JODDE Journal of Open, Distance, and Digital Education

Öncü, S. E. (2024). Transforming open and distance learning with generative AI: Custom micro-credentials from existing curriculums. *JODDE*, *1*(2), 1-18
https://doi.org/10.25619/werera06

Received: 29 October 2024 | Revised: 06 February 2025 | Accepted: 15 February 2025

Transforming open and distance learning with generative AI: Custom micro-credentials from existing curriculums

Sefa Emre Öncü[1]

[1] Open Education Faculty, Anadolu University, Eskişehir, Turkey

Correspondence:
Sefa Emre Öncü | e-mail: seoncu@anadolu.edu.tr

Abstract

Short courses emerged under the name of e-learning in the 1980s and have become widespread in the digital environment worldwide with the advent of Internet accessibility. Applications that provide short and flexible learning, such as micro-credentials, are expanding globally, with higher education institutions like Open University offering this service internally. However, some institutions with large open and distance learning systems, such as Anadolu University, have yet to integrate micro-credentials. The research utilised simulation research and two-step agent-based modelling. In the first step, 100 micro-credential proposals were requested from the books of 522 undergraduate courses taught in the Anadolu University Open Education System through the generative artificial intelligence application designed over ChatGPT-4, MyGPT. This study explores the development of self-micro-credentials by adapting frameworks established by the Open University to Anadolu University. A different MyGPT was created in the second step, and it was requested that the units suggested under various names in the first step be exactly matched. The hallucination rate, initially 79.7% in Step 1, was significantly reduced to 5.3% through a structured validation process. The false negative rate was measured at 6.8%, indicating challenges in recognising domain-specific units. At the end of the two-step process, the accuracy rate was calculated as 92.3%, demonstrating the potential of generative artificial intelligence to facilitate self-micro-credential development. According to the findings, expert human oversight remains essential to ensuring reliable AI-generated recommendations, enabling learners to create tailored micro-credentials from distance learning resources aligned with their interests.

Keywords

higher education; open and distance learning; micro-credential; generative artificial intelligence; simulation-based modelling

1 Introduction

Short courses have a long history. Micro-credentials (MC), a method of certifying these short courses, are offered by higher education institutions or companies in various educational sectors through partnerships with diverse industries. The demand from employers for the professional development of their employees, or the need for workers and job seekers to specialise in a specific area within a short period, shapes MCs. However, with the rapid expansion of the internet today, individuals are increasingly able to meet their learning needs on various platforms according to their desires rather than attending courses set by institutions or organisations. Platforms like YouTube, LinkedIn, Coursera, and Udemy provide learners with flexible learning opportunities on any subject, either for free or at a cost, and either with or without certification.

In the 2020s, following the global COVID-19 pandemic, higher education institutions in developed countries started offering short courses or MCs to address these learner needs, leading to the widespread adoption of these offerings. Open and Distance Learning (ODL) institutions have demonstrated substantial potential in this area due to their existing capacities and expertise. Leading institutions like The Open University (OU) have spearheaded this development. However, in Turkey, Anadolu University, which boasts the most extensive Open Education System (AUOES) with over one million learners, has yet to implement an MC programme, despite the number of programmes and courses that it offered.

Nevertheless, traditional MCs are typically defined by institutions or organisations, even at the micro-level, offering learners a relatively limited range of personalised options to choose from. At this point, the rapid development of Generative AI (GenAI) and adaptable tools such as OpenAI's MyGPT, which can be customised for specific purposes and programmed to align with learner preferences, holds the promise of compiling content that directly meets individual needs, enabling the creation of highly diverse MCs. The idea of fulfilling the "urge to learn whatever they want," which many internet users experience in everyday life, using accredited resources from official higher education institutions at the most micro level, may become a subject of future research. Since the inception of ODL, technology has continuously inspired it. There are examples in theory and practice of using postal services, radio, television, the internet, and now artificial intelligence for different purposes in ODL. Specifically, combining MCs and GenAI under the umbrella of ODL may enable learner-centred personalised MCs to be shaped and created by the learners themselves in institutions like AUOES. Just as elective courses have become more widespread in higher education institutions, allowing learners to choose credits outside of compulsory courses, MCs, whose original purpose is to enable learners to acquire the knowledge they desire flexibly, may become even more liberating with the aid of GenAI. It has the potential not only to create short courses but also to generate certifiable, personalised MCs. ODL institutions must establish an MC pool and train a GenAI system in compliance with the necessary regulations.

2 State of the art and theoretical framework

ODL commenced in Boston, United States, through postal correspondence and has continued to be applied globally using various methods following the expansion of the internet (Holmberg, 1995). With advancing technology, institutions offering ODL have become a significant component of higher education processes. The first generation of distance education in the United States began with land-grant universities providing educational courses through mail. The second generation of distance education was distinguished by the OU using television and Australia's School of the Air employing radio broadcasts. This era saw a proliferation in the use

of broadcast technologies and innovations such as the development of educational materials by teams (Simpson & Anderson, 2012). Access to ODL predates the establishment of OU, extending to public lectures. Initially proposed in 1926 as an "open university"', this idea gained momentum in the early 1960s, leading to the founding of OU in 1969 with a mission to be open to people, places, methods, and ideas. In subsequent years, OU popularised Massive Open Online Courses (MOOC) and began offering MC (Weller, 2014).

In Turkey, Anadolu University (AU), since 1982, has been operating higher education activities based on a central ODL system, serving as a dual-mode institution offering both traditional and ODL. The Anadolu University Open Education System (AUOES) is one of the mega universities with over one million registered learners. AU is a public university in Turkey that teaches in dual mode with approximately one million learners and over four million alums (Koçdar et al., 2024). Additionally, AU offers thousands of open (free) courses to the public through the AKADEMA MOOC platform, attracting millions of clicks, besides its certificate (paid) programs (Aydin et al., 2024).

The first online learning platform emerged in the 1980s under the name e-Learning and has evolved in alignment with advancing technology over time, diverging from traditional learning methods to offer short courses and certificates, with MC gaining momentum post the COVID-19 pandemic (Zou et al., 2024). Brown et al. (2021) state that MCs can quickly provide learners with alternative learning opportunities and enhance their skills in the digital world. MCs are the learning outcomes obtained after a brief learning experience. Although there has yet to be a consensus in the literature on this definition, it transcends badge issuance and certification. MCs are certificates of assessed learning that can be considered additional, alternative, complementary, or part of a formal qualification (Oliver, 2019). MCs, defined as digital credentials given after completing a paper certificate or short learning experience, contain quality-standard metadata. This metadata includes the accrediting institution, issue date, learning outcomes, necessary study hours to pass the course, assessment type, and participation format (Council of the European Union, 2022). Employers and institutions, in response to the chronic shortage of qualified candidates, are developing new MCs that can be accredited (OECD, 2023).

