation research, Openergy Network and UNESCO Chairs / ICDE Open Educational Movement for Latin America
- general public: more than 200,000 participants from more than 50 countries.

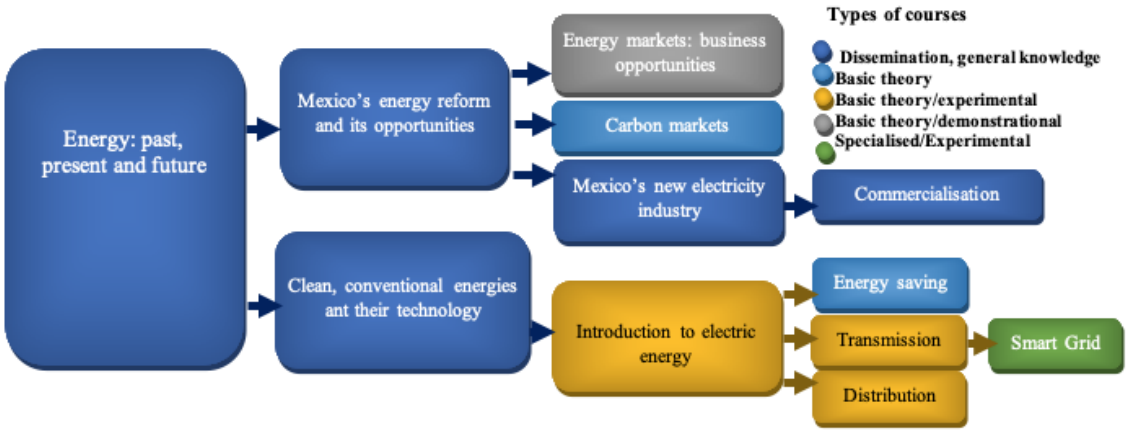

Figure 3. Suggested sequence for taking the courses (Ramírez-Montoya, 2018, p.17)

A total of 35 MOOCs were made available in 2018 to the public through the edX (Figure 4) and MexicoX, where training was geared towards sustainability. For example, through the Energy Saving MOOC, the students were able to examine energy use in the residential, industrial and transport sectors in Mexico, identify how efficient energy is used, learn about energy saving and success stories and propose an energy-saving strategy in the participant's immediate context. The Bi-National Laboratory contributes to educational innovation through the integration of new resources and strategies (biometrics, gamification, challenges, virtual and remote laboratories and open educational resources) in MOOCs (Figure 4).

Figure 4. Digital accreditation in MOOC-based training on sustainability (Ramírez-Montoya, 2018, p. 17)

The Bi-National Laboratory is distinguished by introducing a positive cultural change mainly through training and the mass dissemination of knowledge. Human talent specialised in energy sustainability was developed with five post-doctoral students, 30 PhD students, 118 from the Master of Science in Energy Management and its Renewable Sources, 33 from the Master of Science with a specialty in Energy Engineering, 68 students from the Specialty in Energy Management, 17,776 certifications were granted in energy sustainability and 10,705 certificates of labour competence for employees of the Federal Electricity Commission of the Mexican Government (Figure 5). The production of knowledge has been disseminated through more than 84 articles in journals, 30 in Quartile 1 and Quartile 2 journals and 74 in national and international congresses, four books and four patents (Ramírez-Montoya, 2018).

Figure 5. Promotion of MOOCs on edX platform (Ramírez-Montoya, 2019, p. 6)

Method

We used the ex post facto method, where we compared 35 MOOC courses on two platforms, with regard to the motivations and self-regulation of participants who received certifications. As seen in Beltrán and Ramírez-Montoya (2019), testing learners completing MOOCs has become a common strategy to assess participants' performance and, in addition, motivation, as it is an important element for participants' self-regulated learning. However, the factors that support motivation to achieve learners' goals is a topic yet to be explored.

Participants

For the pilot study, a total of 1315 participants in the MOOC titled Energy reform and its opportunities, offered by Tecnologico de Monterrey in 2017, were used as a sample. A total of 3,971 useful responses were gathered from participants in the 35 MOOCs for the main study.

Figure 6 shows the demographic characteristics of the participants: gender, educational level and occupation. The results were obtained from the registration questionnaires used.

