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Original Article

A bibliometric analysis of pharmacy-student research on critical thinking, problem-solving, and academic performance

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ABSTRACT

Critical thinking, problem-solving and academic performance are central competencies of contemporary pharmacy education, yet the research literature addressing them among pharmacy students has never been mapped systematically. This study applies bibliometric methods to characterise the intellectual structure, productivity and thematic evolution of this field. A dataset of 443 English-language articles indexed in the Web of Science Core Collection (2020–2026) was retrieved and analysed with the bibliometrix R-package, combining performance analysis (annual output, sources, authors, countries, citations) with science mapping (co-word analysis, thematic mapping and factorial analysis). The field averaged 5.61 citations per document and involved 1,940 authors from 41 countries, with 16.0% international co-authorship. Output was strongly shaped by the COVID-19 pandemic, peaking in 2020–2021 and again in 2023. The United States (51.7% of articles), Australia, Canada and Saudi Arabia led production, and Currents in Pharmacy Teaching and Learning, the American Journal of Pharmaceutical Education and BMC Medical Education were the core sources. Science mapping revealed seven themes, with pharmacy education and curriculum as motor themes and assessment, objective structured clinical examinations, simulation and clinical reasoning as developing specialties. The most-cited works concerned emergency remote teaching, team-based learning and productive failure. The findings map an emerging, pandemic-accelerated field and identify priorities for future competency-focused research and international collaboration.

Keywords: Bibliometric analysis, Pharmacy students, Critical thinking, Academic performance, Pharmacy education

Introduction

Pharmacy has evolved from a product-centred discipline into a patient-centred clinical profession, and pharmacy curricula worldwide have followed suit by foregrounding higher-order competencies such as critical thinking, problem-solving and clinical reasoning alongside conventional academic performance [1-3]. Accreditation frameworks now expect graduates to interpret ambiguous clinical information, weigh therapeutic trade-offs and make defensible decisions under uncertainty — abilities that extend well beyond factual recall. As a result, a substantial body of educational research has accumulated around how pharmacy students develop, demonstrate and are assessed on these competencies.

Critical thinking, problem-solving and academic performance are related but distinct constructs, and their interplay is central to pharmacy education. Critical thinking denotes the purposeful, self-regulatory judgement through which a student interprets evidence and evaluates arguments; problem-solving applies that judgement to reach decisions in concrete, often ambiguous, clinical situations; and academic performance provides the measurable outcomes through which programmes gauge whether these abilities are being acquired [4-6]. In pharmacy specifically, these competencies converge in clinical reasoning, the process by which a practitioner moves from a patient presentation to a

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therapeutic decision. Because medication decisions carry direct consequences for patient safety, the stakes attached to developing and assessing these abilities are unusually high, which helps explain the intensity of research attention they have received and the diversity of pedagogical approaches, from team-based learning to simulation and objective structured clinical examinations, brought to bear on them [7-9].

Interest in this area intensified sharply during the COVID-19 pandemic, which forced an abrupt shift to emergency remote teaching and prompted a wave of studies on online learning, assessment integrity and student wellbeing [10-13]. The pandemic simultaneously disrupted experiential education and accelerated the adoption of simulation, virtual patients and technology-enhanced assessment, each of which bears directly on how critical thinking and problem-solving are cultivated and measured [14-16]. Understanding how this literature has developed - its volume, leading contributors, geographical distribution and thematic structure - is therefore timely.

Despite this growth, the field has not been mapped systematically. Narrative reviews address specific instructional methods, such as team-based learning or objective structured clinical examinations, but no study has quantified the overall intellectual structure of pharmacy-student research on critical thinking, problem-solving and academic performance, or traced how its themes have evolved [8, 17, 18]. Bibliometric analysis is well suited to filling this gap: by applying quantitative techniques to bibliographic metadata, it reveals productivity patterns, influential works and the conceptual organisation of a field in a transparent and reproducible way [19-21]. Such mapping complements traditional reviews by offering a bird's-eye view that is difficult to obtain by reading individual papers.

This study addresses that gap through a bibliometric analysis of 443 Web of Science-indexed articles published between 2020 and 2026. It pursues four objectives: (i) to describe the performance of the field in terms of annual output, leading sources, authors and countries; (ii) to identify the most influential documents and outlets; (iii) to uncover the thematic structure and conceptual clusters through science mapping; and (iv) to outline an agenda for future research and international collaboration. In doing so, it provides educators, researchers and policymakers with an evidence-based overview of a rapidly expanding, pandemic-shaped field.

Beyond describing the literature, a mapping of this kind carries practical value for several audiences. For curriculum designers, knowing which competencies attract the most research attention, and where the evidence is thin, helps prioritise pedagogical investment. For early-career researchers, identifying the core journals, seminal papers and active author groups shortens the path to situating new work within established conversations. For accreditation bodies and policymakers, a transparent picture of the field's geographical distribution and collaboration patterns reveals where capacity is concentrated and where it might be built. The competencies at the centre of this review - critical thinking, problem-solving and academic performance - are not peripheral concerns but the explicit targets of modern outcomes-based pharmacy curricula, which makes an accurate map of their evidence base directly consequential for practice [2, 22, 23].

