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Article

Mapping the Evolution of Academic Professional Development: A Bibliometric Review (1973-2024)

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Abstract: Academic professional development (APD) is crucial for adjusting to evolving educational requirements, improving teaching effectiveness, and promoting research productivity. This bibliometric review (1973–2024), based on data from the Web of Science Core Collection and analysed using CiteSpace, identifies major contributors, emerging trends, and research priorities. It reveals that Irby, D.M. is the most prolific author, with the United States leading overall contributions. European countries stand out for strong national and institutional collaboration, promoting knowledge exchange and innovation. Co-occurrence and keyword cluster analyses highlight four main themes: student-centered competencies, organizational reform, APD assessment, and innovative methodologies and technologies. These themes reflect growing scholarly attention to more complex and systemic aspects of APD. Notably, there has been a shift from a traditional focus on medical education toward broader concerns, such as organizational transformation and policy alignment, suggesting a move toward a more holistic and integrated approach. The findings emphasize the need for adaptable, globally relevant APD strategies that respond to evolving challenges in higher education. This study provides future research directions and supports efforts to design more effective APD programs aligned with institutional and societal goals.

Keywords: Academic professional development; knowledge mapping; bibliometric analysis; key themes; emerging hotspots and frontiers

Introduction

Academic professional development (APD) has emerged as a critical focus in educational research, driven by global educational transformations and technological advancements. Since gaining traction in the 1960s and rising significantly in the 1990s, APD is now recognized as essential for promoting academic excellence, teaching quality, facilitating institutional transitions, and supporting broader societal development (Copur-Gencturk, & Orrill, 2023; Geleta & Raju, 2023).

While numerous studies have examined APD through various lenses, including academics' demands, utilization, and satisfaction with various APD initiatives, however, these investigations often remains disconnected from the multiple contextual environments of teaching practice (Ehrenfeld, 2022). Moreover, although scholars have advocated for APD to advance pedagogical strategies, foster workplace learning, and

promote teaching excellence through collaborative idea exchange and innovative practices (Barnawi et al., 2024), empirical evidence to support these claims is limited. Particularly, the diversity of scholarly perspectives on APD research makes it challenging to identify key contributors and influences, consistent patterns, and emerging trends in the field.

Critics have also highlighted a persistent gap between the aspirational goals of APD—such as empowering academics as agents of change—and its actual outcomes. Specifically, the extent to which APD initiatives enable meaningful transformation at the classroom, institutional, or societal level remains underexplored and poorly measured (Martínez Valdivia et al., 2023). Structural challenges, including chronic understaffing, inadequate funding, and the absence of institutional commitment, further compromise the sustainability and effectiveness of APD (Steinert et al., 2016).

In the face of rapidly evolving educational demands—driven by technological innovation, shifting policy environments, and global crises—the failure to systematically assess how APD adapts and responds to these dynamics represents a critical gap in the field (Popova et al., 2022). Insufficient assessment models in APD literature, resulting in limited evidence on themes and research hotspots in APD initiatives yield long-term or impact. This underscores the need for a comprehensive review of the existing literature to identify prevailing patterns and evolving research priorities.

Therefore, to address the question of what the landscape of APD research in higher education, this study conducts a bibliometric analysis of 1,087 peer-reviewed publications from 1973 to 2024. By using CiteSpace for literature visualization, this review maps out the field's developmental pattern, influential contributors, thematic concentrations, and emerging hotspots and frontiers, thereby offering a more integrated and evidence-based understanding of the APD research landscape (Zeng & Liu, 2024). This research is structured by five core questions:

RQ1. What is the landscape for APD research in higher education?
RQ2. Who are the key contributors to APD research?
RQ3. Which references have significant contributions to this field?
RQ4. What major themes characterized the landscape of APD research?
RQ5. What emerging hotspots and frontiers in APD research?

Methodology

1. Research Method

Bibliometric analysis uses scientific publications and statistical methods to explore the structure of a specific field (Aparicio et al., 2019). It provides a structured, visual analysis of its trajectory (Bearman et al., 2012), and enhances academic productivity (Jain et al., 2022). As a quantitative approach, this study employs bibliometric analysis supported by a literature review to identify major themes, research gaps, and notable contributions (Tranfield et al., 2003). CiteSpace (6.2.R7) is employed to facilitate the creation, visualization, and exploration of the bibliographic data related to our research (Chen et al., 2010; Markscheffel & Schröter, 2021).

2. Research Materials

Data source: This study utilizes the Web of Science (WoSCC) as its data source, known for high-quality research contributions, especially widely employed in bibliometric analyses (Chavarro et al., 2018). Literature from 1973 to 2024 was included, marking 1973 as the year of the first article published on APD, with the first high-quality article meeting inclusion criteria published in 1991. The data collection commenced on August 30, 2024, utilizing synonyms to ensure comprehensive coverage, as detailed in the search parameters outlined in Figure 1.

Review documents: Science Citation Index Expanded (SCIE) and Social Science Citation Index (SSCI) were selected from WoSCC due to their robust data availability. We focused on two of the widely used literature types in bibliometric analyses: articles and reviews (Liu, 2021). To refine the dataset to high-quality sources, we excluded various document types: 381 proceedings papers, 396 review articles, 83 book chapters, 31 editorial materials, 4 letters, 13 news items, 4 meeting abstracts, and 1 data paper, resulting in 1,933 relevant

documents. This final dataset comprises 1,396 articles, 53 early access publications, and 2 books. It is important to note that a single article in WoSCC may fall into multiple document categories. The selected literature includes 10,535 related references.

3. Knowledge Mapping

This research aims to assess the conceptual evolution of the topic by integrating two aspects of bibliometric analysis: (i) performance analysis and (ii) scientific mapping (Small, 2003). Performance analysis quantitatively evaluates essential publication characteristics within the field, such as publication year, document count, journals, countries, authors, and indicators of scientific productivity like the H-index (Montalván-Burbano et al., 2020). In contrast, knowledge mapping illustrates the interrelationships among various scientific research areas, visualizing the structure of scientific knowledge and the evolution of research domains through navigational maps. This methodology is widely applied in bibliometric analyses (Van Eck & Waltman, 2014).