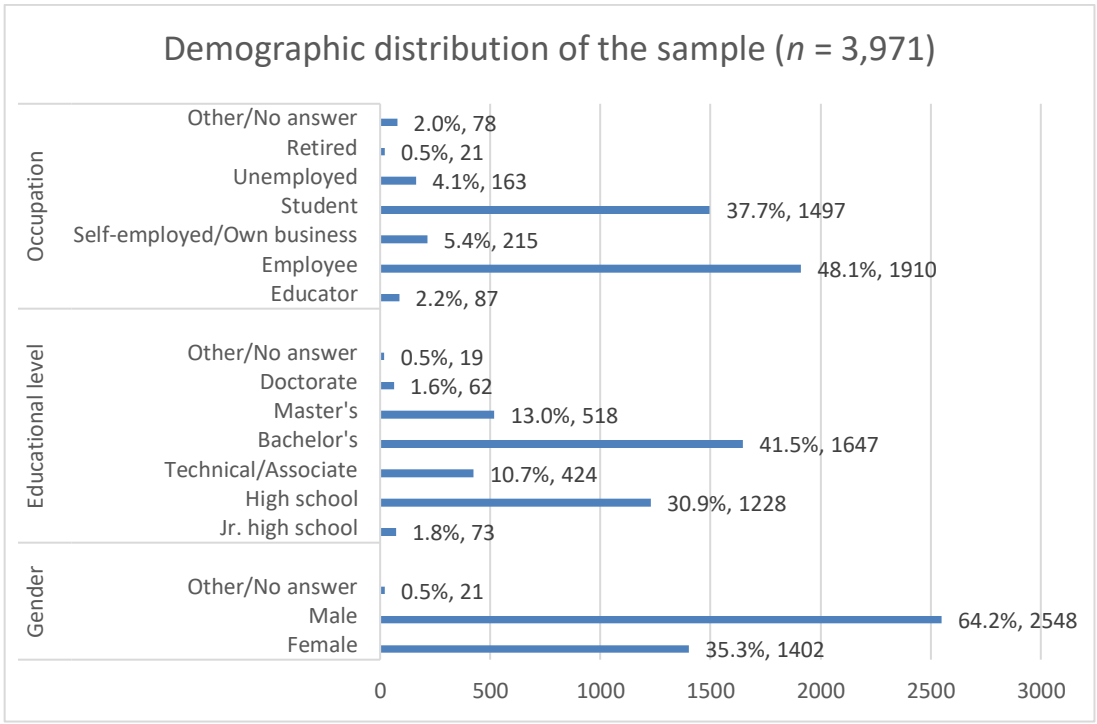

Figure 6. Sample demographics

Measures

We used a combination of instruments to get a sense of the nature of the participants in every course in order to get more valuable results. The first instrument was validated through experts and piloting (Valdivia et al., 2018), consisting of four sections: The first section related to the demographics of the participant, including educational level, age, gender and discipline of study and/or work. The second section has 5-point Likert scales to measure the participant's intentions and motivation in the course. The third section included questions, also in a Likert scale, to capture their perceptions as to what degree they possessed the required previous knowledge to take the course. The fourth section related to their disposition to interact with and evaluate their team members. The second instrument was intended to measure their self-regulation strategies and their motivation for self-directed study (Guajardo-Leal et al., 2019).

A total of 35 items were obtained from combining the applicable parts of the two above-mentioned instruments and used for our own adapted instrument, without considering the demographics. The instruments were applied online in every course.

Procedure

A factor analysis was performed to verify the number of constructs at play. The Varimax method was used to obtain an orthogonal rotation, forcing the factors to be uncorrelated, thus aiding in their interpretation. The rotated component matrix is shown in Table 1.

Table 1
Rotated component matrix

Ítems	**Components**					
	1	2	3	4	5	6
1			0.691			
2			0.806			
3			0.785			
4			0.658			
5			0.722			
6		0.490	0.413			
7		0.691				
8		0.811				
9		0.834				
10		0.757				
11		0.676				
12				0.673		
13				0.761		
14				0.789		
15				0.747		
16				0.702		
17					0.769	
18					0.753	
19					0.763	
20					0.775	
21						0.673
22						0.506
23						0.681
24						0.614
25						0.424
26	0.582					
27	0.483					
28	0.555					
29	0.574					
30	0.561					
31	0.628					
32	0.524					
33	0.483					0.433
34	0.604					
35	0.603					

Note. Extraction method: principal components analysis. Rotation method: Varimax with Kaiser normalisation. The rotation has converged in 6 iterations.