It is also important to clarify what a bibliometric study can and cannot establish. Bibliometrics describes the structure, productivity and influence of a literature; it does not, by itself, adjudicate which teaching methods work best or which assessment is most valid. Its strength lies in objectivity, reproducibility and scale: where a narrative reviewer can synthesise a few dozen studies, bibliometric software can characterise hundreds while minimising selection bias in the description of the field [20, 24-26]. Used well, it complements rather than replaces systematic reviews of effectiveness, providing the macro-level context within which more focused syntheses can be positioned. The present analysis is offered in that spirit - as a map that orients, rather than a verdict that concludes.

Materials and Methods

Research design

A bibliometric design was adopted, combining performance analysis with science mapping [20, 24, 27]. Performance analysis quantifies the productivity and impact of research constituents - documents, authors, sources and countries - whereas science mapping uncovers the conceptual and intellectual structure of a field through co-word, co-citation and clustering techniques [28-31]. Bibliometrics is the application of statistical methods to publications and has become a standard approach for synthesising large, fast-growing literatures [25, 32, 33]. Reporting followed the spirit of the PRISMA 2020 recommendations for the identification and screening of records [34, 35].

Data source and search strategy

The Web of Science (WoS) Core Collection was selected as the single data source because of its curated coverage, citation completeness and structured metadata, which support reliable science mapping [20, 36, 37]. The search combined the population and competency concepts of interest using the query: ("pharmacy student") OR ("critical thinking" AND "problem-solving" AND "academic performance"). The initial retrieval was refined to English-language journal articles within the education, pharmacology/pharmacy, educational research, medical informatics and primary health care WoS categories, and restricted to major publishers, yielding a final corpus of 443 documents spanning 2020–2026. Restricting to a single database avoids the record-matching and de-duplication errors that arise when merging WoS and Scopus, at the cost of some coverage [20, 38].

Screening and dataset

Records were exported in plain-text (tagged) format with full metadata, including cited references, author affiliations and keywords. After removing non-article document types and non-English records, 443 articles were retained for analysis. The final dataset comprised contributions from 1,940 authors and 38

sources, contained 9,613 cited references, and carried 1,101 author keywords and 390 Keywords Plus terms.

The choice to analyse a single, coherent WoS export rather than a merged multi-database corpus was deliberate. Merging databases such as Web of Science and Scopus increases coverage but introduces substantial duplication and metadata-reconciliation problems, because the two sources format author names, affiliations and cited references differently; without careful de-duplication these inconsistencies distort exactly the co-authorship and co-citation structures that science mapping seeks to reveal [20, 36, 39]. By working within a single database with internally consistent metadata, the present analysis trades some breadth of coverage for higher reliability of the network and clustering results. This trade-off is appropriate for a field-mapping study whose primary aim is to characterise structure accurately rather than to enumerate every existing publication.

Analytical tools and indicators

Analyses were performed in R using the bibliometrix package and its Biblioshiny interface, a widely used, open and comprehensive science-mapping toolset [21, 40]. Performance indicators included annual scientific production, average citations per document, most productive and most locally cited authors, most relevant sources, and country production and collaboration (single-country versus multiple-country publications, SCP/MCP). Science-mapping analyses included co-word analysis to detect keyword co-occurrence structure [30, 41], thematic mapping to classify themes by centrality and density into motor, basic, niche and emerging/declining quadrants [42, 43], and multiple correspondence analysis (a factorial method) to position keywords in a conceptual space [31, 44]. Network centrality measures - betweenness, closeness and PageRank - were used to characterise the structural importance of individual terms [45, 46]. Classic bibliometric laws and indicators, including citation counts and productivity distributions, informed interpretation [47-50].

Three families of technique underpin science mapping, and each answers a different question. Co-citation analysis, in which two documents are related when a later paper cites both, reveals the intellectual foundations on which a field rests [29]. Bibliographic coupling, the mirror image, links documents that share references and is better suited to detecting current research fronts. Co-word analysis, used here as the primary mapping method, relates terms that appear together and thereby exposes the conceptual - as opposed to the citation-based - structure of a field [30]. Because author keywords express how researchers themselves frame their work, co-word analysis is particularly appropriate for tracing competencies such as critical thinking and problem-solving, which are conceptual constructs rather than discrete citable objects.

The thematic map operationalises two properties of each keyword cluster. Centrality measures the strength of a theme's links to other themes and thus its importance to the field as a whole; density measures the strength of internal links within a theme and thus its degree of development [43, 51]. Crossing these two dimensions yields four quadrants: motor themes (high centrality, high density) that are both important and well developed; basic themes (high centrality, low density) that are important but still maturing; niche themes (low centrality, high density) that are specialised and self-contained; and emerging or declining themes (low centrality, low density). Interpreting where each theme falls, and how it moves over time, provides a compact summary of a field's maturity and trajectory. Multiple correspondence analysis complements this by projecting keywords onto a low-dimensional conceptual plane, so that proximity in the plot approximates conceptual similarity [31, 52].

