ARTIFICIAL INTELLIGENCE-ENABLED EDUCATIONAL ADVANCEMENTS: A PATENT ANALYSIS APPROACH

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ABSTRACT
This study analyzes patent data from 2014 to 2023 to explore the significant rise of artificial intelligence (AI) applications in the education sector. Over the decade, AI-related patent filings saw an almost eightfold increase, with AI in education patents tripling, marking it as a rapidly growing niche. Major tech companies and education-focused organizations, including IBM, Microsoft, Pearson Education, Shanghai Squirrel Classroom AI Tech, and Riiid, have been instrumental in advancing AI-driven education solutions. Their innovations encompass personalized learning, adaptive content delivery, virtual assistants, and educational experiences using augmented reality (AR) and virtual reality (VR) technologies. Additionally, patents from industries such as healthcare technology (Philips), consumer electronics (Samsung), and training solutions (CAE) emphasize AI's expanding role in professional education and vocational training. This research highlights the evolution of AI-driven education technologies and provides valuable insights into innovation trends, key players, and patenting strategies. These findings are essential for policymakers, educators, technology developers, and business leaders in preparing for AI-driven disruptions, optimizing resources, and formulating effective integration strategies.
Keywords: Artificial Intelligence, Education Technology, Patent Data Analysis

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INTRODUCTION

Artificial intelligence (AI) has increasingly become a cornerstone of modern technological advancement, fostering innovation across diverse sectors. Within education, AI is revolutionizing traditional teaching and learning methods by enabling personalized instruction, streamlining administrative workflows, and supporting data-driven decision-making (Owoc et al., 2021). AI-driven tools facilitate adaptive tutoring, intelligent content curation, and real-time performance assessments, significantly reshaping the educational landscape (Khan et al., 2023). Despite the increasing presence of AI in education, research remains limited in fully capturing the breadth of technological advancements in this domain. This study seeks to address this gap by conducting a thorough analysis of patent data on AI applications in education. By examining patent filings from 2014 to 2023, the study explores the progression of AI-based educational technologies and identifies key patent holders. Furthermore, it investigates the geographical distribution of patent applications and the strategic positioning of major assignees, offering insights into technological developments, competitive trends, and opportunities for collaboration. The insights derived from this study are particularly relevant for policymakers, educators, technology developers, business leaders, and investors, offering a comprehensive understanding of how AI is shaping the educational landscape and highlighting strategic opportunities for further advancement.

LITERATURE REVIEWS

Artificial Intelligence in Education

Artificial intelligence (AI) is an interdisciplinary area within computer science aimed at developing systems capable of performing tasks traditionally requiring human intelligence, such as reasoning, decision-making, and problem-solving (Russell & Norvig, 2021). Interest in the influence of AI in education has grown significantly, with the number of academic publications on the topic increasing more than sixfold between 2013 and 2022 (Jain & Raghuram, 2023). AI is reshaping education by personalizing learning experiences, improving efficiency, and broadening accessibility. Through AI-powered data analysis, educational content can be tailored to individual student needs, ultimately enhancing learning outcomes (WIPO, 2019). One of AI's key advantages is its scalability, allowing educational benefits to reach large populations and maximize societal impact (WIPO, 2019; Kamalov et al., 2023). Research highlights AI's ability to enhance student performance, engagement, and focus (Wang et al., 2024). AI applications in education include adaptive learning systems, intelligent tutoring, automated assessments, and predictive analytics, all of which contribute to improved learning experiences and greater accessibility worldwide (Kamalov et al., 2023; Wang et al., 2024). The emergence of generative AI tools, such as ChatGPT, has further accelerated AI's integration into education, enabling more interactive and dynamic learning experiences (Kamalov et al., 2023). While AI strengthens digital learning and data-driven pedagogy, it also raises ethical concerns, particularly regarding data security, privacy, liability, bias, and equity (Porayska-Pomsta et al., 2023; Yan & Liu, 2024; Yusuf et al., 2024)—issues often amplified by the fact that AI models are predominantly developed in wealthier nations (Jain & Raghuram, 2023). To ensure responsible AI adoption, it is essential to address privacy risks, biases, and the evolving nature of teacher-student interactions.