The solution obtained in the dimension reduction process revealed the existence of six factors. Analysing the meaning of the questions, the following constructs were derived, ordered from left to right in the matrix:

- Component 1: Performance strategic thinking: the level of persistence to be systematically competitive and perform well on the course
- Component 2: Self-efficacy: the degree to which a person believes that they are capable of successfully finishing the course
- Component 3: Perceived usefulness: the degree to which a person identifies the potential use and benefit to be obtained from the MOOC
- Component 4: Knowledge domain and expertise: the perception of the participant about their level of required knowledge and expertise for the course
- Component 5: Group work disposition: the subject's willingness to work with others on a continuous basis
- Component 6: Achievement drive: the degree to which a person is driven to make the necessary effort to attain a goal.

The reliability of the scales was then tested with Cronbach's alpha scores for each factor. The results can be seen in Table 2.

Table 2
Reliability analysis scores (Cronbach's alpha)

Construct	Number of items	Cronbach's alpha
Performance strategic thinking	10	0.802
Self-efficacy	6	0.884
Perceived usefulness	5	0.851
Knowledge domain & expertise	5	0.837
Group work disposition	4	0.868
Achievement drive	4	0.707

Note: From the results in the table above, it can be observed that all scores are indicators of good reliability. The lower value, 0.707 for achievement drive, is considered quite acceptable since it is a common rule to accept any scores over 0.6.

This work took care of ethical issues relevant to the research, aided by obtaining the corresponding approvals under which the data were collected and reported. In the application of the instruments, participants were informed that their data would be treated with confidentiality and in compliance with the applicable information privacy legislation. They were also informed that their responses were to be used for research and publication purposes only. Smith (1990) mentions that the methodological aspects are as important as the epistemological and ethical care of the information. Hence, in this study we tried to count on the informed participation of the participants, confidentiality and respect for the data provided through objective management.

Results

The level of credentialisation is a function of at least three factors: individual characteristics, course characteristics and platform characteristics. In the following, we will focus on individuals and platforms.

For the individual characteristics, Figure 7 shows the scores that the respondents obtained for each factor by gender. These scores were obtained from the 3,965 respondents of the survey, once the incomplete answers were dropped from the sample. It can be seen that most scores are quite high, partly suggesting the reason for terminal efficiency success. Some scores stand out, such as the drive for achievement, the self-efficacy and the perceived potential usefulness. The lower scores are for knowledge domain and expertise and for performance strategic thinking. It is apparent that women have slightly lower scores than men for all factors, with the exception of performance strategic thinking.

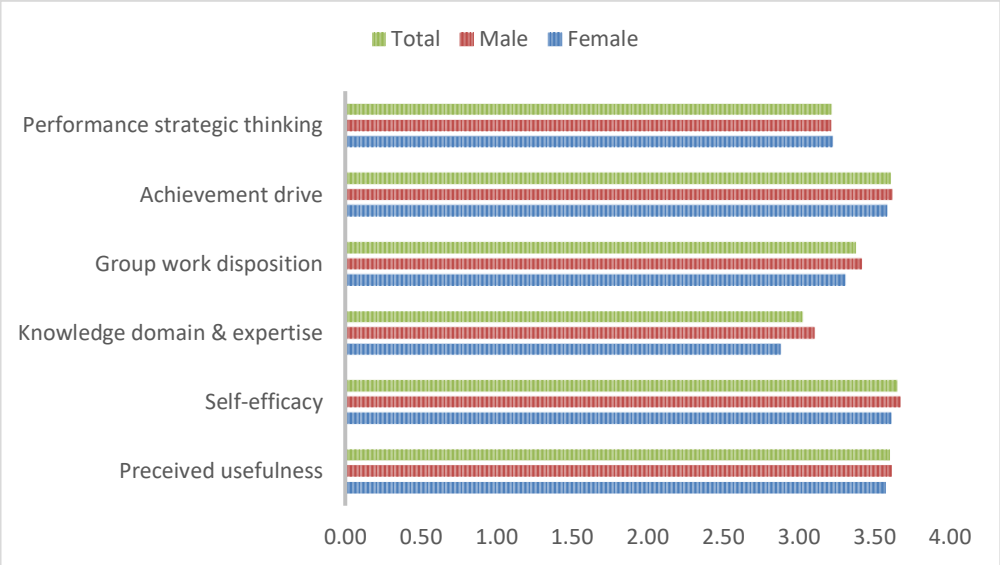

Figure 7. Individual factors scores by gender

The significance of the differences in means between genders for each factor is shown in Table 3.