Educators typically offer MCs on a platform in designated areas (Chakravorty et al., 2023; Hunt et al., 2020). MCs can be provided at various levels, such as beginner, intermediate, and advanced (McGreal & Olcott, 2022). Despite the lack of common standards for defining MCs at national or international levels, the learning in MCs is countable after being assessed by institutions and organisations. With the development of technology, making MCs shareable in digital formats has facilitated their recognition (Bozkurt & Brown, 2022).

MCs have carved out a significant niche in higher education. Different countries can assess non-credit or formal credits in various ways. All European and Organisation for Economic Co-operation (OECD) countries utilise credit point systems. In Europe, the European Credit Transfer System (ECTS) is based on learning outcomes and hypothetical learner workload (Van der Hijden, 2023). The micro-credentials linked to the Bologna Key Commitments (MICROBOL) project represent a cornerstone of European efforts to stabilise and advance the micro-credentialing phenomenon. As highlighted in the European Union's recommendations, these efforts aim to promote the transferability of knowledge and skills across Europe by encouraging micro-credentials, establishing a common recognition framework, adapting legal structures, and fostering the digitalisation of education (The European Commission, 2022). MCs represent a growing movement that offers a flexible and efficient learning environment to advance careers and job positions (Felton et al., 2023). As distance education has become more widespread, there has been an increase in individuals' interest in learning methods that enhance their skills. Some

higher education institutions have developed digital learning models according to learners' demands, directing them towards MC efforts where they can discover their potential. MCs have begun to be offered in many parts of the world, including through MOOC platforms, and higher education institutions have included them at undergraduate and postgraduate levels (Brown et al., 2021). Beukema (2024) stated that over a million learners worldwide have earned MCs. Universities and platforms like Coursera and edX offer different MCs in diverse fields.

Additionally, Coursera also features over 2,500 MCs. MCs are adopted as a meaningful solution to address the skill gap of the stakeholder community (Maina et al., 2022). Despite ongoing debates about ensuring quality assurance, recognition, regulation, and incentivisation of MCs, the consensus is that they should be flexible, portable, transferable, and transparent (Ahmat et al., 2021). Hanshaw (2024) highlights the benefits of MCs as follows:

- MCs quickly respond to individuals' changing needs.
- They provide opportunities to explore subjects without being tied to lengthy and expensive degrees.
- They offer lifelong personal and societal growth opportunities.
- Learning decisions are left to the learner.
- They reduce time and cost barriers and facilitate access.

MCs enable learners to develop themselves in specific areas online, allowing institutions to monitor and share these outcomes. In a world where education transcends boundaries, offering opportunities and alternatives without being confined to particular patterns can attract learners' attention (Panda & Kaur, 2023). The foundations of AI were laid in 1950 with the Turing Test, posed by Alan Turing, questioning what would happen if machines were asked questions and whether they could think (Negnevitsky, 2005). The event recognised as the start of AI as a discipline was the 1956 Dartmouth Summer Research Project. The development of AI has continued with advancements in perception, object recognition, hardware technology, and algorithm performance (Stone et al., 2016). GenAI is a tool capable of learning independently from complex data and has strong capabilities in data creation. Pre-trained AI language models, which learn abstract information from raw data, have significant data generation capabilities. One of the recently developed Natural Language Processing (NLP) models is a variant of the Generative Pre-trained Transformer (GPT) architecture known as ChatGPT (Goar et al., 2023). ChatGPT uses a Large Language Model (LLM).

Large Language Models (LLMs) primarily refer to transformer-based neural language models pre-trained on vast text data, consisting of tens to hundreds of billions of parameters (Minaee et al., 2024). Through LLMs, data-driven predictions can be made, enabling recommendations via chat-based tools such as ChatGPT (Wu et al., 2024). With their deep and expansive capabilities, large language models hold the potential to revolutionise personalisation systems, transform how people interact, and expand the scope of personalisation. The interaction between humans and machines can no longer be classified as simply 'active', where users consciously input data or make decisions, or 'passive', where users rely on machine-generated results with minimal input, as seen in traditional search engines and recommendation systems. Generative AI introduces more dynamic and iterative interactions that transcend this binary classification (Chen et al., 2024). Although robust, ChatGPT exhibits challenges in certain use cases, such as sequence labelling (Qin et al., 2023). The development of LLM is being furthered by various innovative studies on integrating GenAI to allow computers to learn and generate human language. These studies reveal AI's capability to understand and meet users' complex and multi-stage demands (Canbek & Mutlu, 2016). After 2000, terms such as e-learning, online, blended, hybrid, technology-supported, and flexible learning were added to open and distance education terminology. Teaching and learning are continuously transforming with new technologies

(Zawacki-Richter, 2023). With the internet's proliferation, learners have become part of distance education (Eaton & Christensen, 2023). In this context, it is crucial for established ODL institutions to adapt to the new technologies.

ODL platforms, despite having a vast repository of books and materials like those at AU, still need to include MCs. The potential to use course pools to create MCs, as demonstrated by AU's certificate programs, underscores the significant untapped potential within ODL. Despite having over a million learners, the limited number of staff makes it challenging to provide personalised one-on-one support. Therefore, integrating AI-supported systems is becoming crucial in ODL (Öncü & Süral, 2024). In this context, this study investigated creating the most suitable MCs from thousands of units in ODL course books, offering a personalised curriculum with GenAI support tailored to the learner's interests.

GenAI demonstrates the potential to quickly generate the most suitable MCs based on desired fields, topics, and content via easily trainable applications such as MyGPT, provided that the courses and content delivered in an Open and Distance Learning (ODL) system are shared with it. For instance, while it may take time for institutional experts to scan all courses and content for a learner requesting an MC in "Artificial Intelligence in Business," trainable applications like MyGPT can perform this task swiftly and offer recommendations based on its training. However, comprehensive studies are required to assess this process's accuracy and evaluate potential outcomes when such applications are used. This study investigates whether GenAI can offer personalised and flexible MCs by considering the existing courses in ODL.