Geographical Strategy for Patenting

A patent is a form of intellectual property (IP) that is granted territorial protection. Generally, patent applicants initiate the process by submitting an application with their local IP office, setting the 'priority date.' This date is used as the reference point for all following filings related to the same invention. According to the Paris Convention, applicants have 12 months from the priority date to file in other countries or regions (WIPO, n.d.). The Patent Cooperation Treaty (PCT) further extends this timeframe to 30 months (WIPO, n.d.), providing applicants with the

opportunity to decide where to seek international protection through the World Intellectual Property Organization (WIPO). Depending on their needs, applicants may choose to file only in their home country if they are focused on domestic operations or face financial constraints. Alternatively, businesses with international aspirations or sufficient resources may pursue wider protection in foreign markets (Stevnsborg & van Pottelsberghe, 2007). The decisions on which countries or regions to file patents are influenced by several factors, such as market size, the technological competitiveness of local competitors, and the costs involved in securing and maintaining patent rights across territories (Eaton & Kortum, 1996; Henry, 2024).

RESEARCH METHODOLOGY

This research explores technological trends by investigating patents filed from January 1, 2014, to December 31, 2023. The data was obtained from the PatentScope database (https://patentscope.wipo.int) on January 7, 2025. The database is a no-cost resource offered by the World Intellectual Property Organization (WIPO). Petty patents, or utility models, are excluded since they lack the stringent inventive step criteria required for standard patents. It is important to note that patent search results, especially for 2023, may be incomplete due to the 18-month confidentiality period, during which submitted applications remain undisclosed.

Table 1 Relevant Cooperative Patent Classification (CPC) Codes (derived from USPTO, 2025)

CPC Code	Classification Description
G09B	Educational or demonstration appliances; appliances for teaching, or communicating with, the blind, deaf or mute; models; planetaria; globes; maps; diagrams
G09B 5/00	Electrically-operated educational appliances
G09B 7/00	Electrically-operated teaching apparatus or devices working with questions and answers
G09B 9/00	Simulators for teaching or training purposes

Patents related to education were retrieved using the Cooperative Patent Classification (CPC) code ‘G09B,’ along with the more detailed codes listed in Table 1. Identifying patents related to AI is more difficult due to the lack of an explicit CPC code, and AI technologies span a wide range of fields. The work of Leusin et al. (2020) found that 92.1% of AI-related patents can be determined by the following terms: ‘machine learning,’ ‘artificial intelligence,’ ‘machine intelligence,’ ‘neural network,’ ‘support vector network,’ ‘support vector machine,’ ‘fuzzy logic,’ and ‘expert system.’ These keywords were used in conjunction with the CPC codes to identify patents related to AI in education. The search queries employed to collect patent data for this study are presented in Table 2.

Table 2 Patent Search Queries

Technology Domain	Search Query
Education	CPC:(G09B*) AND AD:([01.01.2014 TO 31.12.2023]) ANDNOT DTY:(U)
Electronic-based Education	CPC:(G09B5* OR G09B7* OR G09B9*) AND AD:([01.01.2014 TO 31.12.2023]) ANDNOT DTY:(U)
AI	EN_ALL:("artificial intelligence" OR "machine intelligence" OR "machine learning" OR "neural network" OR "support vector machine" OR "support vector network" OR "expert system" OR "fuzzy logic") AND AD:([01.01.2014 TO 31.12.2023]) ANDNOT DTY:(U)
AI in Education	CPC:(G09B5* OR G09B7* OR G09B9*) AND EN_ALL:("artificial intelligence" OR "machine intelligence" OR "machine learning" OR "neural network" OR "support vector machine" OR "support vector network" OR "expert system" OR "fuzzy logic") AND AD:([01.01.2014 TO 31.12.2023]) ANDNOT DTY:(U)

This patent data analysis reveals trends, identifies gaps, and maps the competitive landscape within AI in education. The top patent assignees in the field were identified and compared,

with a focus on their territorial patent filing strategies and the contents of their patent portfolios. To reinforce the findings, supplementary information from corporate websites, industry reports, and articles was incorporated into the analysis.