Additionally, co-occurrence analysis and co-citation analysis serve as primary tools in this research. Co-occurrence analysis identifies significant authors, journals, institutions, and countries, while co-citation analysis reveals the most frequently cited works in this field (Small, 2003). For this study, we utilized CiteSpace, a robust bibliometric tool that employs a multi-perspective co-citation analysis methodology. This approach offers an overview of the research structure in APD, enabling the identification of emerging issues and trends for future investigation (Liu et al., 2023).

4. Criteria Description

The criteria applied for the eligibility and exclusion of studies were clearly illustrates in Table 1. This study conducted a comprehensive examination of 1,637 articles indexed in the SCI or SCIE databases in the WosCC data set, with a particular focus on the titles, abstracts, and main content to determine if they met the inclusion criteria. The selection process was limited to articles and review articles published from 1973 to August 2024. Additionally, only publications written in English were considered, resulting in a final selection of 1,087 publications.

Table 1. Eligibility and exclusion criteria for academic talent development studies

Category	Criterria
Eligibility	Indexed in Web of Science Core Collection (WoSCC) Published between Jan 1973–Aug 2024 Indexed in SCI or SCIE Document types: Open access articles or review articles Published in English
Exclusion	Not indexed in SCI or SCIE Specific closed document types (e.g., letters, case reports, meta-analyses, comments) Duplicate or redundant records Non-English publications

5. Data Collection and Screen Strategy

The purpose of this study was to investigate the knowledge structure surrounding APD by identifying thematic patterns, research networks, emerging trends, and landmark articles within the field. To achieve this, we conducted a thematic search using WoSCC. Our hypothesized that an article is relevant to the topic of opinion mining if it cites at least one record retrieved from the thematic search (Chen et al., 2012).

The search strategy was constructed using a benchmark that incorporated 'AND' and 'OR' operators, where "TS" refers to the article topic, "xxx" denotes the search term criterion, and "*" indicates the fuzzy search criterion (Jing et al., 2023). The specific operator search benchmark is illustrated in figure 1, with an initial reference size 10535. To ensure the inclusion of high-quality studies, we applied various filters based on publication years, document types, Web of Science index, open access status, and language. The time frame for inclusion spanned from 1973 to August 2024, specifically targeting articles and review articles within the SCI and SCIE datasets published in English to ensure full-text accessibility.

Out of the initial dataset, 1,637 studies met the inclusion criteria, comprising 1,559 inclusion articles (95.23%) and 78 review articles (4.77%). The exclusion category included 26 proceedings papers (1.59%), 38 early access articles (2.32%), and 6 retracted publications (0.37%). Following a rigorous screening of titles and abstracts, 1,087 relevant articles were included, ensuring the reliability and research quality of the data collection and screening process.

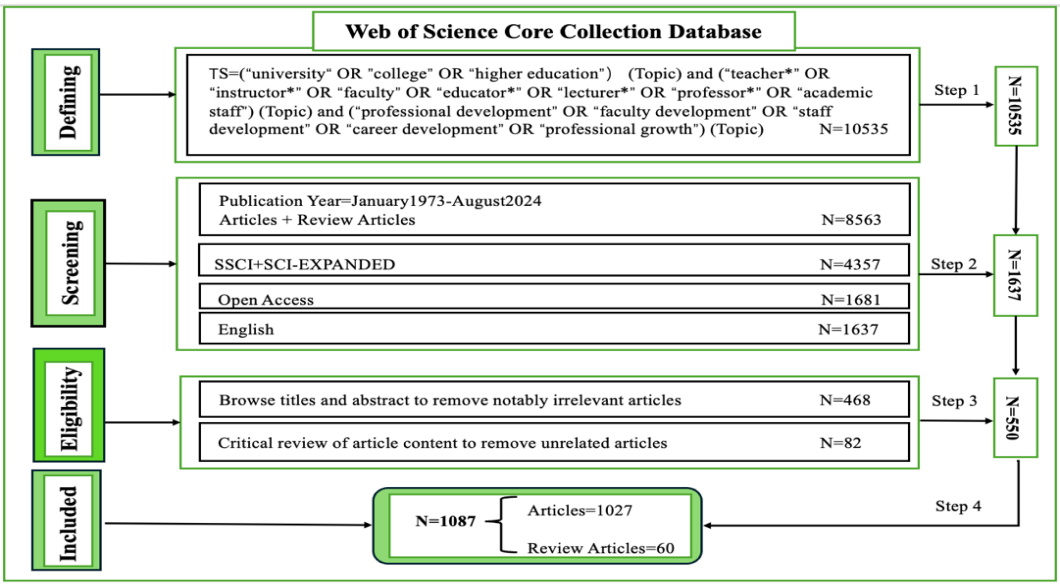

Figure 1. Sample Identification Flowchart

The Findings

This section visualizes the current research landscape in APD. It examines publication timelines, citation trends, and leading contributors, including prominent authors, journals, institutions, and countries/regions. Additionally, co-citation and cluster analyses delineate thematic areas within APD, while keyword timeline and burst analysis trace the evolution of research hotspots and emerging themes in the field.

1. Publications and Citations Analysis

Tracking annual publication and citation counts offers quantitative insight into trends within a research domain (Bakri et al., 2024). Figure 2 presents a timeline of publication volumes and citations, revealing two main phases.

