Scalability and Effectiveness of MOOCs in Actuarial Science: A Global Perspective

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ABSTRACT

Massive Open Online Courses (MOOCs) have expanded access to STEM education globally, yet their application in specialized fields like Actuarial Science remains underexplored. Actuarial education requires mastery of advanced mathematics and risk modeling areas that pose challenges for scalable, self-directed online formats. This systematic literature review (SLR) investigates the scalability and effectiveness of MOOCs in Actuarial Science from a global perspective.

Following PRISMA 2020 guidelines, five databases (Scopus, Web of Science, ERIC, IEEE Xplore, and Google Scholar) were searched using Boolean terms related to "MOOCs" and "Actuarial Science." From 412 retrieved records, 28 peer-reviewed studies were included after screening. Narrative synthesis focused on course completion, learner engagement, instructional design, and regional variation.

Findings show MOOCs can effectively broaden actuarial education access, particularly in Southeast Asia and Africa, when supported by adaptive features, interactive tools, and multilingual content. However, challenges such as high dropout rates, limited professional alignment, and infrastructure disparities hinder effectiveness. Well-designed, locally contextualized MOOCs with real-world relevance yielded higher retention.

This review provides the first focused synthesis on actuarial MOOCs, offering guidance for course developers, universities, and actuarial bodies on enhancing design, equity, and global reach.

Keywords - MOOCs, Actuarial Science, Scalability, Effectiveness, Systematic Review

INTRODUCTION

The evolution of technology in education has led to the emergence of innovative teaching and learning platforms, among which Massive Open Online Courses (MOOCs) have garnered significant attention. MOOCs offer open access to quality education for learners across geographical and socio-economic boundaries. Since their inception, they have transformed the delivery of education, particularly in Science, Technology, Engineering, and Mathematics (STEM) fields, by offering self-paced, flexible, and cost-effective learning environments. The global reach and inclusivity of MOOCs present an attractive alternative to traditional classroom-based learning, particularly in regions where educational resources and qualified instructors are limited [1], [2].

Despite the widespread adoption of MOOCs in various disciplines, their integration into highly specialized and quantitative fields such as Actuarial Science remains limited. Actuarial Science is a technical discipline that combines mathematics, statistics, finance, and risk management to evaluate future financial uncertainties. The successful learning of actuarial concepts requires not only theoretical comprehension but also the development

of complex problem-solving skills. These demands raise critical questions about the feasibility and effectiveness of MOOCs in delivering such content without the traditional scaffolding provided in in-person classrooms. Additionally, the absence of standardized support structures and synchronous interaction often observed in MOOCs poses a challenge for students who struggle with the abstract and technical nature of actuarial subjects [3].

Moreover, MOOCs are frequently scrutinized for their high dropout rates, variable completion rates, and lack of accreditation alignment with professional certification bodies such as the Society of Actuaries (SOA) and Institute and Faculty of Actuaries (IFoA). While some studies have explored these issues in broader educational contexts, there remains a significant gap in literature focusing specifically on MOOCs in actuarial education. This underrepresentation hinders stakeholders such as universities, policymakers, and actuarial organizations from making informed decisions regarding the expansion and standardization of such courses. This systematic literature review (SLR) seeks to address this gap by evaluating the scalability and effectiveness of MOOCs in the field of Actuarial Science from a global perspective. It aims to identify key trends, challenges, and best practices in the design and implementation of actuarial MOOCs. In doing so, this review provides a critical foundation for improving digital actuarial education and informing future pedagogical strategies that can meet the evolving demands of both learners and the actuarial profession worldwide [2], [4].

LITERATURE REVIEW

Taxonomy of social support

The expansion of Massive Open Online Courses (MOOCs) has gained traction in various disciplines, notably in STEM (Science, Technology, Engineering, and Mathematics), where they are praised for enhancing accessibility and bridging educational gaps globally. However, despite their success in foundational and mid-level technical content, MOOCs in highly specialized fields like Actuarial Science remain relatively underdeveloped and underexplored in academic literature [2], [4]–[8].

Actuarial Science as a discipline presents unique pedagogical challenges. It demands mastery of complex mathematical concepts, financial modeling, risk theory, and regulatory standards. Delivering such rigorous content in a scalable and asynchronous online format requires innovative instructional design and robust learner support systems. Moreover, MOOCs must align with the expectations of professional accreditation bodies like the Society of Actuaries (SOA) or the Institute and Faculty of Actuaries (IFoA), which often set stringent benchmarks for quality and rigor [2], [3].