Results and Discussion

Overview of the dataset

The main characteristics of the corpus are summarised in **(Table 1)**. The 443 articles were published across 38 sources between 2020 and 2026 by 1,940 authors, with only nine single-authored documents, reflecting the strongly collaborative nature of pharmacy-education research. On average each document was authored by 5.03 researchers and attracted 5.61 citations, and 16.03% of articles involved international co-authorship. The mean document age of 3.33 years confirms that this is a young, fast-moving field, while the negative annual growth rate (−15.66%) reflects a pandemic-driven surge in 2020–2021 followed by normalisation rather than genuine decline, compounded by the partial indexing of the final year (2026).

Two indicators deserve particular attention. The average of 5.61 citations per document is respectable for a young corpus in which more than a quarter of the articles were published in the last two indexed years and have had little time to accumulate citations; it signals that the field's work is being actively used rather than ignored. The presence of 9,613 cited references against 443 source articles - roughly 22 references per paper - indicates that these studies are, on the whole, well grounded in prior literature, as expected of educational research published in established journals. The large pool of 1,101 distinct author keywords relative to 390 Keywords Plus terms suggests a rich but somewhat fragmented vocabulary, in which many authors coin their own descriptors; this fragmentation is itself a finding, pointing to the absence of a fully standardised terminology for competencies such as critical thinking and problem-solving.

The collaboration profile revealed by the co-authorship statistics also merits emphasis at the outset, because it frames how the field produces knowledge. With just over five authors per paper and only nine single-authored studies among 443 documents, pharmacy-education research on these competencies is a fundamentally team-based enterprise. This is consistent with the practical nature of the work, much of which involves designing, delivering and evaluating educational interventions across cohorts and sites, tasks that require the combined effort of educators, clinicians and methodologists. The relatively low international share of that collaboration, however, means that most teams are assembled within national or institutional

boundaries. The field therefore benefits from the depth that team science provides while remaining more nationally bounded than its globally relevant subject matter would warrant, a tension that recurs throughout the results below [17, 24, 53].

Table 1. Main information about the dataset

Description	Result
Timespan	2020–2026
Sources (journals)	38
Documents	443
Annual growth rate	−15.66%
Document average age	3.33 years
Average citations per document	5.61
Cited references	9,613
Author's keywords (DE)	1,101
Keywords Plus (ID)	390
Authors	1,940
Single-authored documents	9
Co-authors per document	5.03
International co-authorship	16.03%

Annual scientific production

Annual output is shown in **(Figure 1)**. Production began at a high level in 2020 (75 articles) and peaked in 2021 (77), coinciding with the first waves of pandemic-related educational research, before contracting in 2022 (49). A second, larger peak occurred in 2023 (81 articles), after which output stabilised at 67 articles in both 2024 and 2025; the 27 articles recorded for 2026 reflect partial-year indexing. This trajectory indicates that the pandemic acted as a powerful but temporary accelerant: the initial surge concerned emergency remote teaching and assessment, whereas the 2023 resurgence reflects a maturing interest in simulation, competency assessment and clinical reasoning that outlasted the acute crisis [11, 12, 54].

The dip in 2022 is itself informative. It plausibly reflects the natural lag between the pandemic's onset and the completion of more rigorous, non-emergency studies: the rapid-response commentaries and cross-sectional surveys of 2020–2021 gave way, after a publication trough, to the more deliberate empirical work that appeared from 2023 onward. Read this way, the field's output curve is not a simple rise-and-fall but a two-stage response - an initial reactive phase documenting disruption, followed by a reflective phase consolidating lessons into durable pedagogy and assessment. The stabilisation at around 67 articles per year in 2024–2025 suggests the field has settled into a sustainable post-pandemic equilibrium rather than reverting to its pre-2020 baseline, implying that pandemic-era attention to online and simulation-based competency development has become a permanent feature of the research landscape.

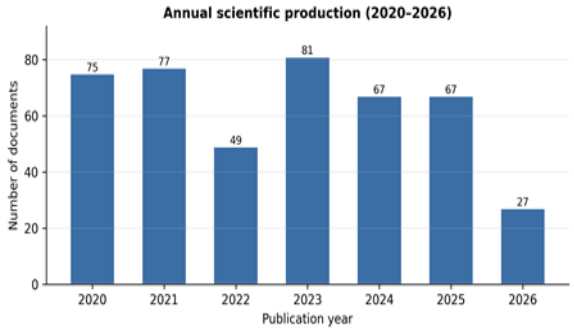

Figure 1. Annual scientific production of pharmacy-student research on critical thinking, problem-solving and academic performance (2020–2026).