Table 3
Differences in means of the factors by gender

		Levene test of equal variances		***t* test for equal means**		
		F	Sig.	*t*	Degrees of freedom	Sig. (bilateral)
Perceived usefulness	Equal variances assumed	0.226	0.634	-3.041	3948	0.002
	Unequal variances assumed			-3.033	2862.152	0.002
Self-efficacy	Equal variances assumed	22.487	0	-4.759	3948	0.000
	Unequal variances assumed			-4.697	2777.445	0.000
Knowledge domain and expertise	Equal variances assumed	8.652	0.003	-12.988	3248	0.000
	Unequal variances assumed			-13.163	2993.959	0.000
Group work disposition	Equal variances assumed	2.219	0.136	-6.776	3947	0.000
	Unequal variances assumed			-6.759	2865.069	0.000
Achievement drive	Equal variances assumed	4.99	0.026	-2.91	3948	0.004
	Unequal variances assumed			-2.867	2763.354	0.004
Performance strategic thinking	Equal variances assumed	0.654	0.419	0.68	3948	0.496
	Unequal variances assumed			0.0676	2832.426	0.499

It is important to clarify that, although not included in Table 3, all means but the one for performance strategic thinking are higher in value for the male group. As it can be seen, there are very highly significant differences for self-efficacy, knowledge domain and expertise and group work disposition. These findings are quite interesting but difficult to explain. There is a possibility that, since the courses are oriented to energy and this can be considered a male-dominated area, women may feel less confident on their ability to succeed and recognise the need to make a larger effort. On the other hand, it is quite surprising to see that males are more prone to work in teams, since this is questionably considered, in common culture, a female trait, given that all-male groups have been observed to underperform (Takeda & Homberg, 2014). Differences for perceived usefulness and achievement drive are only significant at $p < 0.05$. However, given the very large size of the sample, there is no justification for relaxing the significance level; hence, there is a need to be cautious about the possibility of having false positives. Finally, performance strategic thinking is clearly not significant.

Figure 8 shows the scores for individual characteristics as well, but this time the analysis is done based on the level of studies of the participants. For most cases, there is a clear correlation between the scores and the level of studies. Once again, knowledge domain and expertise, and performance strategic thinking seem to score lower in general than the other factors. There are some nuances that are worth noticing.