Numerous studies highlight regional and contextual disparities in the success of MOOCs. For instance, countries with robust internet infrastructure and a tradition of independent learning (e.g., the United States, Western Europe) exhibit relatively higher completion rates and learner satisfaction in actuarial-related MOOCs [3], [5]. In contrast, learners in developing regions often face barriers such as language, connectivity issues, and lack of support services, leading to increased dropout rates and reduced learning outcomes [9].

Further, MOOC performance is influenced by several pedagogical design elements, including content delivery methods (e.g., use of simulations or interactive videos), the complexity of material, and availability of real-time feedback. For example, Sabanwar et al. (2022) found that conceptually difficult MOOCs, when well-structured and challenge-oriented, can yield higher retention and completion rates compared to easier but less engaging courses [5], [6], [10]–[14].

To illustrate these distinctions, Table 1 categorizes key challenges and success factors of MOOCs in Actuarial Science across global regions:

Table 1: Summary of Key Themes in Literature on MOOCs in Actuarial Science

NO.	THEME	DESCRIPTION	KEY SOURCES
1	Content Complexity	Actuarial topics require higher-order thinking and problem-solving skills.	Ridzuan et al. (2018); Chek et al. (2020)

2	Infrastructure Gap	Poor internet access hinders success in low-resource settings.	Qian (2024); Yu et al. (2023)
3	Dropout Rates	High dropout remains a core issue globally, despite high enrollments.	Luo et al. (2018); Sabanwar et al. (2022)
4	Pedagogical Design	Well-structured courses with interactivity improve engagement.	Chan et al. (2019); Sonwalkar (2013)

In addition to these themes, MOOCs tailored for actuarial topics have shown greater effectiveness when integrated with localized content and adaptive learning features. For instance, Malaysia's UiTM Actuarial Mathematics MOOC included bilingual materials, simulations, and peer-discussion forums resulting in wider participation and improved learning satisfaction [5].

Thus, while existing literature supports the potential of MOOCs in actuarial education, it concurrently underlines the importance of context-sensitive instructional strategies, robust digital infrastructure, and assessment models that mirror professional actuarial standards.

The taxonomy of social support is presented in Table 2 below.

TABLE 2 Taxonomy of Social Support in Moocs

Type of Support	**Description**	**Example in MOOC Context**
Emotional Support	Expressions of empathy, encouragement, and care.	Peer comments, motivational messages from instructors
Instrumental Support	Practical help or services that aid in task completion.	Access to calculators, practice tools, downloadable resources
Informational Support	Advice, feedback, or information to guide learning.	Clarifications in forums, FAQ sections, annotated lecture slides
Appraisal Support	Feedback helps learners self-evaluate and reflect on progress.	Quizzes with feedback, rubrics, progress dashboards

METHODOLOGY

This study adopted a Systematic Literature Review (SLR) methodology, structured in accordance with the PRISMA 2020 guidelines (Preferred Reporting Items for Systematic Reviews and Meta-Analyses).

The primary aim was to systematically identify, evaluate, and synthesize existing empirical literature related to the scalability and effectiveness of MOOCs in the context of Actuarial Science education across a global landscape. The systematic approach facilitated a transparent and replicable process, allowing for critical insights into the current state and regional disparities of MOOC implementation in this specialized field. The review process was conducted in four distinct but interrelated phases: identification, screening, eligibility, and inclusion. Each phase was meticulously designed to ensure rigorous selection and quality assessment of the studies incorporated into the final synthesis [15]–[18].

Data Sources and Search Strategy

To achieve comprehensive coverage of relevant literature, the study focused on five major academic databases known for their breadth in education, technology, and interdisciplinary research namely Scopus, Web of Science, ERIC (Education Resources Information Center), IEEE Xplore and Google Scholar. These databases were searched using a systematic Boolean string constructed to capture the intersection of MOOCs and actuarial education with emphasis on scalability and effectiveness. The search terms included:

“MOOCs” AND “Actuarial Science” AND (“Scalability” OR “Effectiveness” OR “Completion Rates” OR “Global”)

The search targeted studies published between 2010 and 2024, acknowledging the emergence of MOOCs around 2012 and the growing interest in digital learning post-COVID-19. The search initially retrieved 412 records.