Most relevant sources

Publication was highly concentrated in a small set of specialist outlets, consistent with Bradford's law of scattering [49]. As shown in **(Table 2)**, Currents in Pharmacy Teaching and Learning was the dominant source (183 articles, 41.3% of the corpus), followed by the American Journal of Pharmaceutical Education (87) and BMC Medical Education (61). Together these three journals published 74.5% of all articles, forming the core zone of the field. Pharmacy-practice and regional outlets - Saudi Pharmaceutical Journal, the Journal of the American College of Clinical Pharmacy and Research in Social & Administrative Pharmacy - constituted a secondary zone. This concentration provides researchers with a clear set of target journals but also signals a degree of disciplinary insularity, since general higher-education and assessment journals are comparatively underrepresented [55].

The nature of the three core journals shapes the character of the literature. Currents in Pharmacy Teaching and Learning and the American Journal of Pharmaceutical Education are dedicated pharmacy-education outlets with a strong tradition of publishing instructional innovations, curricular evaluations and assessment studies, which explains the prominence of teaching-method and OSCE research in the corpus. BMC Medical Education, a broader health-professions journal, contributes a more methodologically diverse and internationally authored stream, and its substantial presence (13.8%) indicates that pharmacy-student competency research is increasingly read and cited beyond pharmacy's disciplinary boundaries. The comparative scarcity of articles in general education-research or cognitive-science journals, however, suggests that the field remains somewhat self-referential: it draws on but does not yet frequently publish alongside the wider scholarship on critical thinking and assessment, an integration that could strengthen its theoretical foundations [4, 55, 56].

Bradford's law predicts that a small nucleus of journals accounts for as many articles as a much larger number of peripheral sources, and the present distribution conforms closely to that pattern: three core journals match the combined output of the remaining thirty-five. For authors, this has a clear strategic implication - the probability of reaching the field's primary readership is greatly increased by targeting the core zone - but it

also raises the concern that editorial priorities in a handful of outlets exert an outsized influence on which competencies and methods receive attention. Diversifying publication venues, particularly towards journals that bridge pharmacy and mainstream education research, would reduce this dependence and broaden the field's intellectual inputs.

Table 2. Most relevant sources

Source	Articles	Share
Currents in Pharmacy Teaching and Learning	183	41.3%
American Journal of Pharmaceutical Education	87	19.6%
BMC Medical Education	61	13.8%
Saudi Pharmaceutical Journal	19	4.3%
Journal of the American College of Clinical Pharmacy	17	3.8%
Research in Social & Administrative Pharmacy	9	2.0%
Exploratory Research in Clinical and Social Pharmacy	8	1.8%
Journal of Pharmaceutical Policy and Practice	7	1.6%

Most productive and most cited authors

Authorship was widely distributed across 1,940 researchers, consistent with Lotka's law of scientific productivity, under which most authors contribute a single paper [48]. The most prolific author was Charrois TL (5 articles), followed by a cluster of authors with four articles each, including Ali M, Alkofide H, Basheti IA, Kerr A, Kiles TM, McLaughlin JE, Saad AH and Spivey CA. When productivity is weighted by author share (fractionalised counts), Charrois TL again ranked highest, indicating genuinely leading rather than merely frequent contributions. Local citation analysis, which counts citations received from within the dataset itself, identified Daugherty KK and Malcom DR as the most locally influential authors, followed by Dinkins MM, Fillius AG and Haltom WR. The divergence between global productivity and local influence is common in emerging fields and suggests that different scholars drive volume versus intellectual centrality [57].

The productivity distribution is steeply skewed: with 1,940 authors producing 443 articles at 5.03 authors per paper, the overwhelming majority appear only once, while a small core sustains repeated output. This is the classic Lotka signature of a field that is broad but not yet dominated by large, institutionalised research programmes [48]. The prominence of Charrois TL, whose work spans professionalism, clinical reasoning and pandemic-era learning, illustrates how a single sustained research agenda can anchor a developing area. The four-article cluster is notably international - including authors based in Saudi Arabia (Ali M, Alkofide H), Jordan (Basheti IA) and the United States - which reinforces the picture of a field with multiple regional centres rather than a single dominant school.

The gap between the most productive authors and the most locally cited authors is analytically important. Productivity counts how much a scholar publishes; local citation counts how much their work is used by others studying the same topic. That Daugherty KK and Malcom DR lead on local citations without appearing among the most prolific authors indicates that they have produced a small number of highly influential, frequently referenced studies - the kind of foundational work that shapes a field's internal conversation. For researchers seeking to understand the intellectual core of pharmacy-student competency research, these locally central authors are at least as important as the most prolific ones, and their key papers merit close reading.

Most cited documents

The most cited documents, listed in **(Table 3)**, reveal the intellectual anchors of the field and are dominated by pandemic-era studies. The single most cited article examined the impact of COVID-19 lockdown on pharmaceutical education in Saudi Arabia and argued for remote-teaching contingency strategies (83 citations) [11]. It was followed by studies of pharmacists' pandemic readiness [58] and of pharmacy students' perceptions of distance online learning [12]. Beyond the pandemic cluster, highly cited works addressed the role of online learning in pharmacy education [10], the effect of team-based learning on critical-thinking skills [7], and the concept of productive failure drawn from the learning sciences [59]. This citation profile confirms that emergency remote teaching, active-learning pedagogy and assessment of higher-order skills form the citation backbone of the field.