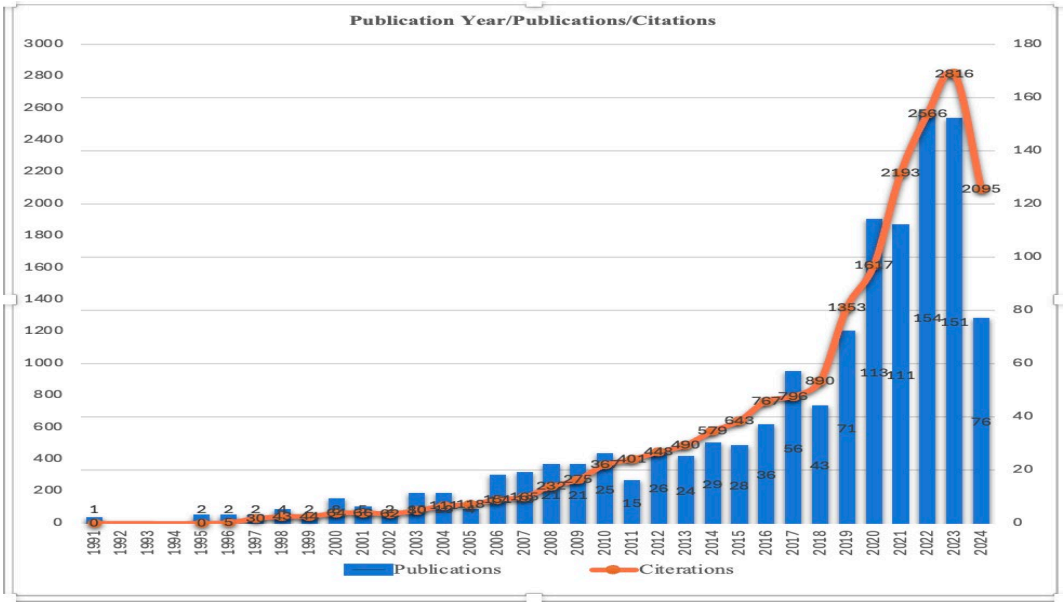

Figure 2. Publications and Citations Trends Over Time

The first phase (1991–2017) show modest increase in both publication output and citation frequency suggests that this field has yet to establish itself as a significant area within higher education research. The second phase (2018–2024) marks an accelerated increase in publications and citations, reflecting heightened scholarly engagement. Notably, post-2020, annual publications stabilized above 100, and citations rose sharply from 890 to 2,816 from 2020 to 2023. This surge aligns with the COVID-19 pandemic, which heightened interest in addressing the challenges faced by APD, however, the specific key contributors still need to be identified through more detailed bibliometric analysis.

2. Performance Analysis

This section highlights key contributors in the field, sheds light on prevalent research directions and points out areas where further investigation is needed to advance knowledge and innovation. Authors Contribution. An analysis of author publication volumes identifies the leading scholars and core contributors within university faculty professional development. Table 1 presents the primary authors in this research area, as determined by citation and publication data from WoSCC, highlighting those who significantly shape and drive research.

Research priorities among scholars in APD vary, with notable contributions from the top 10 authors (Table 2). Irby, D.M. from the University of California, San Francisco, is the most productive scholar, with an H-index of 47. His body of work includes 166 publications, totalling 7,598 citations, with an average of 47.94 citations per paper, and eight influential papers among 1,087 high-quality studies in APD. His colleague O'Sullivan, P.S. has published seven significant papers with an H-index 46, collaborating with Irby, D.M. on APD in medical education, particularly on its societal impact (Irby, 1995; O'Sullivan & Irby, 2015).

Table 2. Top 10 Productive Authors

Rank	Authors	Record in 1087	H-Index	Publications	Citing Articles	Times Cited	Average
1	Irby,DM	8	47	166	5828	7958	47.94
2	O'sullivan, PS	7	46	269	7361	8160	30.25
3	Steinert, Y	7	44	183	5766	7762	42.42
4	Macphail, A	7	28	126	2027	2689	21.34
5	Turner, R	6	13	43	801	931	21.47
6	Tondeur, J	5	43	104	4949	7207	69.3
7	Macaro, E	5	26	77	1713	2484	32.26
8	Rehman, R	5	17	164	1118	1297	7.91
9	Guberman, A	5	8	18	290	353	19.61
10	Wang, J	5	2	6	6	8	1.33

In addition, CiteSpace software visualizes key contributors through node size and colour, with larger nodes representing greater impact and red hues highlighting alignment with current trends. Author collaboration visualization (Figure 3) shows Irby, D.M as the leading contributor, followed by Feldman,M.D and Macaro,E. CiteSpace analysis identifies seven particularly influential scholars (Centrality > 0.1): Steiner, Y. (Centrality = 0.23), Anonymous (0.14), Bandura, A. (0.13), Stes, A. (0.11), Boyer, E. L. (0.15), Bland, C. J. (0.17), and Skeff, K. M. (0.12). Centrality scores above 0.1, combined with citation counts and H-indices over 40, designate these authors as leading figures in APD research. Notably, both Irby, D. M., and Steiner, Y.'s publications are considered foundational to the field.

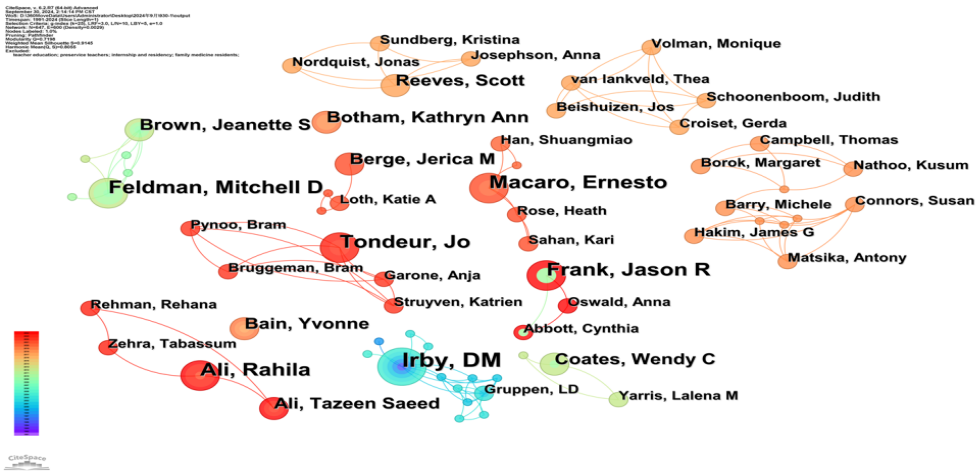

Figure 3.Network of Co-Authorship

Journals Contribution. Researchers maximize their impact by targeting journals with high Journal Citation Reports (JCR) impact factors, which signify publication quality and relevance (Bornmann & Mutz, 2015). This strategic approach enhances visibility and the perceived value of their work within their field (Chavarro et al., 2018). In 2023, the top journals by impact factor include SCIENCE (IF=9.91, Q1), ANN INTERN MED (IF=4.45, Q1), REV EDUC RES (IF=3.82, Q1), TEACH TEACH EDUC (IF=2.11, Q1), and AM EDUC RES J (IF=2.06, Q1).