2.1 Research Problem

MCs, developed with specific guidelines for the digitalised higher education landscape, are expected to be implemented and disseminated according to a standardised framework. Establishing quality standards and ensuring certification is essential for MCs to become a trusted form of recognition valued by learners, employers, and society. The challenge lies in balancing flexibility, fostering institutional cultures of continuous improvement, and implementing robust Quality Assurance (QA) processes that ensure public accountability. One of the most critical aspects is the ability to offer MCs that meet the needs and demands within the higher education system as part of a broader societal application (Brown & Duart, 2024). Utilising the course pool to create MCs, as seen in AU's certificate programs, showcases the significant potential of ODL. For learners demanding short and flexible learning options, how content in ODL courses is presented is just as important as the alternative proposal itself. Despite having over a million learners, due to the limited number of staff, the subject of this research is whether GenAI, with strong LLM capabilities, can be used to create MCs. From this perspective, this research involved a simulation of creating Self-Micro-Credentials (SMC) on AUOES, selecting nine undergraduate MCs from OU, one of the most renowned ODL institutions, which are commonly used on online course platforms. The simulation of how GenAI could develop content for AUOES based on OU's current MCs. The selected MCs from OU are as follows:

- Discover your genre and develop your style (Digital photography)
- Financial accounting for non-financial roles
- Fundamentals of management accounting
- Improving organisational practice
- Marketing principles and practice
- People management and leadership
- Programming
- Project management
- Transforming your organisation for sustainability (Climate change)

AUOES, with over 500 courses and more than 4000 units (topics) in its programs, has the potential to provide learners with the freedom to select their subjects from a vast topic pool. The proposed model in this research was designed to enable learners enrolled in a program to choose topics from a broad subject pool to create their SMC. In this context, an SMC allows learners to determine the subjects they want to learn within a course; an SMC with GenAI supports selecting the subjects of interest.

If implemented in real life, the proposed model would allow learners to specify their demands, and GenAI, through its LLM capabilities, could provide the most suitable responses. No existing study simultaneously addresses MCs, GenAI, and ODL in the literature, making this one of the first in the field. This study addresses potential scenarios if GenAI-supported MCs were implemented in ODL. "If a learner wishes to create a micro-credential, could GenAI perform micro-credentialing according to the existing course pool in AUOES?" to answer this question, a two-step simulation was conducted in this study, focusing on the following research questions:

- RQ1. What is the status of units suggested by GenAI in the first and second steps being taught at AUOES?
- RQ2. How are micro-credentials distributed across the first and second simulation steps?
- RQ3. What are the four most frequently suggested units by GenAI for each course at the end of the second step, and what is the success rate of these recommendations?

3 Method

This study utilises simulation research methods and agent-based modelling (ABM) to examine the potential for implementing MCs within the context of ODL. Simulation research systematically collects and analyses data under controlled conditions, modelling real-world processes and systems to predict and understand potential outcomes through mathematical and statistical methods. The simulation model's output behaviour can be examined qualitatively or quantitatively, with this study opting for quantitative analysis due to the specific number of simulations conducted (Sargent, 2013) This approach was designed to showcase the usage of these tools and help improve the various steps involved in modelling. The study's use of ChatGPT's dialogue-based approaches was intended to demonstrate whether GenAI could be a helpful tool in simulations. The study examines the effectiveness of MyGPT in generating MCs from an existing open education curriculum. The methodological approach involves a two-stage validation process, ensuring the generated units align with verified course structures. Key performance indicators were systematically analysed to assess reliability, including accuracy rates and hallucination metrics.

3.1 Simulations

In this study, the 522 undergraduate courses taught in the program accessible through the "Digital Ders Platformu (DDP)" at AUOES were analysed (Anadolu Üniversitesi, 2024). Additionally, the responses given by GenAI in the two steps of the research were examined. For this, the SMC tool developed through OpenAI's MyGPT application simulated the processes for creating SMCs based on the undergraduate courses taught during the 2023-2024 academic year at AUOES and published in the DDP with open access.

In the first step of the research, a MyGPT has been created on the OpenAI page based on the GenAI, proposing MC for the units in the courses taught in AUOES undergraduate programs. MyGPT, equipped with the given introduction, has been tasked to generate SMCs consisting of four units, each according to the units in the course pool of AUOES undergraduate programs specific to the learner's request. To observe the consistency of ABM in the research, each SMC

request has been repeated 100 times and simulated. At the end of the simulation, the frequency distribution of the units in the first step was analysed to examine the MC performance of the GenAI. To counteract the potential for hallucination in applications like MyGPT supported by GenAI, a second distinct MyGPT was designed in the second step of the research. In the second step, the first GenAI matched the units in AUOES exactly. The most frequently recommended four units per course were finally used at the end of the second step, and the collected data were analysed. The stages of creating the SMC for the learner experience are shown in Figure 1.

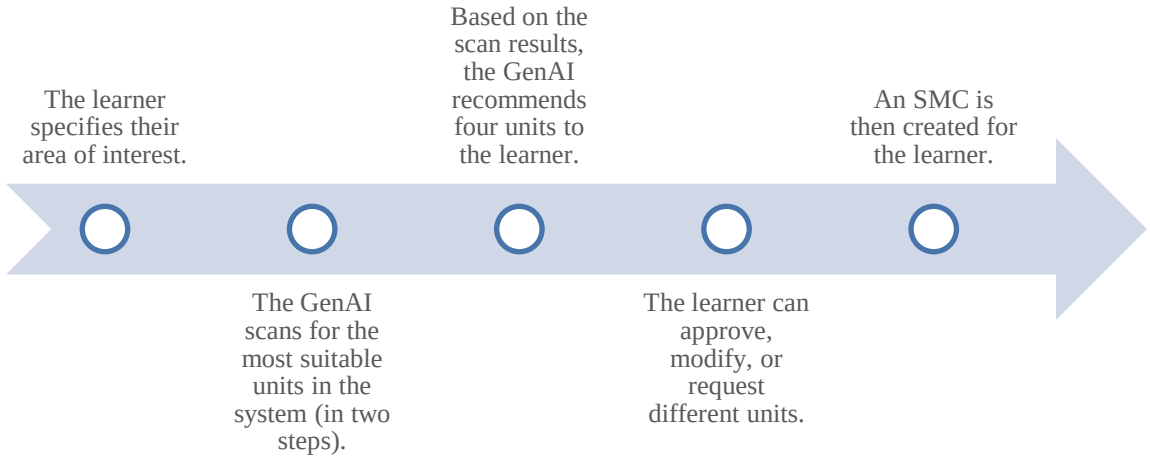

Figure 1: Flowchart of Generating SMC

According to Figure 1, which illustrates the stages of GenAI's SMC creation based on the learner's request, the process is as follows: Initially, the learner specifies their area of interest—subsequently, the GenAI scans for suitable courses within the AUOES undergraduate programs in two steps. Based on the scan results, GenAI recommends four units. The learner can approve these units, request changes, or make a new request. Finally, an SMC is created for the learner. These stages are designed to accommodate the learner's needs and interests, ensuring that the most relevant educational content is provided. The process considers suitable units for 522 courses taught in the AUOES undergraduate programs and accessible through DDP, organising them into coherent and tailored SMCs per the described steps.