RESEARCH RESULTS

Trends in patent applications related to AI, education, and the use of AI in education

Figure 1 presents the patent search results analyzed in this study. Between 2014 and 2023, the AI sector accounted for 953,368 patent applications (662,746 patent families), while the education sector saw 100,568 applications (76,085 patent families). Within education, 36,679 applications (27,835 patent families) focused on electronic-based education, with 3,926 applications (2,725 patent families) specifically addressing AI in education. A patent family refers to a group of related applications originating from the same invention (European Patent Office, n.d.).

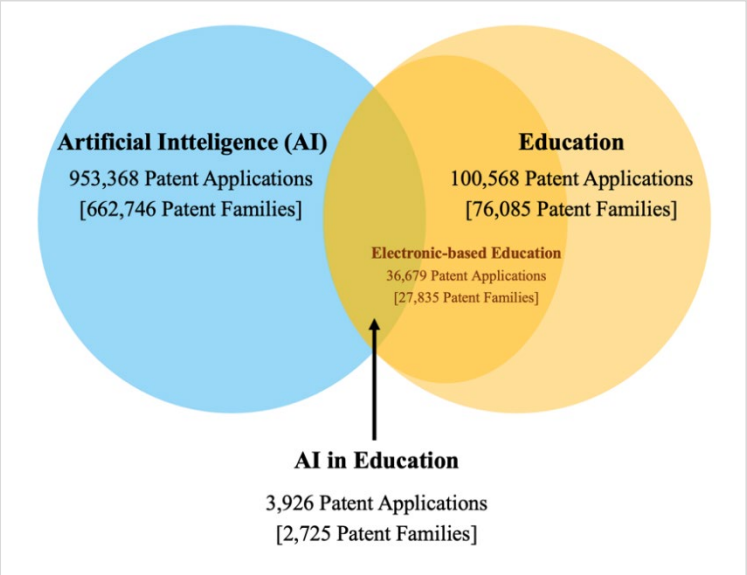

Figure 1 The Quantity of Patent Applications and Patent Families in AI, Education, and AI in Education