Additionally, co-citation analysis conducted with CiteSpace software provides insight into the journals with the highest centrality, underscoring their influence within the field. Among these, ANN INTERN MED (Centrality=0.09, IF=4.45, Q1), REV EDUC RES (Centrality=0.07, IF=3.82, Q1), AM EDUC RES J (Centrality=0.07, IF=2.06, Q1), HARVARD BUS REV (Centrality=0.07, IF=0.33, Q1), and SCIENCE (Centrality=0.06, IF=9.91, Q1) stand out as particularly impactful. Combining impact factor and centrality, the four most influential journals are SCIENCE, ANN INTERN MED, REV EDUC RES, and TEACH TEACH EDUC, indicators are listed in Table 3.

Table 3.Top 10 Journals Sorted by Centrality

Rank	Counts	Centrality	Year	Journal	2023IF	JCR
1	60	0.09	1995	ANN INTERN MED	4.45	Q1
2	160	0.07	2007	REV EDUC RES	3.82	Q1
3	86	0.07	2006	AM EDUC RES J	2.06	Q1
4	33	0.07	1999	HARVARD BUS REV	0.33	Q1
5	88	0.06	2005	SCIENCE	9.91	Q1
6	60	0.06	1995	FAM MED	0.89	Q2
7	54	0.06	1995	J HIGH EDUC	1.43	Q1
8	33	0.06	1995	J MED EDUC	0.79	Q2
9	275	0.05	2007	TEACH TEACH EDUC	2.11	Q1
10	111	0.05	2008	INT J ACAD DEV	0.73	Q2

Contribution of Countries/Regions and Institutions. The analysis of publications by country/region indicates the level of interest and leadership in APD. The visualization of collaborative networks illustrates the relationships between countries/regions in this field. In these visualizations, the size of each node corresponds to the volume of publications from that country; larger nodes signify greater publication output. Performed the 'delete duplicates' function in CiteSpace, time slicing data from 1991 to August 2024. By applying pruning parameters based on the pruning /pathfinder slicing network, it consisted of 87 nodes, highlighting the diverse contributions to the literature in this area.

In terms of publication frequency in WoSCC, the USA leads with 411 papers, followed by England (147) and China (103), underscoring their research as key references for scholars worldwide as presented in Table 4. On the other hand, the country with the highest analytical centrality of CiteSpace software is Scotland, with a centrality of 0.96, which plays a pivotal role in the network, followed closely by Nigeria (0.82) and Ireland (0.76), all of which exhibit strong connections within the field as showed in Table 5.

Table 4. Top 10 Countries/regions by Frequency

Rank	Country	Frequency	% of 1,087
1	USA	411	37.81%
2	England	147	13.52%
3	China	103	9.48%
4	Canada	63	5.80%
5	Australia	62	5.70%
6	Netherlands	62	5.70%
7	Spain	55	5.06%
8	South Africa	35	3.22%
9	Germany	2	2.39%
10	Ireland	25	2.30%

Table 5.Top 10 Countries/regions by Centrality

Rank	Centrality	Counts	Countries
1	0.96	14	Scotland
2	0.82	7	Nigeria
3	0.76	25	Ireland
4	0.71	147	England
5	0.57	55	Spain
6	0.35	13	New Zealand
7	0.33	62	Australia
8	0.32	9	Italy
9	0.28	63	Canada
10	0.28	22	Saudi Arabia

Institutions Contribution. The data (Table 6) indicates that eight of the top ten institutions contributing to research on APD are based in the USA, emphasizing the leadership role of American institutions in advancing this field. The two non-U.S. institutions: McGill University (Canada) and the University of London (UK), also attract significant international scholarly interest. Among these, the top three institutions are the University of California System, which leads with 62 publications, followed by the University of California San Francisco with 25 publications, and the University System of Ohio with 20 publications. Given this, performance analysis responds to RQ 2 and helps future researchers and policymakers identify influential scholars, partnerships, and effective dissemination methods, contributing to the advancement of knowledge in the ATD field.

Table 6. Top 10 Institutions and Publications

Institutions	Publications
University of California System, 1998（USA）	62
University of California San Francisco, 1998（USA）	25
University System of Ohio, 2006（USA)	20
Harvard University, 2003 （USA）	17
State University System of Florida, 1998（USA）	15
Pennsylvania Commonwealth System of Higher Education (PCSHE), 2006（USA）	15
University of Colorado System, 2004（USA）	15
McGill University, 2003 (Canada)	14
University of London, 2004 (England)	14
Indiana University System, 2002（USA）	13

3. Co-cited References

The frequency with which an article is most cited from 1,087 publications as a reference by others serves as an indicator of its scientific impact, supporting synthesize of emerging trends in the field (Li et al., 2024). In Figure 4 each node represents a cited document, with the size of each node indicating citation frequency. The colour gradient, transitioning from violet to red, reflects the temporal evolution of cited literature on APD from 1991 to 2024. The colour transition—from violet to red—illustrates the progression from earlier to recent publications. The network contains 366 nodes with a Harmonic Mean of 0.8925, indicating high specificity in scientific mapping through co-citation clustering and a clear structure in the research landscape.