In the first step, the same prompt was used 100 times to query MyGPT because, unlike most humans, Generative AI was inconsistent. Additionally, MyGPT's LLM failed to respond accurately. Thus, Step 2 was applied in this study. Even though the LLM in Step 1 lacked accuracy, it performed more reliably in Step 2.

The simulation was conducted in two steps due to the low performance of the LLM in the first step. Initially, the LLM's ability to propose MCs based on existing units aligned with the study's objectives was examined. However, a second step became necessary since the current ChatGPT-4-based MyGPT performed poorly in executing the given task in a single step. It was identified that the LLM in Step 1 tended to propose its own suggestions rather than using AUOES's unit pool (despite being trained and constrained in the instructions). Therefore, a simpler task was assigned in Step 2, for which a second MyGPT was created. The LLM in the second step proposed existing units, achieving a much higher accuracy rate compared to Step 1. Prompt summaries are below.

Step 1: Propose a four-unit micro-credential by examining the courses listed on the AUOES undergraduate program website and the detailed information provided in the course information package. The proposed units must be identical to those in the course materials.

Step 2: For the four-unit SMC proposals in Step 1, replace any units that do not exist in AUOES with appropriate existing units from the AUOES curriculum.

3.1.1 Step-1

In Step-1, the courses and units taught in the AUOES undergraduate programs are initially shared with the GenAI-based MyGPT. As requested by MyGPT, it has been asked to create SMCs consisting of four units from AUOES undergraduate courses corresponding to the field specified. This process has been simulated 100 times in the study. In the research, MyGPT is requested to create an SMC of four units from the AUOES undergraduate courses according to the specified field of interest. This process was simulated 100 times to ensure robustness and consistency in the findings. Robustness was measured through repeated simulations, with deviations in generated units assessed using standard deviation ($\sigma = 3.45$) and confidence interval calculations (95% CI = ±2.1). This statistical approach ensures that MyGPT's output variability remains within an acceptable range, reinforcing model stability under repeated conditions. These calculations align with established methodologies outlined in Introduction to Statistical Quality Control of Montgomery (2020). The Configuration section outlines what is requested from the GenAI in Step-1, including the instructions and the sharing of the SMC database. SMCs can be made in specific fields based on user requests, such as "Excel for office workers", beyond typical simulation examples.

3.1.2 Step-2

After each SMC suggestion process in Step-1 is simulated 100 times, Step-2 involves a different GenAI-based MyGPT. This version matches the units suggested in Step-1, which are not precisely the same in AUOES, with existing units. This step ensures that the recommendations are practical and applicable, refining the process to align closely with the actual coursework available in AUOES. In the second step, the GenAI precisely matched the units recommended in the first step, which do not exist in the AUOES course pool with the nearest existing units. The conversion of units that do not exactly exist in Step 1 into existing ones in Step 2 is illustrated in Table 1.

Table 1: Example of Steps of SMC for Programming

	Units			
Step	**Unit 1**	**Unit 2**	**Unit 3**	**Unit 4**
Step 1	Fundamentals of Programming	Algorithms and Programming	Object-Oriented Programming	*Database Management Systems*
Step 2	Fundamentals of VBA Programming	Concept of Algorithm and Fundamentals of Programming	Introduction to Object-Oriented Programming	*Database Management Systems*

At the final stage of the second step, the frequency of all units in the course pool was evaluated on an SMC basis, and the four most frequently recommended units were considered as the SMC.

The research is limited to the responses provided by the MyGPTs developed via OpenAI's paid ChatGPT-4 application (October 2023) at the time of the study. Additionally, the ChatGPT-4 application was used for translation and proofreading.

4 Findings

4.1 Status of Units Suggested by GenAI in AUOES Teaching

In the first step of the research, the GenAI-based MyGPT was tasked with making four suggestions in nine different fields based on the units of courses taught in the AUOES undergraduate programs. This step focused on generating MC suggestions tailored to the identified fields. In the second step, the GenAI-based MyGPT was asked to identify which units suggested in the first step correspond exactly to units within AUOES. This involves matching the proposed units to actual units taught in the AUOES, ensuring that the recommendations are applicable and relevant to the existing educational content (as detailed in Table 1). This process ensures that the suggestions made by the GenAI not only fit the theoretical framework but are also practically implementable within the current structure of the AUOES courses, bridging the gap between automated recommendations and actual educational content.

Table 2: Frequencies of All Units Recommended by GenAIs in Step-1 and Step-2

Step	Number of Units in the List	Number of Units Not Listed	Total
Step-1	174	682	856
Step-2	341	0	341

Table 2 reveals that while the GenAI proposed 856 units in the first step, 682 needed to match the units available in AUOES precisely. As a result, in the research's second step, a different GenAI-based MyGPT was employed to perform direct matching. In this second step, 341 units were suggested, all corresponding directly with the course pool units. This number includes the exact matches identified in Step-1 and represents the units fully aligned with the AUOES course pool. The findings indicate that GPT could be more effective in performing one-step data analysis with exact matching; however, it achieves a high level of success when it is tasked solely with the matching process in the second step.

4.2 Distribution of Micro-Credentials Based on the Number of Units in the First and Second Steps

Table 2 shows the frequences of micro-credentials based on the number of units in both steps. This table likely outlines how units have been adapted or utilised within the scope of micro-credentialing, reflecting how effectively GenAI's suggestions are integrated into the academic structure and the potential for offering micro-credentials based on these units. Such micro-credentialing could provide learners flexibility and modular learning opportunities within the AUOES programs.

Based on Table 3, the field "Transforming your organisation for sustainability (Climate change)" received the highest number of suggestions with 175, whereas "Marketing principles and practice" had the least with 59 suggestions in Step-1. The most frequently recommended "Discover your genre and develop your style (Digital photography)" was 66, and the least was for "Programming" with 32 in Step-2. The findings reveal that GPT in the second step provided suggestions at a lower frequency than GPT in the first step. Based on the results obtained from the first research question, it is observed that GPT in Step-2 produced more consistent suggestions. This suggests that GPT in Step-1, instead of performing the desired exact matching, generated alternative recommendations.