The dominance of 2020–2021 publications among the most cited works reflects both the salience of their subject matter and the citation advantage that accrues to earlier papers, which have had longer to be discovered and referenced [57]. Yet the composition of the list is not merely an artefact of timing. Several of these documents endure because they addressed problems that outlasted the pandemic: the transferable lessons of Steenhof and colleagues on productive failure, for instance, speak to a general principle of how difficulty promotes learning, while Silberman and colleagues' demonstration that team-based learning improves critical-thinking skills bears directly on the competencies at the heart of this review [7, 59]. The presence of Malau-Aduli and colleagues' 2022 study of workforce readiness, one of the few recent papers to break into the top tier, hints at where durable citations are now accruing - in work that links education to graduate capability rather than to crisis response [60].

Taken together, the most-cited documents delineate three enduring conversations: how to deliver pharmacy education at a distance without sacrificing quality; how active-learning methods such as team-based learning and simulation build higher-order competencies; and how to assess and assure the readiness of graduates for practice. These conversations map closely onto the thematic clusters described below, confirming that the field's most influential works and its dominant

Table 3. Ten most cited documents

#	First author, topic (year)	Source	TC
1	Alqurshi A - COVID-19 lockdown and pharmaceutical education (2020)	Saudi Pharm J	83
2	Basheti IA - pharmacists' pandemic readiness (2021)	Res Social Adm Pharm	72

3	Shawaqfeh MS - distance online learning perceptions (2020)	J Med Educ Curric Dev	71
4	Hamilton LA - online learning in pharmacy education (2020)	Curr Pharm Teach Learn	44
5	Silberman D - team-based learning and critical thinking (2021)	Curr Pharm Teach Learn	36
6	Steenhof N - learning from productive failure (2020)	Adv Health Sci Educ	35
7	Lim AS - online virtual experience tool (2020)	Am J Pharm Educ	32
8	Malau-Aduli BS - readiness to enter the workforce (2022)	BMC Med Educ	32
9	Stranges PM - pharmacists in transitions of care (2020)	J Am Coll Clin Pharm	31
10	Al-Alami ZM - remote anatomy/histology learning (2022)	Anat Sci Educ	29

Note. TC = total citations in the Web of Science Core Collection.

Country production and collaboration

Research was geographically concentrated but internationally distributed across 41 countries **(Table 4)**. The United States was overwhelmingly dominant, contributing 229 corresponding-author articles (51.7%), far ahead of Australia (26), Canada (25), Saudi Arabia (22) and the United Kingdom (17). Collaboration patterns, captured by the ratio of multiple-country publications (MCP) to total output, varied markedly. The United States produced almost entirely domestic work (MCP 2.2%), whereas smaller producers were far more internationally connected: Lebanon (85.7% MCP), Jordan (50.0%), Qatar (40.0%), Saudi Arabia (36.4%) and Australia (34.6%). This pattern is typical of a field with a dominant national producer surrounded by smaller, collaboration-reliant contributors, and it highlights the Middle East as an emerging and highly networked region in pharmacy-education research [17, 55]. Overall international co-authorship (16.0%) remained modest, indicating scope for greater cross-border collaboration.

Table 4. Leading countries by corresponding-author production and collaboration

Country	Articles	Share	SCP	MCP %
USA	229	51.7%	224	2.2%
Australia	26	5.9%	17	34.6%
Canada	25	5.6%	21	16.0%
Saudi Arabia	22	5.0%	14	36.4%
United Kingdom	17	3.8%	15	11.8%
China	13	2.9%	12	7.7%
Ireland	10	2.3%	7	30.0%
Qatar	10	2.3%	6	40.0%
Lebanon	7	1.6%	1	85.7%
Jordan	6	1.4%	3	50.0%

Note. SCP = single-country publications; MCP = multiple-country publications.

The contrast between the United States and the smaller producers reflects two different models of knowledge production. The large domestic literature of the United States is self-sufficient: with dozens of colleges of pharmacy and a well-established education-research infrastructure, American scholars can sustain a substantial output without international partners. Smaller producers, by contrast, achieve visibility partly through collaboration, and the very high multiple-country rates of Lebanon, Jordan and Qatar indicate that their researchers frequently co-author with colleagues abroad, often in the Gulf region or with Western institutions. The emergence of a Middle Eastern cluster is one of the most striking findings of the analysis and suggests that the geography of pharmacy-education research is broadening beyond its traditional Anglophone centres [17, 55]. From a policy perspective, the modest overall international co-authorship rate of 16.0% represents an opportunity rather than a deficiency. Competency frameworks for critical thinking and problem-solving are often developed in high-income, English-speaking settings, and their transferability to other educational and cultural contexts cannot be assumed. Greater international collaboration, especially involving under-represented regions in Asia, Africa and Latin America that are largely absent from the leading-country table, would test that transferability and enrich the field with a wider range of pedagogical traditions. The existing Middle Eastern collaboration networks offer a practical template for how such partnerships can be built [2].