Focusing on weighted nodes, as suggested by Wildgaard (2015) allows us to monitor citation spikes for specific references, offering valuable insights into shifts in research interest and the emergence of new significant areas. The foremost co-cited document is Shulman (2019), closely followed by Steinert et al. (2016) and Hair (2014). Table 7 presents the top 10 co-cited references from the 1,087 publications.

The co-citation network in response to RQ 3 shows that frequently cited references, such as Shulman (2019), Steinert et al. (2016), and Hair (2014), have led research in the ATD field on topics like student-centered academic capability, institutional reforms, and APD assessment models. More recent references highlight emerging research interests in the field, such as MacIntyre et al. (2020), whose study explores how academics adapted to the impact of COVID-19 on teaching.

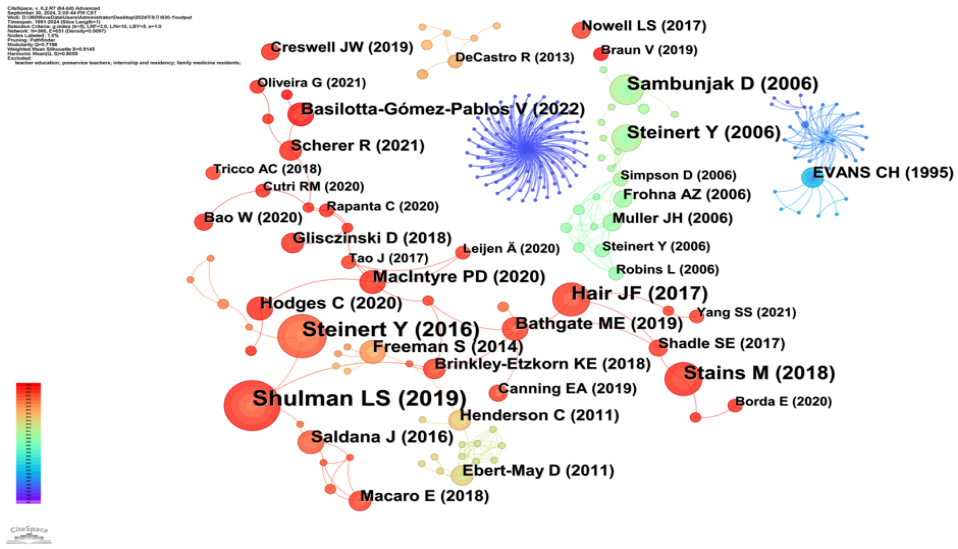

Figure 4. Document Co-Citation Network

Table 7. Top 10 Co-Cited Documents

Counts	Reference	DOI/ISBN	Reference Information
15	Shulman, L.S. (2019)	https://doi.org/10.30827/profesorado.v23i3.11230	Shulman, L. S. (2019). Aquellos que Entienden: Desarrollo del Conocimiento en la Enseñanza. Profesorado. Revista de Currículum y Formación de Profesorado, 23 (3), 269-295.
13	Steinert,Y. (2016)	https://doi.org/10.1080/0142159X.2016.1181851	Steinert, Y., Mann, K., Anderson, B., Barnett, B. M., Centeno, A., Naismith, L., ... & Dolmans, D. (2016). A systematic review of faculty development initiatives designed to enhance teaching effectiveness: A 10-year update: BEME Guide No. 40. Medical teacher, 38(8), 769-786.
10	Hair,J.F. (2014)	https://doi.org/10.1007/978-3-030-80519-7	Hair Junior, J. F., Hult, G. T. M., Ringle, C. M., & Sarstedt, M. (2014). A primer on partial least squares structural equation modeling (PLS-SEM).
10	Stains, M. (2018)	https://doi.org/10.1126/science.aap8892	Stains, M., Harshman, J., Barker, M. K., Chasteen, S. V., Cole, R., DeChenne-Peters, S. E., ... & Young, A. M. (2018). Anatomy of STEM teaching in North American universities. Science, 359(6383), 1468-1470.
9	Sambunjak, D. (2006)	https://doi.org/10.1001/jama.296.9.1103	Sambunjak, D., Straus, S. E., & Marušić, A. (2006). Mentoring in academic medicine: a systematic review. Jama, 296(9), 1103-1115.
8	Steinert,Y. (2006)	https://doi.org/10.1080/01421590600902976	Steinert, Y., Mann, K., Centeno, A., Dolmans, D., Spencer, J., Gelula, M., & Prideaux, D. (2006). A systematic review of faculty development initiatives designed to improve teaching effectiveness in medical education: BEME Guide No. 8. Medical teacher, 28(6), 497-526.
7	Bathgate, M.E. (2019)	https://doi.org/10.1186/s40594-019-0166-3	Bathgate, M. E., Aragón, O. R., Cavanagh, A. J., Waterhouse, J. K., Frederick, J., & Graham, M. J. (2019). Perceived supports and evidence-based teaching in college STEM. International journal of STEM education, 6, 1-14.

7	Freeman,S. (2014)	https://doi.org/10.1073/pnas.1319030111	Freeman, S., Eddy, S. L., McDonough, M., Smith, M. K., Okoroafor, N., Jordt, H., & Wenderoth, M. P. (2014). Active learning increases student performance in science, engineering, and mathematics. Proceedings of the national academy of sciences, 111(23), 8410-8415.
7	MacIntyre, P.D. (2020)	https://doi.org/10.1016/j.system.2020.102352	MacIntyre, P. D., Gregersen, T., & Mercer, S. (2020). Language teachers' coping strategies during the Covid-19 conversion to online teaching: Correlations with stress, wellbeing and negative emotions. System, 94, 102352.
7	Saldana, J. (2016)	http://katalog.nukat.edu.pl/lib/item?id=chamo:3624877&theme=nukat	Saldaña, J. (2016). The coding manual for qualitative researchers. Sage. http://katalog.nukat.edu.pl/lib/item?id=chamo:3624877&theme=nukat

4. Cluster Map of Keywords Analysis

Keyword cluster analysis is utilized to identify and analyse shifts in research trends and the interconnections among various areas of study (Chen et al., 2010). This method enables researchers to systematically track the evolution of topics over time, providing insights into the relationships between different research trends and enhancing understanding of the broader research landscape. The co-occurring keyword network for APD, depicted in Figure 5 consists of 516 nodes and 1,442 links, with a time-slice length of 1 year. Selection criteria include a g-index of 10, LRF of 3.0, L/N of 10, LBY of 5, and e-value of 1.0. Network pruning /pathfinder strategy, enabling a thorough analysis of relationships and trends within the research landscape.