Table 3: Frequencies of Units in Step-1 and Step-2

Field	Step-1	Step-2
Discover your genre and develop your style (Digital photography)	130	66
Financial accounting for non-financial roles	114	56
Fundamentals of management accounting	94	45
Improving organisational practice	138	64
Marketing principles and practice	61	47
People management and leadership	75	48
Project management	123	37
Programming	59	32
Transforming your organisation for sustainability (Climate change)	175	63

As explained in the example in Table 1 above, in Step 1, MyGPT was instructed to perform 'recommendation + matching' based on the units of the existing courses. However, due to the high hallucination rate at this stage, the process proceeded to the second step. In Step 2, the system was required to perform only 'matching' by filtering the recommendations from Step 1 (eliminating non-exactly matching units). This allowed Step 2 to be completed with a lower workload than the first step. The summary of these processes is as follows: Table 2 presents all units suggested in Step 1, including hallucinated entries, while Table 3 reflects validated unit matches. The filtering process reduced inappropriate suggestions from 79.7% to 5.3%. Hallucination rate is the proportion of AI-generated outputs that are factually incorrect or non-existent. This metric has been widely studied in LLM processing and text generation models. (Ji et al., 2023). MyGPT was fine-tuned on educational datasets, utilising structured prompts to minimise hallucinations. A two-step verification mechanism was implemented, incorporating human oversight in Step 2 to ensure accuracy. False negatives occur when a model fails to identify correct instances, leading to the under-representation of valid outputs (Sokolova et al., 2006). False negatives at this study were identified as instances where valid AUOES course units were not suggested. A 6.8% false negative rate was observed, with the majority occurring in specialised subject areas (Table 4).

Table 4: False Negative Rate and Accuracy Improvement

Step	Hallucination Rate (%)	False Negative Rate (%)	Accuracy Improvement (%)
Step 1	79.7	nan	nan
Step 2	5.3	6.8	92.3

4.3 Most Frequently Recommended Units and Success Rate of Suggestions in Step-2

The two-step model, specifically designed for offering four-unit MC recommendations based on the most frequent suggestions in various fields, showed the frequency of unit suggestions per f in Table 3. This table typically outlines which units are being successfully matched and recommended most frequently by the GenAI in Step-2, indicating the effectiveness and relevance of the GenAI's learning algorithm in accurately identifying and suggesting units that align with existing courses and their content within AUOES. This also provides insights into how well the GenAI adapts to the academic structure and the needs of the learners.

Table 5: The Four Most Commonly Recommended Units Based on SMC According to Step-2

	Units (Recommendation Frequences in Scenarios)			
Field	**Unit 1**	**Unit 2**	**Unit 3**	**Unit 4**
Discover your genre and develop your style (Digital photography)	Digital Photography (37)	Digital Media and Privacy (24)	Social Security Techniques (19)	Artistic Applications of Digital Image Processing Methods (17)
Financial accounting for non-financial roles	Financial Statements and Financial Analysis (36)	Arrangement of Financial Statements (34)	Basic Concepts of Accounting and Chart of Accounts Related to Foreign Trade Transactions (28)	Accounting Process (25)
Fundamentals of management accounting	Management Accounting in Hospitals (49)	Introduction to Cost Accounting (45)	Order Management Customer Services and Logistics Information Systems (38)	Transportation Management and Information Systems (35)
Improving organisational practice	Institutionalisation in Labor Relations in Turkey: 1960-1980 (44)	Institutional Foundations Reasons Environments of the Interview (40)	Corporate Reputation Management (37)	Institutional Structure of Turkey-EU Partnership Relationship (37)
Marketing principles and practice	Consumer Markets and Consumer Behaviors (43)	Destination Marketing (38)	Marketing Communications for Destinations (38)	Concepts of Content and Digital Content Marketing (37)
People management and leadership	International Human Resources Management (59)	Leadership and Motivation (31)	Organisational Communication (28)	Management and Human Resources Management in Enterprises (22)
Programming	Concept of Algorithm and Fundamentals of Programming (74)	Computer Programming (61)	Development of Computers and Programming (45)	Basic Concepts of Programming and Introduction to C (45)
Project management	Project Management (108)	Financial Planning and Control (33)	Report Proposal and Project Preparation (24)	New Collaboration Searches in the World Economy: New Silk Road Project, BRICS and Shanghai

				Cooperation Protocol (23)
Transforming your organisation for sustainability (Climate change)	Sustainability (81)	Entrepreneurial Climate (55)	Ecology and Sustainability Awareness (36)	Impact of Reverse Logistics Activities on Costs and Sustainability (34)

The frequencies of units on an SMC basis reveal that the "Project Management" unit is the most frequently recommended, with 108 occurrences, and is part of the Project management field. In contrast, the least commonly recommended unit, with 22 occurrences, is "Management and Human Resources Management in Businesses," which belongs to the People management and leadership field.

Different calculations can be made for the analysis of qualitative data. In this research, the accuracy of responses provided by the GenAI was examined using the concordance percentage by Miles & Huberman (1994). According to Table 5, the responses of two experts who specialise in preparing AUOES course textbooks and materials were individually examined, and a consistency rate (concordance percentage) of 0.94 was calculated. However, expert opinions revealed that specific suggested units did not align well with their fields; for instance, the unit "Social Security Techniques" was found unrelated to the field of "Discover your genre and develop your style (Digital photography)," and "Management Accounting in Hospitals" was found unrelated to "Fundamentals of management accounting."

According to the findings, in Step 1, the LLM, which could only match a small percentage of existing units and offered different suggestions in each simulation, was assigned to directly match Step 1 suggestions with existing units in Step 2. In Step 2, the LLM, which selected all units from the AUOES pool, was evaluated by experts, who noted that only two units (even though they existed in AUOES) were deemed unsuitable for MCs. Thus, the LLM in Step 2 recommended existing units and selected highly appropriate units for MCs with a high accuracy rate. As the study was simulation-based and the ChatGPT version used during the research period performed the task poorly in a single step, a two-step process was necessary.

5 Results and Discussion

The study aims to improve methodological transparency by explicitly defining hallucination identification and mitigation criteria, providing a structured evaluation framework that enhances the interpretability of results. The two-step validation process suggests that generative AI tools have the potential to achieve high accuracy rates and may be effectively applied in generating micro-credentials from existing course units. The two-stage validation process enhances MyGPT's reliability for micro-credential generation. However, reliance on a pre-trained large language model without domain-specific fine-tuning presents a limitation. Future work should explore ontology-based validation techniques to reduce false negatives further. The study demonstrates a 74.4% reduction in hallucination rates, decreasing from 79.7% in Step 1 to 5.3% in Step 2, highlighting the effectiveness of structured prompts in improving output reliability. The 6.8% false negative rate reflects challenges in recognising domain-specific content, while σ = 3.45 and CI ±2.1 confirm the stability of generated outputs. Accuracy rate, a key evaluation metric in AI-driven classification and recommendation systems, measures the proportion of correctly predicted outputs against ground-truth data. At the conclusion of the two-step validation process, the accuracy rate was calculated as 92.3%, demonstrating the model's improved alignment with existing course units.