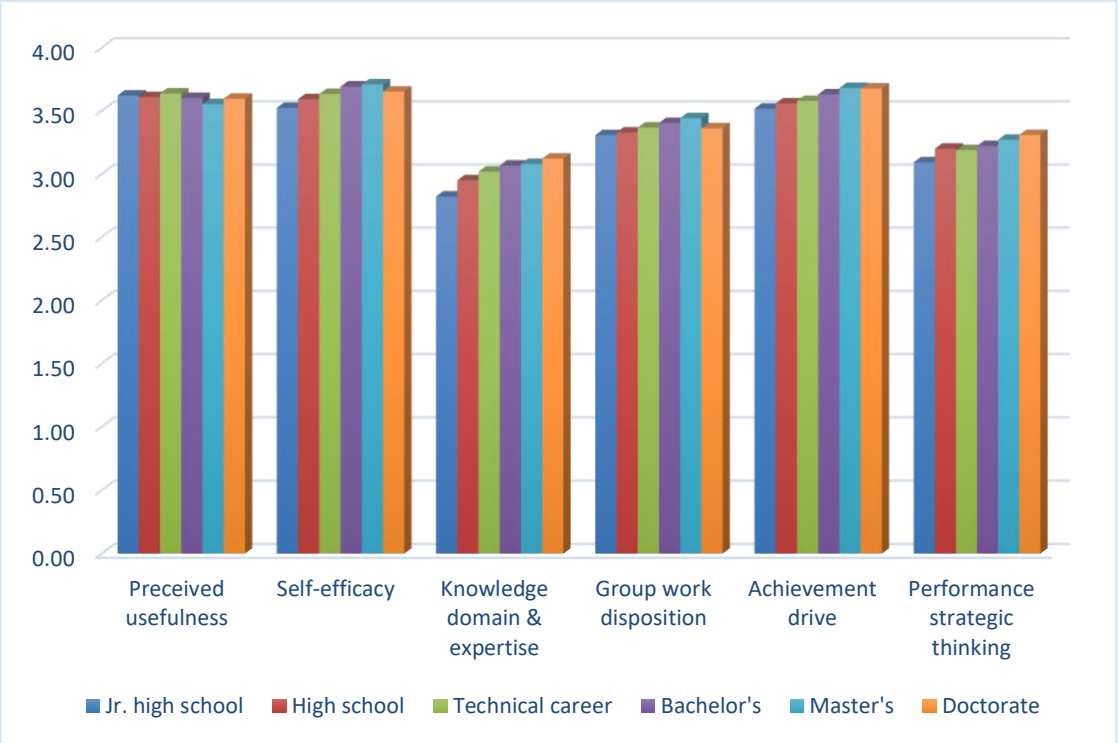

Figure 8. Individual characteristics by level of education

First, the potential benefit seems to be perceived higher by participants with a technical career or with a bachelor's degree. It may be the case that current college students are not still fully aware of the full value of the course contents, and people who have gone to graduate school are already well established in their field; thus, they do not find that the MOOC provides an opportunity to enhance or change career. This may play as a significant factor to consider when designing a MOOC, so that the expectations for profiting from the course can be highlighted, therefore fostering interest and performance. Another interesting aspect is that participants with a doctoral degree are surprisingly lower in self-efficacy scores than those with only a master's degree. Also, doctoral degree holders have a lower disposition to work in groups than their master's counterparts.

The results highlight the relevance of the potential benefit perceived by students. While it is true that, by registering to the course, anyone seeks a personal benefit and recognises the achievement of completing the MOOC, this benefit is not always fully recognised by all students, especially when it is mandatory to register. The feeling of benefit acquires a much larger impact with students who have a greater preparation or who are motivated by their workplace. When the organisation asks its employees to take this type of course, it has an intrinsic benefit that the company itself will give to the student, either by obtaining a greater curricular value or because it is directly related to some recognition developed by the company (whether voluntary or not). From the job point of view, MOOCs provide benefits to people who complete them, offering them the ease and opportunity to acquire new knowledge or complement traditional education, as well as build knowledge through learning communities, strengthen their competencies and professional skills. Whether or not companies encourage the use of MOOCs to reinforce knowledge or develop skills necessary for a job position, they recognise the advantages of their use as a training medium.

To better understand the significance of the differences, an analysis of variance (ANOVA) was undertaken to detect significant differences in means for more than two groups. The results are shown in Table 4.

Table 4
Analysis of variance to determine differences in means for each factor by level of education

ANOVA

Factor	Observation	Sum of squares	df	Quadratic mean	F	Sig.
Perceived usefulness	Between groups	2.089	6	.348	2.032	.058
	Within groups	668.106	3899	.171		
	Total	670.195	3905			
Self-efficacy	Between groups	11.587	6	1.931	12.741	.000
	Within groups	591.003	3899	.152		
	Total	602.590	3905			
Knowledge domain and expertise	Between groups	16.545	6	2,757	10.065	.000
	Within groups	1068.147	3899	.274		
	Total	1084.692	3905			
Group work disposition	Between groups	7.839	6	1.306	5.599	.000
	Within groups	909.511	3899	.233		
	Total	917.350	3905			
Achievement drive	Between groups	8.951	6	1.492	9.364	.000
	Within groups	621.210	3899	.159		
	Total	630.161	3905			
Performance strategic thinking	Between groups	4.007	6	.668	3.325	.003
	Within groups	783.237	3899	.201		
	Total	787.245	3905			

From Table 4, it can be seen that the differences in means among the level of education groups are highly supported for all but perceived usefulness (no significance) and performance strategic thinking (mildly supported). Thus, the discussion on how individuals may perceive a different benefit depending on the stage of their career cannot be declared a fact, but is worth deeper exploration.