A total of 10 significant clusters were presented, as illustrated in Figure 5, which were labelled using the Latent Semantic Indexing (LSI) method, relying on author keywords for naming. CiteSpace enables the generation of cluster labels year by year, utilizing terms identified by LSI (Chen, 2017). The silhouette metric assesses the average homogeneity of clusters and produces a score of 0.8055, indicating significant homogeneity among cluster members (Rousseeuw, 1987). The size of each keyword cluster reflects its membership, with colour coding representing community affiliation (Blondel et al., 2008). Each cluster is labelled using title terms, keywords, and abstract terms from the associated articles. The clusters are organized by size, with cluster #0, labelled "education", being the largest and containing 35 members. The most cited terms in this cluster include 'academics' (n=130), 'education' (n=126), and 'students' (n=119). Followed by #1"initiatives" and #2"comprehensive approach". Notably, clusters #0 to #9 form a framework for APD.

Furthermore, keyword frequency within these clusters clarifies the concentration of research themes. The size of each node reflects the frequency of keyword occurrences within the dataset. The top 10 most active keywords were "professional development"(frequency = 227, Cluster #6), "higher education" (frequency = 182, Cluster #2), "faculty development" (frequency = 151, Cluster #8), "education" (frequency = 126, Cluster #0), "students" (frequency = 96, Cluster #0), "teachers" (frequency = 68, Cluster #0), "faculty" (frequency = 67, Cluster #1), "impact" (frequency = 67, Cluster #9), and "medical education" (frequency = 66, Cluster #0) "university" (frequency = 54, Cluster #0).

It is essential to note that high-frequency keywords may not fully accurately reflect the significance of a study. Instead, centrality serves as a key indicator of keyword importance within CiteSpace software, where a centrality scores greater than 0.1 indicates a significant research hotspot (Ibekwe-SanJuan & Hou, 2010). As such, "faculty development" (centrality = 0.31) is a central point of the network and a major research hotspot, followed by "education" (centrality = 0.21), "faculty" (centrality = 0.18), "professional development" (centrality = 0.17), "medical education" (centrality = 0.16), and "university" (centrality = 0.12). This component effectively supports the network, establishing a foundation for its overall stability. It is noteworthy that "professional development" appears in both cluster #6 cluster and as a tag within cluster #3. Given its role as the primary focus of this search, this keyword will be excluded from further discussion. Finally, table 8 lists the top ten expressive keywords and their clusters, sorted by frequency of occurrence and centrality, respectively. The largest cluster, "education," emphasizes the importance of improving academic practices and promoting the development of both academics and students. The centrality scores further support these findings and reinforce the research category focused on APD.

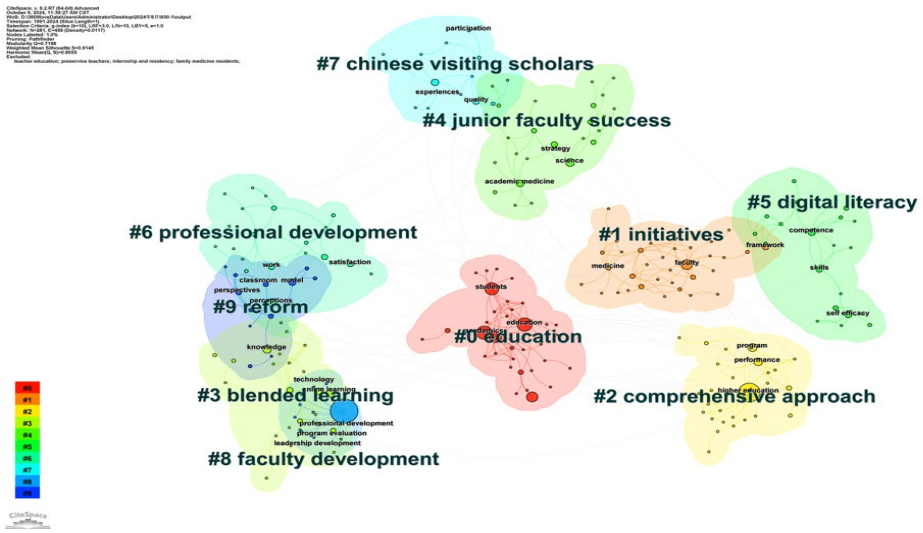

Figure 5. Cluster Map of Keywords
(The colored regions represent the initial appearance of keywords, with blue fields indicating earlier occurrences than the subsequent green, yellow, and red fields.)

Table 8. Top 10 Keywords and Their Clusters, Sorted by Frequency and Centrality

Rank	Frequency	Keyword	Cluster
1	227	professional development	#6
2	182	higher education	#2
3	151	faculty development	#8
4	126	education	#0
5	96	students	#0
6	68	teachers	#0
7	67	faculty	#1
8	67	impact	#9
9	66	medical education	#0
10	54	university	#0
Rank	**Centrality**	**Keyword**	**Cluster**
1	0.31	faculty development	#8
2	0.21	education	#0
3	0.18	faculty development	#1
4	0.17	professional development	#6
5	0.16	medical education	#0
6	0.12	university	#0
7	0.1	higher education	#2
8	0.07	performance	#2
9	0.06	teacher education	#2
10	0.06	beliefs	#3

5. Research Hotspots and Frontiers

This study identifies keywords over time and the most "burst" keywords, revealing shifting research priorities and emerging trends for future research in APD. Timeline Visualization of Keywords. The keyword timeline effectively illustrates the evolution of research directions and emerging topics in APD over time (Liao et al., 2018). Figure 6 displays keywords along a horizontal timeline from 1991 to 2024, with clusters arranged from left to right. Clusters are vertically ordered by size, and a legend at the bottom indicates their release times. Warmer colours—yellow, orange, and red—represent more recent studies, while red rings highlight nodes with citation bursts during specific periods, and purple rings indicate other notable properties.