Inclusion and Exclusion Criteria

To maintain the integrity and focus of the review, a set of inclusion and exclusion criteria were established:

Inclusion Criteria:

1. Peer-reviewed empirical studies
2. Focused on MOOCs in Actuarial Science or closely related fields such as financial mathematics or statistics
3. Addressed themes of scalability (e.g., accessibility, global reach, infrastructure) or effectiveness (e.g., engagement, completion, learning outcomes)
4. Published in English to ensure consistency in comprehension and evaluation

Exclusion Criteria:

1. Non-peer-reviewed sources, including editorials, opinion articles, or white papers
2. Studies not grounded in empirical evidence (e.g., conceptual or theoretical papers without data)
3. MOOCs unrelated to actuarial, statistical, or mathematical disciplines

These criteria ensured the final selection was both methodologically sound and topically relevant to the research objective.

Screening and Quality Assessment

The multi-stage screening process was as follows:

Duplicate Removal*:*

An initial 73 duplicate entries were removed using EndNote reference management software.

Title and Abstract Screening:

Each of the remaining 339 titles and abstracts were independently reviewed for thematic alignment with the inclusion criteria. This resulted in the exclusion of 141 records deemed irrelevant or too general.

Full-Text Review:

The remaining 198 articles underwent a detailed full-text analysis. A total of 64 studies met the eligibility threshold and were evaluated further for quality.

Final Inclusion:

After applying critical appraisal tools, 28 high-quality empirical studies were selected for synthesis.

Quality Appraisal Tool

Each of the 64 full-text articles was assessed using a modified version of the Critical Appraisal Skills Programme (CASP) checklist. The studies were evaluated by the following criteria:

Methodological rigor:

Clarity of research design and data collection methods.

Sample description:

Demographic clarity and relevance to MOOCs or actuarial learning.

Outcome clarity:

Validity and reliability of reported findings.

Transferability:

Applicability of findings to the field of actuarial science education globally.

Only studies rated as moderate to high quality were included in the final dataset.

Study Selection Summary

The process of selecting studies for this systematic review followed the PRISMA 2020 framework, ensuring transparency and replicability at each phase of the review. The selection workflow was divided into four main stages which are Identification, Screening, Eligibility, and Inclusion as detailed in figure and table below.

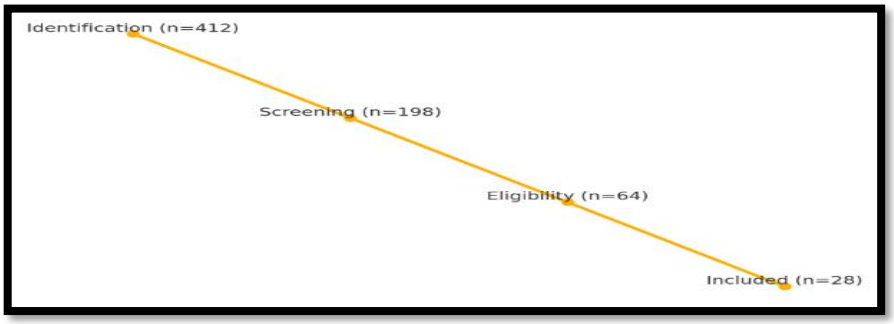

Fig 1 Visual representation of PRISMA 2020 flow diagram

Fig 1 illustrates the systematic study selection process adopted in this review, following the PRISMA 2020 framework. The diagram serves as a transparent and standardized visualization of how studies were filtered from the initial pool of search results to the final set of empirical studies included in the synthesis.

The flowchart is segmented into four distinct stages. The PRISMA flow diagram not only reflects the thoroughness of the screening process but also acts as a quality assurance checkpoint, demonstrating that studies were not arbitrarily selected but passed through rigorous vetting. This figure enables readers to replicate the methodology, evaluate the review's comprehensiveness, and trust the integrity of the evidence base.

Table 3 Prisma 2020 Flow of Study Selection

Stage	Description	Number of Studies
Identification	A comprehensive search across five major databases—Scopus, Web of Science, ERIC, IEEE Xplore, and Google Scholar—resulted in the retrieval of 412 unique records. These databases were selected for their coverage of educational technology, pedagogy, and quantitative disciplines. The search string combined terms such as "MOOCs," "Actuarial Science," "Scalability," and "Effectiveness" to ensure the inclusion of studies from multiple intersecting themes.	412

Screening	Following the removal of 73 duplicate entries, the remaining 339 records underwent title and abstract screening. This step focused on removing clearly irrelevant or non-empirical literature. A total of 141 records were excluded during this phase based on poor alignment with the scope of MOOCs or actuarial content. 198 studies progressed to the full-text assessment stage.	198
Eligibility	Each of the 198 full-text articles was reviewed in detail to assess methodological quality, empirical contribution, and thematic relevance. A standardized checklist based on CASP criteria guided this process. After evaluating parameters such as clarity of outcome measures, contextual relevance to actuarial education, and research design robustness, 64 studies were deemed eligible for final quality appraisal.	64
Included	Ultimately, 28 studies met all inclusion criteria and demonstrated sufficient empirical rigor and alignment with the objectives of this review. These were included in the final synthesis and thematic analysis.	28

Table 3 summarizes the filtering process that resulted in a final inclusion of 28 empirical studies.