In the first step, while the GenAI recommended 856 units, 682 did not match exactly with those in the AUOES. This issue highlights the challenges in using GenAI in ODL, as noted by Bozkurt (2024a), who mentioned generating synthetic data by machines as one of the significant challenges. Chelli et al. (2024) found a 28.6% hallucination rate in ChatGPT-4. Mikroyannidis et al. (2024) concluded that ChatGPT was only 40% successful in generating course materials, emphasising the need for a different GenAI-based MyGPT in Step-2 for direct matching, which was ultimately successful (100%) as it solely focused on exact matching of units. The Step-2 MyGPT generated 341 units, matching those in the course pool. Ali et al. (2024) mention that MCs can be broadly integrated into online programs. The frequences in Step-2 is more meaningful as it was directly based on existing AUOES courses and units. It has been found that using AI to provide content that might interest learners MCs has resulted in learners being excited about the MC (Mallette, 2024). Regarding unit frequencies based on SMC, indicating variability in GenAI responses across simulations suggested that considering the total responses across repeated queries might provide a more consistent outcome. The match quality, as rated by experts in AUOES, found issues with some units not aligning well with their intended fields, though overall consistency was high (0.94). Although the units are part of the AUOES curriculum, experts identified two units as incompatible with the MC because they are irrelevant.

The research underscores the importance of dynamically adapting MCs to meet learner demands and maintain quality standards, as highlighted by Xu & Babaian (2021). Gauthier (2020) found that organisations were not satisfied with the skill levels of employees, underlining the need for MCs. Miao et al. (2024) concluded that when learners' skills are not rewarded (e.g., badges, certificates, MCs), they tend to neglect learning, emphasising the need for higher education institutions to cater to learner demands through MCs. This holistic approach to integrating MCs based on learner feedback and expert validation is crucial to evolving educational practices in higher education.

The widespread use of the internet has facilitated access to information, leading to the increase of personalised learning systems and the creation of skill sets tailored to the workforce and specific topics. However, when offered by higher education institutions, MC may be confined to particular patterns (Tamoliune et al., 2023). Presented through the diversified resources of universities, MC has the potential to contribute to lifelong learning that liberates individuals and communities (Desmarchelier & Cary, 2022). If the skills and traits targeted by MCs are deemed necessary for learners, perhaps their best integration into the curriculum is feasible. If the benefits of MC are acknowledged, integrating them into the curriculum could facilitate participation for all learners (Pollard & Vincent, 2022).

GenAI technology can be used in various fields for different purposes. Notably, the configuration of OpenAI's ChatGPT application via MyGPT allows the management of institutions to create their GenAIs without coding. Universities are redefining learning methods by introducing small-scale educational forms such as short courses. MC enhances human skills and teamwork, preparing individuals for employment. These programs play a significant role in guiding learners' careers (Peisachovich et al., 2021). MC is a part of lifelong learning, supports employment, and is easily accessible (Guzik et al., 2024).

The findings indicate that GenAI can efficiently generate MCs in ODL, offering flexibility and speed. With improved training, AI could enable learners to create institution-compliant MCs independently. Future prompt engineering advances ethics, automation, interdisciplinarity, human-AI interaction, efficiency, empirical research, and innovative solutions (Bozkurt, 2024b).

6 Conclusion

This study highlights the potential of AI-driven micro-credential recommendations in open education, demonstrating that structured and iterative validation methods significantly improve accuracy. While hallucinations were substantially reduced, according to the false negative rate, indicating challenges in recognising domain-specific content, particularly in specialized disciplines such as Financial Accounting and Digital Photography. These findings suggest that enhancing AI-generated recommendations requires advanced validation techniques, such as knowledge-structured frameworks and confidence-weighted ranking mechanisms, to mitigate hallucinations and false negatives. Future research should explore adaptive learning approaches to minimise errors and enhance reliability. The study underscores the need for hybrid validation frameworks integrating AI automation with human oversight, ensuring contextual accuracy and meaningful curriculum alignment.

As short courses gain global traction, the emphasis shifts from course enrolment to knowledge assimilation. Despite the operational challenges of tailoring MCs to specific fields and contents desired by learners, it remains crucial to define learning outcomes. GenAI could accurately discern learners' needs with LLM capabilities, facilitating MC design from the existing course pool. MCs offer a transformative potential for traditional educational frameworks and can be implemented alongside or independently from compulsory courses in higher education. These courses could be certified through elective courses, aiding those who struggle to graduate. Integrating AI with virtual reality might enable learners to visualise and choose unit content more effectively during their MC creation process. Giga universities like AU host a vast repository of textbooks and units crafted by expert authors and editors, adhering to high-quality standards. This allows for a flexible approach where learners can either directly select, or experts can use the model proposed in this study to devise alternative MCs. Institutions can integrate GenAI-based applications.

The study's limitation stems from the fact that MyGPT, a trainable Generative AI-based application, was used during the research period. Since MyGPT could not deliver the desired results in a single step at that time, using an improved version of its LLM within this study would be more appropriate. Otherwise, considering sustainability issues, such as the energy consumption and environmental impact of LLMs, would be beneficial.

References

Ahmat, N. H. C., Bashir, M. A. A., Razali, A. R., & Kasolang, S. (2021). Micro-credentials in higher education institutions: Challenges and opportunities. *Asian Journal of University Education*, *17*(3), 281–290. https://doi.org/10.24191/AJUE.V17I3.14505

Ali, M., Raza, S. A., Puah, C. H., & Qazi, W. (2024). Editorial: Micro-credential as a digital enabler for higher education ecosystems. *International Journal of Educational Management*, *38*(4), 893–896. https://doi.org/10.1108/IJEM-05-2024-655

Anadolu Üniversitesi. (2024). *Dijital Ders Platformu*. Açıköğretim Sistemi. https://ddp.anadolu.edu.tr

Aydin, C. H., Uçar, H., Koçdar, S., Okur, R., Taşci, D., & Bozkurt, A. (2024). Reflections and transformations in an Open University. *The Journal of Applied Instructional Design*, *13*(2), 185–191. https://doi.org/10.59668/1269.15710

Beukema, P. L. (2024). *Second class no longer: Online degrees and microcredentials are sweeping the world*. iUniverse.