Nodes with a mediator centrality exceeding 0.1 are indicated by a purple circle, with a thickness corresponding to the centrality value (Chen et al., 2010). The timeline overview reveals varying sustainability among keywords, with "professional development" persisting for over 15 years, while other clusters exhibit shorter lifespans. Keywords such as "education," "students," "medical education," "higher education," "academics," "faculty," and "professional development" are notable on the timeline and appear prominently

as large red nodes, indicating high citation frequency and bursts (Chen, 2017).Table 9 presents highly cited keywords from the timeline graph with a centrality of ≥ 0.1. Notably, "medical education" emerges as an early keyword, bridging to subsequent concepts, while "career" and "competence" apply "medical education" principles to enhance the APD.

Timeline Visualization of Keywords reveals that research in the APD field is shifting towards more in-depth and specific areas of digital capability and professional development, including self efficacy, blended learning, design, and policy.

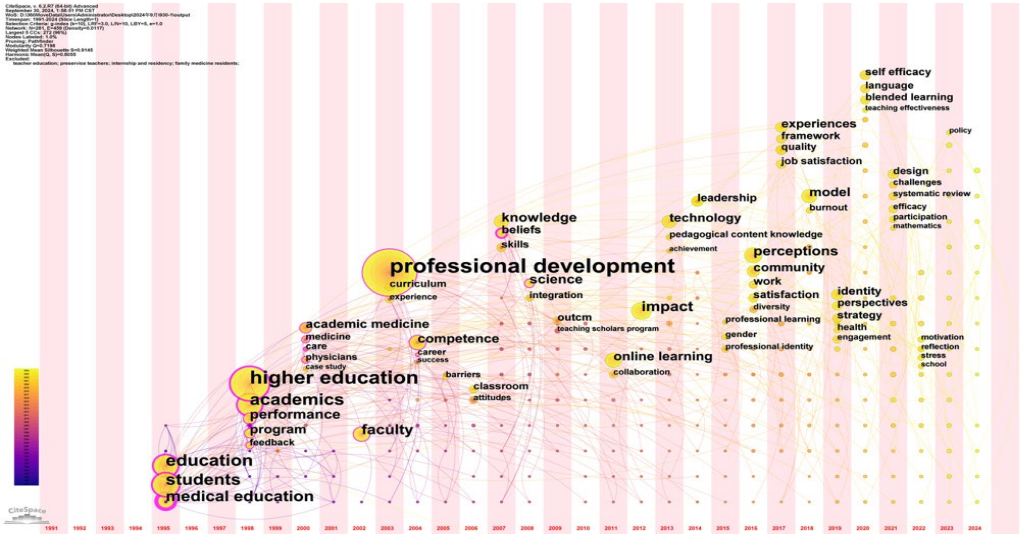

Figure 6. Network Keyword Timeline

(The vertical axis displays keyword clusters by size, while the horizontal axis represents time. Node size reflects keyword frequency, and connecting lines indicate collaborations between keywords. Color gradients—from oldest to newest—illustrate the evolution of research trends over time)

Table 9. Keywords Timeline Sort by Frequency and Centrality

Year	Keywords	Frequency	Centrality
2003	professional development	455	0.17
1998	higher education	257	0.25
1998	academics	130	0.2
1995	education	126	0.25
1995	students	119	0.21
1995	medical education	87	0.67
2002	faculty	67	0.13
1998	performance	45	0.13
2008	science	39	0.14
1998	program	37	0.15
2004	competence	35	0.1
2000	academic medicine	33	0.12
2007	beliefs	24	0.25
1998	feedback	14	0.14
2000	medicine	14	0.15
2000	care	13	0.14
2000	physicians	12	0.16
2004	career	10	0.17
2003	experience	9	0.1
1998	improvement	2	0.15

Keywords Burst Analysis. Keyword bursts indicate topics that have experienced a short-term increase in citation frequency and may signal an emerging research frontier in the field (Chen et al., 2010). To uncover these emerging trends, we utilized CiteSpace to identify the 20 keywords with the strongest citation bursts, which were subsequently sorted by the onset year of each burst, providing a visual representation of temporal

patterns in the research field in Figure 7.

The earliest research focus was on "medical education" (burst strength= 4.95, 1995–2007). The most intense topic, "care," exhibited a burst strength of 6.95 from 2000 to 2014, followed by "medicine" (burst strength= 5.98, 2000–2012) and "academic" (burst strength= 5.84, 2000–2019). Furthermore, certain keywords, such as “medical education” (burst strength= 4.95, 1995–2007) and “success” (burst strength = 2.19, 2004–2016), have maintained centrality in the field due to their sustained presence and impact.

To facilitate research, we classified the 20 keywords with the strongest citation bursts into two main categories. The first category, focused on career success, includes "career" (2004–2011), "success" (2004–2016), "attitudes" (2006–2015), "skills" (2007–2010), "outcome" (2009–2012), "teaching scholar's program" (2009–2012), "faculty" (2009–2018), and "diversity" (2016–2020). The second category highlights recent trends in the ecosystem for APD, featuring keywords such as "self-efficacy" (2020–2024), "online learning" (2021–2024), "design" (2021–2024), and "technology" (2022–2024).

Keyword burst analysis reveals the rise of applying medical education principles to APD, the importance of career success as a key factor, and the evolution towards areas such as self efficacy, program design, and technological advancements, signalling future research trends in the field.