Conceptual structure: co-word analysis

The conceptual structure of the field was examined through the co-occurrence network of author keywords [30]. The most frequent terms were pharmacy education (92 occurrences), pharmacy (73), pharmacy students (53), education (37), simulation (21), assessment (20), curriculum (19) and experiential education (18), with COVID-19 (16) and objective structured clinical examination (13) also prominent. Network centrality analysis identified education and pharmacy education as the terms with the highest betweenness and PageRank centrality, confirming their role as conceptual hubs connecting otherwise distinct sub-topics. Three broad keyword communities emerged: a first centred on pharmacy education, simulation and skills; a second on education, curriculum and pharmacists; and a third on pharmacy students, perceptions and attitudes. The co-word structure thus links a pedagogy-and-assessment cluster, a curriculum-and-workforce cluster, and a student-experience cluster, reflecting the field's dual concern with how competencies are taught and how they are perceived and measured [4, 61].

The high betweenness centrality of education and pharmacy education is structurally significant. Betweenness measures how often a term lies on the shortest path between other terms, so a high value means the term acts as a bridge through which otherwise separate topics connect [45]. That these two general terms dominate betweenness indicates that the field's specialised topics, such as simulation, objective structured clinical examinations, professionalism and clinical reasoning, are linked to one another largely through their common relationship to education and curriculum rather than through direct connections

among themselves. This is characteristic of a field that is thematically broad but not yet tightly integrated. Strengthening the direct conceptual links among assessment, simulation and professionalism, for example by studying how simulated encounters develop the professional identity that underpins sound clinical reasoning, would move the field towards greater integration [54, 62].

The comparative infrequency of explicit critical-thinking and problem-solving keywords, despite their centrality to the field's stated purpose, is itself noteworthy. These competencies appear to be pursued under a variety of proxy terms, including clinical reasoning, metacognition, skills and performance, rather than named directly, which both reflects and reinforces the terminological fragmentation noted earlier. A more consistent vocabulary would improve the discoverability of this research and facilitate cumulative synthesis, and represents a concrete opportunity for the editors and author communities of the core journals to provide leadership [4, 61].

Thematic structure and evolution

Thematic mapping classified the literature into seven themes positioned by centrality (relevance) and density (development), as depicted in **(Figure 2)**. Pharmacy education and the education/curriculum theme occupied the motor-and-basic region - high-centrality themes that structure the field and connect to many others. Assessment (including objective structured clinical examinations and metacognition) and simulation with clinical reasoning appeared as well-developed but more specialised themes, indicating active, internally coherent research programmes on how higher-order competencies are measured and rehearsed [8, 54]. The COVID-19 impact theme, encompassing attitudes, community pharmacy and pharmaceutical care, was highly relevant but comparatively less developed, consistent with a rapidly assembled pandemic literature. Professionalism and team-based learning formed a smaller, emerging cluster linked to identity formation and admissions [22, 62]. The overall configuration portrays a field organised around a stable educational core, a maturing assessment-and-simulation specialty, and a still-consolidating professionalism strand.