Bozkurt, A. (2024a). GenAI et al.: Co-creation, authorship, ownership, academic ethics and integrity in a time of generative AI. *Open Praxis*, *16*(1), 1–10. https://doi.org/10.55982/openpraxis.16.1.654

Bozkurt, A. (2024b). Tell me your prompts and I will make them true: The alchemy of prompt engineering and generative AI. *Open Praxis*, *16*(2), 111–118. https://doi.org/10.55982/openpraxis.16.2.661

Bozkurt, A., & Brown, M. (2022). Microcredentials. *EdTechnica*, 155–161. https://doi.org/10.59668/371.8264

Brown, M., & Duart, J. M. (2024). Exploring gaps in the quality assurance of micro-credentials: a global mapping review of current practices. *Journal of Open, Distance, and Digital Education*, *1*(1), 1–16. https://doi.org/10.25619/2BWHVW68

Brown, M., Nic Giolla Mhichil, M., Beirne, E., & Mac Lochlainn, C. (2021). The global micro-credential landscape: Charting a new credential ecology for lifelong learning. *Journal of Learning for Development*, *8*(2), 228–254. https://doi.org/10.56059/JL4D.V8I2.525

Canbek, N. G., & Mutlu, M. E. (2016). On the track of Artificial Intelligence: Learning with Intelligent Personal Assistants. *Journal of Human Sciences*, *13*(1), 592–601. https://www.j-humansciences.com/ojs/index.php/IJHS/article/view/3549

Chakravorty, D. K., Edu Hprc, C., Lawrence, R., Brashear, W., Edu Hprc, W., Liu, H., Edu Hprc, H., Palughi, A. J., Perez, L. M., Yang, X., Pavelka, J., Edu Hprc, P., Mcdonald, R., & Pedraza, G. (2023). *Access to computing education using micro-credentials for cyberinfrastructure*. https://doi.org/10.22369/issn.2153-4136/14/2/5

Chelli, M., Descamps, J., Lavoué, V., Trojani, C., Azar, M., Deckert, M., Raynier, J. L., Clowez, G., Boileau, P., & Ruetsch-Chelli, C. (2024). Hallucination rates and reference accuracy of ChatGPT and Bard for systematic reviews: Comparative analysis. *Journal of Medical Internet Research*, *26*. https://doi.org/10.2196/53164

Chen, J., Liu, Z., Huang, X., Wu, C., Liu, Q., Jiang, G., Pu, Y., Lei, Y., Chen, X., Wang, X., Zheng, K., Lian, D., & Chen, E. (2024). When large language models meet personalization: perspectives of challenges and opportunities. *World Wide Web 2024 27:4*, *27*(4), 1–45. https://doi.org/10.1007/S11280-024-01276-1

Council of the European Union. (2022). *Council Recommendation on a European approach to micro-credentials for lifelong learning and employability – European Sources Online*. https://www.europeansources.info/record/council-recommendation-on-a-european-approach-to-micro-credentials-for-lifelong-learning-and-employability/

Desmarchelier, R., & Cary, L. J. (2022). Toward just and equitable micro-credentials: an Australian perspective. *International Journal of Educational Technology in Higher Education*, *19*(1), 1–12. https://doi.org/10.1186/S41239-022-00332-Y

Eaton, S. E., & Christensen, J. (2023). Academic Integrity in Canada: Historical perspectives and current trends. In *Academic Integrity in Canada Ethics and Integrity in Educational Contexts 1*. https://link.springer.com/bookseries/16725

Felton, S. D., Whitehouse, G., Motley, C., Jaeger, D., & Timur, A. (2023). How I stopped fearing micro-credentials and began to love digital badging – a pilot project. *Industry and Higher Education*, *37*(2), 309–317. https://doi.org/10.1177/09504222221117951

Gauthier, T. (2020). The value of microcredentials: The employer's perspective. *The Journal of Competency-Based Education*, *5*(2). https://doi.org/10.1002/CBE2.1209

Goar, V., Singh Yadav, N., & Yadav, P. S. (2023). Conversational AI for natural language processing: An review of ChatGPT. *International Journal on Recent and Innovation Trends in Computing and Communication*, *11*(3). https://doi.org/10.17762/ijritcc.v11i3s.6161

Guzik, A., Tomczak, M. T., & Gawrycka, M. (2024). What is the future of digital education in the higher education sector? An overview of trends with example applications at Gdańsk Tech, Poland. *Global Journal of Engineering Education*, *26*(2). http://www.wiete.com.au/journals/GJEE/Publish/vol26no2/06-Guzik-A.pdf

Hanshaw, J. (2024). Micro-credentials in higher and vocational education: An innovation or a disruption? A review of the literature. *Journal of Applied Learning and Teaching*, *7*(1), 256–265. https://doi.org/10.37074/JALT.2023.7.1.39

Holmberg, B. (1995). The evolution of the character and practice of distance education. *Open Learning: The Journal of Open, Distance and e-Learning*, *10*(2), 47–53. https://doi.org/10.1080/0268051950100207

Hunt, T., Carter, R., Zhang, L., & Yang, S. (2020). Micro-credentials: the potential of personalized professional development. *Development and Learning in Organizations*, *34*(2), 33–35. https://doi.org/10.1108/DLO-09-2019-0215

Ji, Z., Lee, N., Frieske, R., Yu, T., Su, D., Xu, Y., Ishii, E., Bang, Y. J., Madotto, A., & Fung, P. (2023). Survey of hallucination in natural language generation. *ACM Computing Surveys*, *55*(12). https://doi.org/10.1145/3571730

Koçdar, S., Hamutoğlu, N. B., Erdoğdu, E., & Uçar, H. (2024). Academic performance of learners with special needs in open and distance learning: a study in Anadolu University open education system. *European Journal of Special Needs Education*. https://doi.org/10.1080/08856257.2024.2380594

Maina, M. F., Guàrdia Ortiz, L., Mancini, F., & Martinez Melo, M. (2022). A micro-credentialing methodology for improved recognition of HE employability skills. *International Journal of Educational Technology in Higher Education*, *19*(1), 1–22. https://doi.org/10.1186/S41239-021-00315-5

Mallette, J. C. (2024). Preparing future technical editors for an artificial intelligence-enabled workplace. *Journal of Business and Technical Communication*, *38*(3), 289–302. https://doi.org/10.1177/10506519241239950

McGreal, R., & Olcott, D. (2022). A strategic reset: micro-credentials for higher education leaders. *Smart Learning Environments*, *9*(1), 1–23. https://doi.org/10.1186/S40561-022-00190-1

Miao, M., Ahmed, M., Ahsan, N., & Qamar, B. (2024). Intention to use technology for micro-credential programs: evidence from technology acceptance and self-determination model. *International Journal of Educational Management*, *38*(4), 948–977. https://doi.org/10.1108/IJEM-02-2023-0066

Mikroyannidis, A., Sharma, N., Ekuban, A., & Domingue, J. (2024). Using Generative AI and ChatGPT for improving the production of distance learning materials. *24th IEEE International Conference on Advanced Learning Technologies (ICALT 2024)*. https://oro.open.ac.uk/97397/1/Accepted%20Manuscript.pdf

Miles, M. B., & Huberman, A. M. (1994). Qualitative Data Analysis Second Edition: Expanded Sourcebook. In *Sage Publications: International Educational and Professional Publisher. Thousand Oaks.* (Issue 100). Sage Publications.