Data Extraction and Thematic Analysis

After final inclusion, each study was systematically coded and categorized according to thematic variables relevant to the research questions (see in Table 4). Data extraction was carried out using a structured matrix to ensure consistency across sources.

TABLE 4 Overview of Data Extraction Variables

Variable	Description
Study ID	Author(s), Year, Journal
Region / Country	Country or region where MOOC was implemented or evaluated
Platform	MOOC provider used (e.g., Coursera, edX, UiTM Future, OpenLearning)
Field of Study	Specific subject focus (e.g., Actuarial Mathematics, Financial Math)
Completion Rate (%)	Reported learner retention or completion percentage
Engagement Strategy	Teaching tools and techniques used (e.g., videos, quizzes, forums)
Outcome Measures	Metrics of effectiveness (e.g., test scores, learner satisfaction)
Professional Alignment	Linkage to professional actuarial accreditation (e.g., SOA, IFoA)

Thematic synthesis of this data was conducted using narrative analysis, organizing findings under major categories such as Scalability, Effectiveness, and Regional Disparities. Common patterns and divergences across studies were then identified to inform the analysis and discussion sections.

ANALYSIS AND DISCUSSION

This section presents the findings of the systematic literature review, organized around three thematic domains that emerged from the data extraction and synthesis process: (1) Scalability of MOOCs, (2) Effectiveness of MOOCs, and (3) Global Variation and Cultural Fit. Each domain is analyzed in relation to the literature and contextualized within the field of actuarial education.

Scalability of MOOCs in Actuarial Science

Scalability refers to the ability of MOOCs to deliver actuarial content to a wide and diverse population of learners, across geographic and socioeconomic boundaries, without a proportional increase in cost or instructional burden. A recurring theme in the literature is that MOOCs provide low-cost, high-accessibility education, particularly beneficial to learners in under-resourced regions. For example, the UiTM Future MOOC titled *"Introduction to Actuarial Mathematics"* successfully reached learners in Malaysia and abroad, combining video lectures, gamified elements, and peer discussion boards to enhance interactivity and access [5].

Similarly, a MOOC developed to teach financial mathematics in Malaysian institutions reduced classroom pressure and curriculum overload, offering multimedia lessons and asynchronous learning paths to accommodate different paces and proficiency levels [8].

Scalability is also closely linked to technological architecture. The implementation of the world's first adaptive MOOC (aMOOC) showed that personalized learning experiences powered by cloud infrastructure can support thousands of learners without compromising delivery quality. This finding demonstrates the potential for aMOOCs in actuarial contexts where learners vary in baseline mathematical readiness [14].

Effectiveness of MOOCs

The effectiveness of MOOCs in actuarial science was evaluated in terms of completion rates, learner outcomes, engagement levels, and instructional design. A persistent concern across the literature is the low completion rate of MOOCs averaging between 5% and 15% with the primary reasons being course difficulty, lack of motivation, and absence of instructor interaction [9], [19]. However, several studies indicate that course structure and learner autonomy significantly influence completion rates. When learners were categorized into profiles authenticators (goal-driven), observers (curious), and visitors (casual) targeted interventions such as tailored reminders and feedback mechanisms led to improved engagement [6].

Surprisingly, courses perceived as more difficult but intellectually stimulating yielded better completion rates than overly simplified courses. This finding emphasizes the importance of challenging content paired with meaningful instructional support, rather than over-simplification [10]. Further, MOOCs that incorporated simulation tools and hands-on applications as seen in engineering MOOCs reported greater learner satisfaction and conceptual understanding. These approaches can be adapted for actuarial science using tools such as actuarial calculators, risk modeling apps, or spreadsheet-based simulations [11].