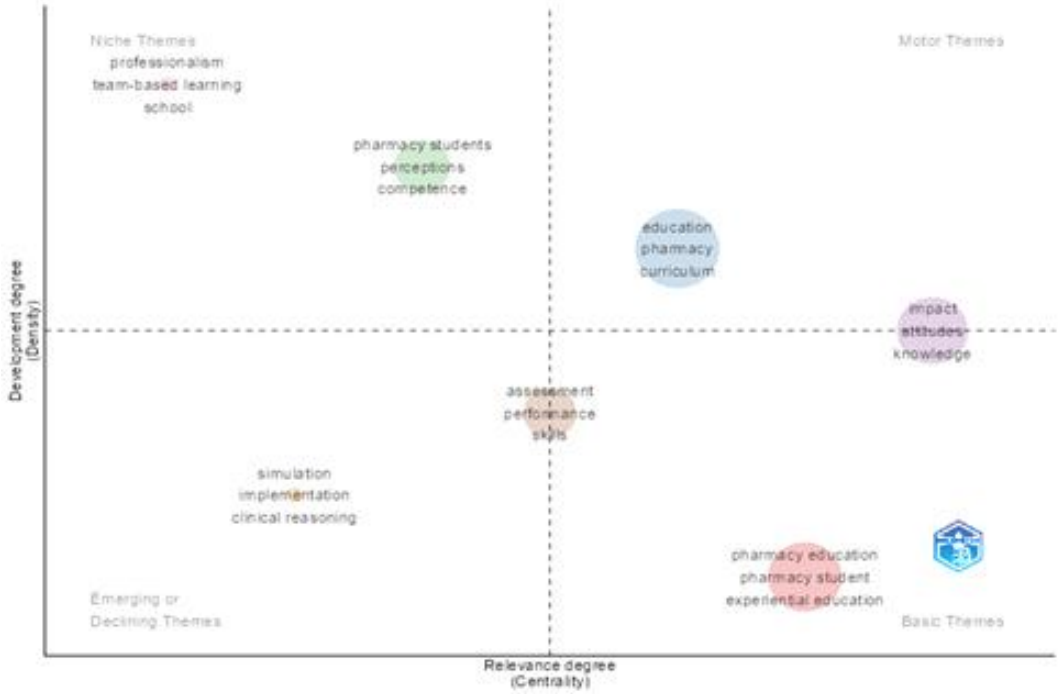

Figure 2. Thematic map of the field, positioning seven themes by centrality (horizontal) and density (vertical). Bubble size is proportional to keyword occurrences.

Multiple correspondence analysis of the keyword space corroborated this structure, separating a teaching-and-curriculum dimension from a perceptions-and-impact dimension and situating terms such as pharmacy students, perceptions and impact away from the curriculum-centred core. Taken together, the co-word, thematic and factorial analyses converge on a coherent picture: the field is anchored by pharmacy education and curriculum design, is actively developing assessment and simulation methods for critical thinking and clinical reasoning, and retains a distinct, experience-oriented strand concerned with student perceptions, professionalism and the lingering influence of the pandemic [43, 55].

Examining the composition of each theme deepens this interpretation. The assessment theme brings together objective structured clinical examinations, metacognition, communication and performance, indicating a research programme concerned not merely with testing knowledge but with capturing higher-order and reflective competencies under standardised conditions [8]. The simulation theme couples clinical reasoning and critical thinking with implementation and qualitative research, suggesting that studies in this area are as much about how

simulation is embedded in curricula as about its effects. The impact theme, dominated by COVID-19, attitudes and pharmaceutical care, captures the field's reflexive response to disruption, while the professionalism theme links team-based learning, admissions and professional identity, connecting how students are selected and socialised to how they are taught. These internal compositions show that the seven themes are not arbitrary keyword groupings but substantively meaningful research programmes, each with its own questions and methods.

The thematic map also carries a temporal message. The positioning of the COVID-19 impact theme as highly relevant but only moderately developed is consistent with a literature that was assembled quickly and has not yet fully matured into cumulative theory; as the pandemic recedes, this theme may either consolidate into durable lessons about resilience and flexible delivery or fade as attention returns to perennial concerns. The assessment and simulation themes, by contrast, sit in a more developed position, implying that these are the areas where the field is currently building its most robust methods. For researchers deciding where to invest, the map suggests that competency assessment and simulation offer the firmest existing foundations on which to build, while the professionalism strand offers greater room for original, field-shaping contributions [5, 62].

It is worth situating these seven themes against the broader trajectory of health-professions education. The movement from knowledge transmission towards competency-based and outcomes-focused models, articulated in influential global commissions on health-professional education, provides the backdrop against which pharmacy's emphasis on critical thinking and clinical reasoning has intensified [2]. The thematic structure identified here mirrors that wider shift: the prominence of assessment, simulation and professionalism reflects a discipline actively translating competency ideals into concrete teaching and testing practices. Viewed in this light, the field is not merely responding to the pandemic but participating in a longer disciplinary transformation, using the disruption of 2020 as an accelerant for changes that were already under way. This alignment with the mainstream of health-professions education is a source of strength, and it reinforces the case for closer engagement between pharmacy-education researchers and the wider scholarship on learning and assessment [63, 64].

Discussion and research agenda

Three findings warrant emphasis. First, the field is young, productive and pandemic-shaped: the twin output peaks of 2020–2021 and 2023 show how an external shock can both accelerate and reorient a research area, shifting attention from emergency remote delivery towards durable questions of competency assessment [10, 11, 54]. Second, the literature is intellectually concentrated - in three core journals and in a dominant national producer - yet increasingly internationalised at its periphery, with Middle Eastern and Australasian groups driving collaboration [17, 55]. Third, the thematic structure reveals a maturing but still-fragmented field in which assessment, simulation and professionalism are developing semi-independently rather than as an integrated science of competency development.

These observations suggest several priorities. Research on critical thinking and problem-solving would benefit from shared, validated instruments and longitudinal designs that link instructional interventions to downstream academic and clinical performance, moving beyond the single-institution, cross-sectional perception studies that currently predominate [5, 61]. Greater international collaboration - particularly involving under-represented regions in Asia, Latin America and Africa - would broaden the evidence base and test the cultural transferability of competency frameworks. Finally, integrating the assessment, simulation and professionalism strands around a common model of clinical reasoning could convert a set of parallel literatures into a cumulative science. For educators and policymakers, the concentration of high-impact work in a few outlets offers a practical roadmap for staying current, while the modest international co-authorship rate signals a clear opportunity for capacity-building partnerships.