Minaee, S., Mikolov, T., Nikzad, N., Chenaghlu, M., Socher, R., Amatriain, X., & Gao, J. (2024). *Large Language Models: A Survey*. https://arxiv.org/abs/2402.06196v2

Montgomery, D. C. . (2020). *Introduction to statistical quality control*. John Wiley & Sons, Inc.

Negnevitsky, M. (2005). *Artificial Intelligence* (2nd ed.). Pearson Education.

OECD. (2023). *Micro-credentials for lifelong learning and employability: Uses and possibilities*. https://www.oecd-ilibrary.org/education/micro-credentials-for-lifelong-learning-and-employability_9c4b7b68-en

Oliver, B. (2019). Making micro-credentials work for learners, employers and providers. In *Deakin University*.

Öncü, S. E., & Süral, İ. (2024). Leveraging AI for enhanced support: Satisfaction levels of users utilizing virtual assistant in Open Education. *Asian Journal of Distance Education*, *19*(1). http://www.asianjde.com/ojs/index.php/AsianJDE/article/view/778

Panda, S., & Kaur, N. (2023). Beyond degrees: Navigating the digital frontier in higher education credentialing. *University News*, *61*(43), 43–53. https://doi.org/10.5281/ZENODO.10052788

Peisachovich, E. H., Dubrowski, A., Silva, C. Da, Kapralos, B., Klein, J. E., & Rahmanov, Z. (2021). Using simulation-based methods to support demonstration of competencies required by micro-credential courses. *Cureus*, *13*(8). https://doi.org/10.7759/CUREUS.16908

Pollard, V., & Vincent, A. (2022). Micro-credentials: A Postdigital Counternarrative. *Postdigital Science and Education*, *4*(3), 843–859. https://doi.org/10.1007/S42438-022-00311-6

Qin, C., Zhang, A., Zhang, Z., Chen, J., Yasunaga, M., & Yang, D. (2023). Is ChatGPT a general-purpose natural language processing task solver? *EMNLP 2023 - 2023 Conference on Empirical Methods in Natural Language Processing, Proceedings*, 1339–1384. https://doi.org/10.18653/v1/2023.emnlp-main.85

Sargent, R. G. (2013). Verification and validation of simulation models. *Journal of Simulation*, *7*(1), 12–24. https://doi.org/10.1057/JOS.2012.20

Simpson, M., & Anderson, B. (2012). History and heritage in open, flexible and distance education. *Journal of Open, Flexible, and Distance Learning*, *16*(2), 1–10. https://www.learntechlib.org/p/147885/article_147885.pdf

Sokolova, M., Japkowicz, N., & Szpakowicz, S. (2006). Beyond accuracy, F-Score and ROC: A family of discriminant measures for performance evaluation. *AAAI Workshop - Technical Report*, *WS-06-06*, 1015–1021. https://doi.org/10.1007/11941439_114

Stone, P., Brooks, R., Brynjolfsson, E., Calo, R., Etzioni, O., Hager, G., Hirschberg, J., Kalyanakrishnan, S., Kamar, E., Kraus, S., Leyton-Brown, K., Parkes, D., Press, W., Saxenian, A., Shah, J., Tambe, M., & Teller, A. (2016, October 31). Artificial intelligence and life in 2030: The one hundred year study on artificial intelligence. *Report of the 2015 Study Panel*. https://doi.org/10.48550/arxiv.2211.06318

Tamoliune, G., Greenspon, R., Tereseviciene, M., Volungeviciene, A., Trepule, E., & Dauksiene, E. (2023). Exploring the potential of micro-credentials: A systematic literature review. *Frontiers in Education*, *7*, 1006811. https://doi.org/10.3389/FEDUC.2022.1006811

The European Commission. (2022). *European project MICROBOL Micro-credentials linked to the Bologna Key Commitments*. https://microbol.microcredentials.eu/microbol-framework-published/

Van der Hijden, P. (2023). Short courses, micro-credentials, and flexible learning pathways: a blueprint for policy development and action: policy paper. In M. Martin (Ed.), *International Imstitute for Educational Planning*. UNESCO International Institute for Educational Planning. https://unesdoc.unesco.org/ark:/48223/pf0000384326

Weller, M. (2014). The battle for open. In *Ubiquity Press*. Ubiquity Press. https://doi.org/10.5334/BAM

Wu, L., Zheng, Z., Qiu, Z., Wang, H., Gu, H., Shen, T., Qin, C., Zhu, C., Zhu, H., Liu, Q., Xiong, H., & Chen, E. (2024). A survey on large language models for recommendation. *World Wide Web*, *27*(5), 1–31. https://doi.org/10.1007/S11280-024-01291-2

Xu, J. J., & Babaian, T. (2021). Artificial intelligence in business curriculum: The pedagogy and learning outcomes. *The International Journal of Management Education*, *19*(3), 100550. https://doi.org/10.1016/J.IJME.2021.100550

Zawacki-Richter, O. (2023). The Origins of the term distance education and the roots of digital teaching and learning. *Canadian Journal of Learning and Technology*, *49*(3), 1–7. https://doi.org/10.21432/CJLT28662

Zou, H., Ullah, A., Qazi, Z., Naeem, A., & Rehan, S. (2024). Impact of micro-credential learning on students' perceived employability: the mediating role of human capital. *International Journal of Educational Management*, *38*(4), 897–915. https://doi.org/10.1108/IJEM-01-2023-0002

Data Availability

In this study, the Anadolu Univerrsity's "Dijital Ders Platformu", which is open access data, was used.

Ethics and Consent

This study does not involve the use of human or animal subjects, and no confidential institutional information has been included.

Competing Interests

The author declares no competing interests.

Acknowledgement of Use of Generative AI Tools

The research is limited to the responses provided by the MyGPTs developed via OpenAI's paid ChatGPT-4 application (October 2023) at the time of the study (July 2024). Additionally, the ChatGPT-4 application was used for translation and proofreading.

For the translation and localization of content, ChatGPT-4 (October 2023) was employed. Human translators subsequently reviewed and adjusted the translations to ensure accuracy, cultural appropriateness, and contextual relevance. The final text was thoroughly reviewed and approved by the author to ensure it accurately reflects the intended research outcomes and ethical standards. The authors also assessed and addressed potential biases inherent in the AI-generated content. The final version of the paper is the sole responsibility of the human author.