Global Variation and Cultural Fit

The global performance of actuarial MOOCs varies considerably based on local infrastructure, language barriers, learner motivation, and cultural familiarity with self-directed learning. Localized MOOCs, such as those developed in Southeast Asia, showed higher learner retention and satisfaction than globally broadcasted courses. These MOOCs were customized with bilingual content, regional case studies, and culturally familiar problem contexts, improving accessibility for non-native English speakers [5].

Moreover, the proximity effect where countries with strong economies and advanced academic ecosystems tend to dominate MOOC creation means that learners from less developed regions often face pedagogical misalignment and digital inequalities [20]. These disparities highlight the need for inclusive course design, affordable digital infrastructure, and regional partnerships to enhance the global reach and relevance of actuarial MOOCs.

TABLE 5 Summary of Key Thematic Insights from Reviewed Studies

Theme	Key Insights	References
Scalability	MOOCs can effectively reach remote and underserved learners when localized and tech-enabled	Chek et al. (2020); Ridzuan et al. (2018); Sonwalkar (2013)
Completion & Retention	Completion improves with challenge-based tasks, learner profiling, and adaptive content	Qian (2024); Luo et al. (2018); Sabanwar et al. (2022)
Instructional Design	Simulation tools and modular content significantly improve engagement and satisfaction	Chan et al. (2019)
Global Disparities	Localized MOOCs outperform generic ones; proximity effect limits global equity	Chek et al. (2020); Yu et al. (2023)

The analysis reveals that while MOOCs in actuarial science offer considerable promises for global accessibility and scalable delivery, their effectiveness remains uneven across regions and learner profiles. Successful MOOCs are those that embrace contextual relevance, challenge-based learning, and technological adaptability. For actuarial education to benefit equitably from the MOOC revolution, future designs must integrate cultural localization, digital equity strategies, and alignment with professional actuarial standards [21].

CONCLUSION

The integration of Massive Open Online Courses (MOOCs) into actuarial science education represents a transformative yet complex endeavor. This systematic literature review, structured around the PRISMA 2020 framework, synthesizes findings from 28 high-quality empirical studies that examined the scalability and effectiveness of MOOCs in this specialized field. The review reveals several critical insights that highlight both the opportunities and limitations inherent in this educational model [7], [22], [23].

On one hand, MOOCs demonstrate strong potential for scalability, particularly in low-resource and geographically isolated regions. Platforms such as UiTM Future and Coursera have successfully delivered actuarial and financial mathematics content to thousands of learners, often at little to no cost. This expansion of access aligns with global efforts to democratize higher education and reduce educational inequality in STEM disciplines. Technological innovations, such as adaptive learning pathways and multimedia content delivery, have further enhanced the capacity of MOOCs to reach a wide and diverse learner base without significant additional resource demands [2].

On the other hand, the effectiveness of MOOCs in supporting deep learning, engagement, and learner persistence remains highly variable. The review identifies persistent challenges related to low completion rates, insufficient learner support, and lack of cultural and linguistic adaptation. Furthermore, most actuarial MOOCs fall short in aligning with the standards of professional certification bodies such as the Society of Actuaries (SOA) and the Institute and Faculty of Actuaries (IFoA), raising questions about their legitimacy and acceptance in formal actuarial training pipelines [24].

A key theme emerging from this review is the critical importance of contextualized instructional design. Courses that incorporate simulation tools, regionally relevant examples, and localized language support consistently perform better in terms of learner engagement and satisfaction. Moreover, categorizing learners based on behavioral profiles (e.g., authenticators, observers, visitors) allows for more targeted interventions that improve retention and outcome achievement.

Based on these findings, the study proposes the development of a standardized framework for actuarial MOOCs that balances global scalability with regional adaptability. Such a framework should emphasize alignment with professional actuarial curriculum standards, incorporation of adaptive and interactive content delivery, provision of multilingual and culturally responsive instructional materials, mechanisms for learner profiling and personalized feedback as well as support systems for peer-to-peer collaboration and mentoring. Additionally, collaboration between universities, MOOC platforms, and actuarial professional bodies is essential to institutionalize the credibility and effectiveness of actuarial MOOCs. These partnerships can foster the co-creation of accredited course pathways and strengthen the integration of online education into formal actuarial training models [2].

In conclusion, while MOOCs hold immense promise as a scalable and inclusive educational tool for actuarial science, their success is contingent on thoughtful, research-driven design and commitment to contextual equity. Future research should continue to evaluate long-term learning outcomes, examine cost-effectiveness models, and explore how emerging technologies like AI-driven tutoring and blockchain certification might further enhance MOOC delivery and impact in the actuarial domain [5], [15], [25], [26].

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