One big limitation found was triggered by the nature of the sample itself. Validating a causal model to predict credentialisation success would have been ideal. Unfortunately, nothing was found, very likely due to a lack of size effect. This may be leading to a false negative or type II error. Most participants in the sample have close enough scores to prevent enough explanatory variation. This is one of the possible reasons for having a higher certification rate than in most common MOOCs. It would certainly be worth exploring this phenomenon further.

Regarding platform differences, Figure 9 shows the total number of students registered in one of the different MOOCs for both platforms, as well as the number of people who passed and the percentage of terminal efficiency.

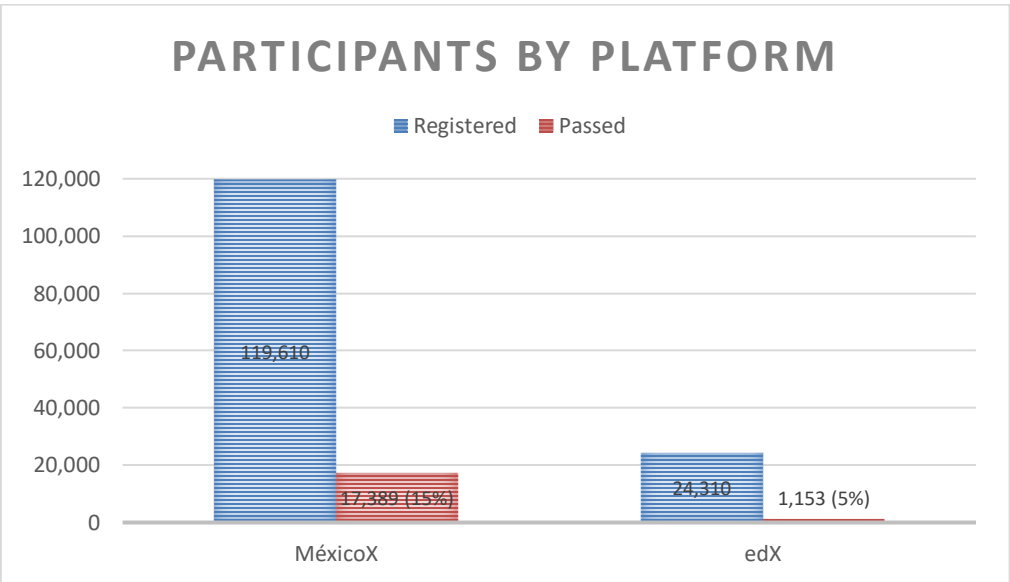

Figure 9. Participants by platform

The differences are statistically significant. A t test procedure was undertaken to determine the differences in terminal efficiency for those students registered in the MexicoX platform and those in edX. The result is higher than the corresponding one for the edX participants, although the courses were the same. According to these results, this test is deemed optimal since the comparison is only between two groups. Table 5 shows the results of the t test analysis performed with SPSS version 23. It is clearly significant with a p value < 0.000. This result was the same regardless of having equal variances or not.

Table 5
Differences in mean terminal efficiency between platforms

Platform	Mean terminal efficiency	Standard deviation	Bilateral significance
MexicoX	14.963	3.5462	0.000
edX	6.875	2.0310	

This can be explained by the difference in institutional character of each platform. edX started in 2012 as an open MIT course where more than 155,000 students from 162 countries enrolled. In 2013, the Open edX platform was launched as open software, and in 2014 the Research Data Exchange was established, to advance the science of learning. In 2017, MicroMasters® programmes were launched and in 2020 edX launched MicroBachelors® programmes. In Mexico, the Mexican Ministry of Public Education through Televisión Educativa signed a collaboration agreement as a partner with edX, offering new audiovisual education alternatives aimed at solving educational backwardness, especially in rural areas, through the EDUSAT Network (Gobierno de México, n.d.).

On the other hand, MexicoX is a platform for MOOCs of the Ministry of Public Education, through the General Directorate of Educational Television. It began in 2015 and currently has solid results and has generated one of the most important digital learning communities in the country, having more than 2.6 million users enrolled in MexicoX courses. According to its website (https://www.mexicox.gob.mx/), more than 700,000 certificates of participation have been delivered to users who have successfully completed the courses.