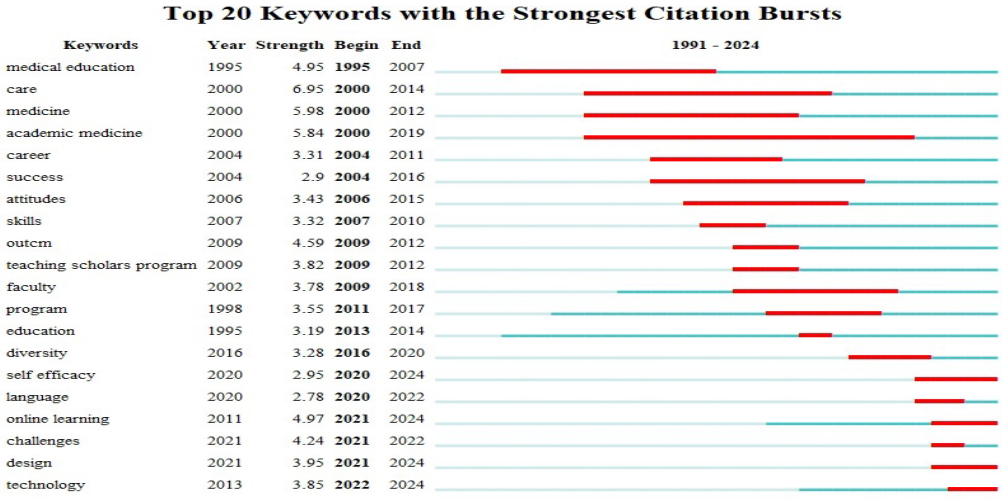

Figure 7.Top 20 Keywords with the Strongest Citation Bursts

Discussion

This study contributes to the understanding and expansion of research in the APD field by visualizing publication patterns, contributors, research themes, emerging hotspots, and research frontiers. In response to the research questions, the following findings emerge: The literature review reveals that APD spans multiple disciplines, yet there is no consensus on foundational aspects, such as core concepts, design, and assessment practices. Research on APD has shown steady, though modest, growth, with a marked acceleration due to the COVID-19 pandemic. This limited increase can be attributed to two primary factors: (i) the evolving nature of the field, which has unclear boundaries and an underdeveloped knowledge framework, leading to ongoing challenges in conceptual harmonization; and (ii) its interdisciplinary character, which spans pedagogy, management, and sociology, thereby dispersing research efforts. While this interdisciplinary approach enriches perspectives, it also hampers concentrated development. The growth trends in publications and citations related to APD suggest that this field will attract increasing research and publication interest from more researchers in the future.

The co-authorship network reveals key contributors, collaboration patterns, and channels of knowledge dissemination within the research field.It's visualization identifies Irby, D.M. leading in productivity, while Steiner, Y. stands out in influence. However, limited collaboration and sparse network connections suggest a lack of cross-pollination in APD research. High-impact and centrality journals such as SCIENCE, ANN INTERN MED, REV EDUC RES, TEACH TEACH EDUC are recognized as top publication outlets. Regionally, the USA emerges as the key contributor in terms of publications and institutional resources.

Unexpectedly, the cooperation network reveals strong centrality among European countries, suggesting a significant role in advancing global APD knowledge exchange.

Co-citation and keyword analyses findings echoed in the literature review, highlight that student-centred academic competencies, as supported by key contributions (Stains et al., 2018; Bathgate et al., 2019; Shulman, 2019). Additionally, keyword clustering emphasizes the importance of APD initiatives focused on organizational reform (Sambunjak et al., 2006) and a comprehensive approach (Saldaña, 2016; Hair, 2014). However, it also reveals that the APD assessment was inadequate (Steinert, 2016), which underscores an urgent need for targeted studies to develop and refine assessment systems for APD. In contrast, the recent highly co-cited work by MacIntyre et al. (2020) highlights a COVID-19-driven shift in APD research, with a strong focus on digital competence and the application of technology.

In response to the ongoing impact of COVID-19, this study synthesizes keyword data from 2020 to 2024 to elucidate current research hotspots within the field. Four keywords have emerged as significant trends: self-efficacy, online learning, design, and technology. The findings from the knowledge mapping review the current literature highlights the urgent necessity for ongoing research in these areas, particularly concerning their effects on teaching and research performance and the adaptability of educational frameworks to shifting demands, consistent with the findings of Guerra et al.(2024) and recent research.

Conclusion

This paper explores the knowledge patterns of APD through a bibliometric approach using CiteSpace provides the perceives on publication volume, key contributors, and emerging research hotspots and frontiers. It is crucial to reflect on the broader implications of these findings and their practical significance for both policy and practice in APD.

The study suggests that policymakers need to realign APD policies by developing a comprehensive framework centered on student-centered academic competencies, organizational reform, robust APD assessment, and innovative research methodologies or techniques, ensuring alignment with institutional development strategies. In particular, organizational reform is essential within digitally mediated learning environments. Furthermore, the study highlights that the current lack of APD assessment mechanisms undermines the system's ability to adapt to changes in the educational landscape. Researchers are encouraged to adopt diverse methodologies and technologies to develop effective evaluation standards for APD.

The keywords timeline analysis highlights a post-pandemic shift in APD research. In the future, those designing and implementing APD programs must respond to the rapid advancement of digital technologies and online learning by providing targeted initiatives that enhance both academics and students self efficacy, supporting successful APD.

Limitation

This study is limited by its reliance on a single database—the Web of Science Core Collection (WoSCC). This may affect the comprehensiveness of the findings, as relevant studies published in other databases or journals may have been overlooked. Future researchers are encouraged to broaden their data collection to encompass a variety of databases-to enhance the comprehensiveness findings in this field. Additionally, the reliance on keyword and co-citation analyses may limit the capture of newer, innovative themes that lack significant citations, leading to potential gaps in coverage. Future research should consider a mix of methodologies to build a more complete understanding of this evolving landscape of APD.

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