A further priority concerns methodological rigour and construct clarity. Much of the current literature relies on self-reported perceptions and satisfaction measures, which, while valuable for capturing the student experience, provide limited evidence of whether critical thinking or problem-solving has actually improved. Advancing the field will require the adoption of validated, behaviourally anchored assessments, ideally administered at multiple time points, together with clearer conceptual definitions that distinguish critical thinking from adjacent constructs such as clinical reasoning, metacognition and decision-making. The learning-sciences concepts that already appear among the most-cited works, such as productive failure and deliberate practice, offer ready theoretical scaffolding for this more rigorous programme, and their prominence suggests the field is receptive to importing robust frameworks from cognitive and educational psychology [1, 4, 59]. Aligning terminology, measurement and theory in this way would transform a descriptively rich but methodologically uneven literature into one capable of supporting confident causal claims about how competencies are best developed.

For practice, the map translates into concrete guidance. Educators seeking to strengthen critical thinking and problem-solving can look to the assessment and simulation themes, which represent the field's most developed methods, for validated approaches such as team-based learning, objective structured clinical examinations and simulation-based clinical-reasoning exercises [7, 8, 54]. Programme leaders planning research or curriculum evaluation can use the source and country analyses to identify where relevant expertise resides and which journals will reach the appropriate readership. And those building new programmes in under-represented regions can draw on the highly collaborative Middle Eastern and Australasian networks as models for partnership. In each case, the value of the bibliometric map lies in converting a large, dispersed literature into an actionable orientation, showing not only what is known but

where the expertise, the methods and the publication venues are concentrated.

Several limitations should be acknowledged. The analysis relied on a single database (Web of Science), which, although curated, omits records indexed only in Scopus, PubMed or regional databases, so absolute counts should be read as indicative rather than exhaustive [20]. The search was restricted to English-language articles and to specific WoS categories and publishers, potentially underrepresenting non-English and grey-literature contributions. Bibliometric indicators quantify structure and influence but not methodological quality; citation counts favour older documents and popular topics, and the partial indexing of 2026 depresses recent counts. Author-name and keyword ambiguity may introduce minor noise despite the software's disambiguation. Future work could triangulate across databases, incorporate full-text or altmetric indicators, and complement the mapping with a qualitative systematic review of instructional effectiveness.

A second set of considerations concerns interpretation. Bibliometric indicators are descriptive, not evaluative: a highly cited paper is influential but not necessarily correct or methodologically strong, and a sparsely cited paper may nonetheless report rigorous, important findings that have simply not yet been discovered. Citation practices also vary across sub-topics and journals, so raw counts should be compared with caution. Similarly, the thematic map is sensitive to analytical choices such as the minimum keyword frequency, the clustering algorithm and the treatment of synonyms; different but defensible settings can shift the position of borderline themes. The results presented here were generated with widely used default parameters and are robust to minor variation, but they should be read as one coherent representation of the field rather than the only possible one [21, 43]. Finally, because keywords are supplied by authors, the map reflects how researchers describe their work, which may lag behind the actual content of their studies, particularly for rapidly evolving competencies whose vocabulary is still settling.

Conclusion

This bibliometric analysis mapped 443 Web of Science articles published between 2020 and 2026 on pharmacy-student critical thinking, problem-solving and academic performance. The field is young and highly collaborative, averaging 5.61 citations per document and drawing on 1,940 authors from 41 countries, and its output was strongly shaped by the COVID-19 pandemic, peaking in 2020–2021 and again in 2023. Production was concentrated in the United States and in three core journals - Currents in Pharmacy Teaching and Learning, the American Journal of Pharmaceutical Education and BMC Medical Education - while smaller Middle Eastern and Australasian contributors drove international collaboration. Science mapping identified seven themes organised around a stable educational core, a maturing assessment-and-simulation specialty, and an emerging professionalism strand. The most influential works concerned emergency remote teaching, team-based learning and productive failure. By making the structure of this rapidly expanding field visible, the study offers researchers a set of target outlets and collaborators, and points towards validated instruments, longitudinal designs and broader international partnerships as the next steps in building a cumulative science of competency development in pharmacy education.

More broadly, this analysis illustrates the value of bibliometric mapping for a professional education field at an inflection point. The COVID-19 pandemic compressed what might otherwise have been a decade of gradual change into a few intense years, leaving behind a literature that is large, fast-moving and not yet fully organised. Making its structure visible is a precondition for steering it deliberately rather than reactively. As pharmacy education continues to embed simulation, technology-enhanced assessment and competency-based frameworks, periodic re-mapping of this kind will allow the community to track whether the field is integrating its currently parallel strands, broadening its geographical base and converging on shared instruments for the competencies it most values. The map presented here provides a baseline against which that future progress can be measured, and an invitation to the international pharmacy-education community to build the connected, cumulative and methodologically rigorous science that the education of future pharmacists deserves [2, 20].

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