So, while edX is a regular open platform, where anybody can register for a MOOC, driven exclusively by their interest in acquiring new knowledge, this interest can be focused only in one part of the course, not necessarily on the whole content. Additionally, there is no other incentive for finishing the course, other than personal satisfaction. MexicoX, on the other hand, regardless of also being an open platform where anybody can participate, it is an institutional platform, promoted by the federal government. Furthermore, obtaining a certificate in the MexicoX platform is free of charge, whereas there is a cost involved in the EdX platform. These differences are likely influencing factors, considering the fact that both courses and students' characteristics are somewhat constant across platforms. The terminal efficiency in edX is within the normal range of success ratio for MOOCs, that is, between 4% and 6%, clearly indicating that the level of institutionalisation of a platform is of significant importance.

Discussion

The results indicate that MOOCs enhance the acquisition of six individual factors: perceived usefulness, self-efficacy, knowledge domain and expertise, group work disposition, achievement drive, and performance strategic thinking.

Predominant individual factors that influence the accreditation success were found to be perceived usefulness, self-efficacy and achievement drive. By comparing the results in Figures 7 and 8, they seem to matter more than previous knowledge and expertise, disposition to work in groups and strategic thinking for performance. This is aligned with Bandura's (1997) self-efficacy, but it is somewhat in contraposition with Stark et al. (2007), who emphasised the relevance of relating personal characteristics to the ability to work in a team. Thus, it is very important for an individual to believe the course will add some value to their career and trust in their capacity to complete it successfully, accompanied by the right motivation to attain that goal.

Surprisingly, performance strategic thinking, though important, does not stand out as one of the most important factors. The results in Figures 7 and 8 show a smaller size of the scores of this factor when compared both between genders and among educational levels. This partly contradicts the study of Van

Knippenberg (2000), who pointed out that motivation and performance strategic thinking are key elements in this process. This leads us to believe that work habits are important, but not as decisive for success as those related to self-regulation and self-motivation.

The factors perceived usefulness, self-efficacy, knowledge domain and expertise, group work disposition, achievement drive, and strategic performance thinking are success factors that lead to ensuring terminal efficiency. They should be considered as such, provided that they are pre-existing conditions in groups of students who are likely to succeed, as shown by the high values displayed in Figures 7 and 8. In a different approach, previous research treat all individual factors as characteristics that MOOCs help develop (Berestova et al, 2021; Castaño-Muñoz, 2017; Cheng, 2020; Ma et al., 2017). It is therefore apparent that a virtuous cycle may exist between all individual factors and MOOC practice. Thus, the likelihood of success is reinforced by the factors, and the factors, in turn, are enhanced by the MOOC experience in every round.

Another important and relevant success factor is provided by the level of institutionalisation of the delivery platform. The analysis of differences in means between the MexicoX and the edX platforms makes this evident, since there is a statistically significant greater degree of accreditation for the MexicoX platform, and all other factors related to course and individual characteristics are the same in both cases. It is likely that the more institutionalised a platform is, the greater the level of engagement by the participants, proving to be valuable for success, as mentioned by Drake et al. (2015). This characteristic has relevance for the design of training programs that are based on MOOCs, so that the reach of accreditation rates increases considerably.

Among the factors that positively influence participants' terminal efficiency in a MOOC is the benefit it will bring to their training or professional performance. This data is reflected in Figure 8, which shows a clear correlation between the scores and the level of studies, where the potential benefit seems to be perceived more highly by participants who have a higher level of education or who are motivated by their workplace. This finding agrees with those of Romero-Rodriguez, Ramírez-Montoya, and Valenzuela (2020), who analysed expectancy value and achievement goals as decisive factors for the higher engagement of MOOC participants; also, in the acquisition of competencies (Berestova et al., 2021). A key aspect of MOOC design in attracting and retaining participants lies in making very clear the learning benefits participants will have through these experiences.

Digital certifications in MOOCs motivate participants to successfully finish their courses, and this can be capitalised for educational practices and research on educational innovation. Figure 5 illustrates digital accreditation in sustainability MOOC-based training, where accreditations spanned course certifications, specialties and badges. Furthermore, Table 5 shows the terminal efficiency of participants of the MexicoX platform as 14.96% (where there was no cost for the digital credential) and edX with 6.87% (where there was a cost for the digital credential). This is in contrast to MOOCs with terminal efficiency between 4.3% (Coffrin et al., 2014) and 6.5% (Jordan, 2014). Badges, diplomas and certificates, as alternative credentials to be obtained through platforms, represent opportunities for practical implications and research to locate good practices that lead to strengthening this training modality.

Conclusions

The findings of this study offer practical implications for competence development, the implementation of emerging technologies and learning innovation through alternative digital credentials via MOOCs. As can be seen, digital accreditations in MOOC-based training, as elements of sustainability, identify six factors that influence terminal efficiency: perceived usefulness, self-efficacy, knowledge domain and expertise, group work disposition, achievement drive, and performance strategic thinking.

The credentialisation efficiency of MOOCs remains a diverse and controversial scenario; we know that completion rates are often low, as stated by Jordan (2014), and it is necessary to identify features and characteristics that allow understanding this process further. Our study may prove to be relevant because the completion of the energy sustainability course, for the Bi-National Laboratory, yielded valuable information suitable for analysis. The MOOC courses that shaped this project established different challenges for the participants, and it is thanks to this experience and their contributions that significant

data was obtained for the credentialisation of those who managed to complete the course. The participation of a diverse audience in different ways, the application of digital tools and the follow-up of the participants, allowed us to obtain valuable information about the success factors for the completion and obtaining of the corresponding digital credentials.

First, we conclude that perceived usefulness, self-efficacy, knowledge domain and expertise, group work disposition, achievement drive, and performance strategic thinking are important success factors for the proposed objective.

Second, the level of institutionalisation of the platform and the cost of credentialisation represent defining factors that may greatly raise the level of success in the course. Even if no additional incentives are provided, just the fact that there is institutional support and promotion for the employees of one organisation to access a certain platform, increases significantly the likelihood of success. Costs are also very influential, especially when there are free and paid alternatives to the same course simultaneously.

For design purposes, a MOOC must explicitly express the value that potential participants may obtain by completing the course. This is evident since perceived usefulness is one of the factors that are most highly ranked in the participants' scores. Furthermore, perceived usefulness is not necessarily correlated with educational level as one could expect, but it is rather higher for participants with technical or undergraduate degrees. Value perception is therefore a function of how much the contents of the MOOC may influence their professional careers through specific demanded skills generation.

The literature on MOOCs and their success factors are varied and not very uniform, but the results shown here allow us to establish those issues that can significantly contribute to studies on the efficiency and success in the implementation of new MOOCs. This information may be of interest to administrators and in general to any facilitator in these MOOC learning environments. Thus, resources, strategies or diagnostic processes can be considered to explore these ideas in order to refine them for more successful efficiency pathways.

The comparison between the two platforms on which the course was offered is also noteworthy. The one that involved government backing, with a strategy more focused on distribution and mastery, through different governmental and academic partnerships, registered a higher achievement rate for credentialing. It is true that both are open platforms, but the institutional support for learners and the federal government's hallmark established different motivations for the participants.

Finally, one must recognise the technological and tracking limitations that the MOOC harbored. Although the entire course included a plan for its completion, most of the course topics were self-managed and offered on a mass scale. Thus, we were not able to implement a more sophisticated follow-up design and the strategy of the surveys applied was not 100% adequate, so it is necessary to consider that this type of course must face these difficulties and grant resources to guarantee more constant and efficient forms of accompaniment.

Another limitation may be the profile of the participants (interested in the energy field), where there were direct invitations from government entities to their employees (e.g., employees of the Mexican Federal Electricity Commission), who may have had motivation for the accreditations and been influenced by the field (energy sustainability). A differential study among the type of participants may also be of interest to locate distinctive elements of support for alternative credentialing.

For future research, the technological platform used could provide more information on the implementation of the challenge in order to establish more relationships between the factors: perceived usefulness, self-efficacy, knowledge domain and expertise, group work disposition, achievement drive, and performance strategic thinking.

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Corresponding author: María Soledad Ramírez-Montoya, solramirez@tec.mx

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