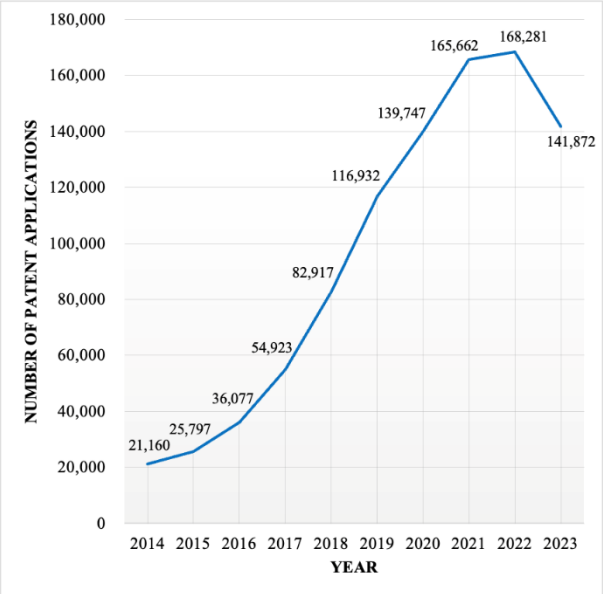

Figure 2 Trend in AI Patent Applications

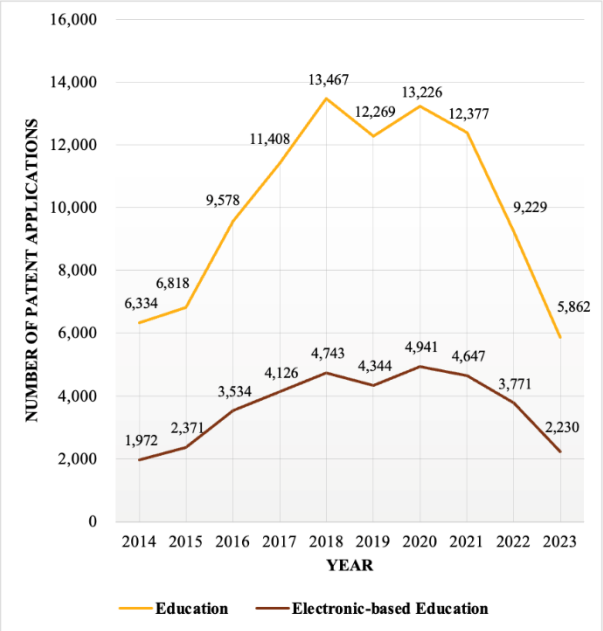

Figure 3 Trends in Educational Patent Applications

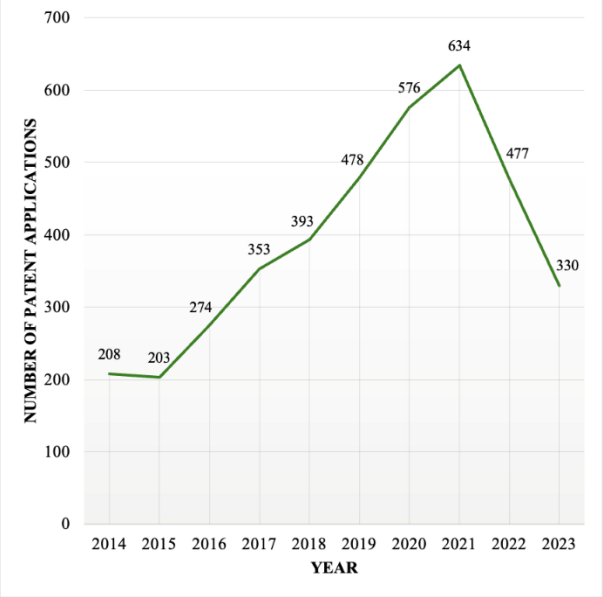

Figure 4 Trend in Patent Applications for AI in Education

Figures 2 to 4 illustrate global trends in patent filings for AI, education, and the convergence of AI in education. AI-related patent applications experienced a significant surge, increasing nearly eightfold from 21,160 in 2014 to a peak of 168,281 in 2022, before declining slightly to 141,872 in 2023. In the education sector, patent filings more than doubled, rising from 6,334 in 2014 to 13,467 in 2018. However, the numbers fluctuated in the following years, briefly declining in 2019, rebounding in 2020, and then steadily decreasing to 5,862 in 2023. Patent applications for electronic-based education followed a similar trend, though at roughly one-third of the volume. Meanwhile, AI-driven education patents saw a threefold increase, growing from 208 in 2014 to 634 in 2021, before dropping to 330 in 2023.

Top Patent Assignees in AI for Education and Their Patenting Strategies

The patent landscape analysis of AI in education highlights a variety of filing strategies among the top patent assignees, as outlined in Table 3. International Business Machines (IBM) holds the largest number of patents in the AI in education sector, with the majority of its filings in

the United States (US). Additionally, IBM has submitted a small number of patent applications to the World Intellectual Property Organization (WIPO) and in China. Similarly, Aspen Performance Technologies has filed most of its AI in education patents in the US, with a few applications at WIPO. Samsung Electronics has also focused its filings in the US, with additional patents submitted to WIPO and the European Patent Office (EPO). Tornier, on the other hand, has primarily filed its AI in education patents with WIPO, along with a few submissions to the EPO and in China. In contrast, companies such as Microsoft Technology Licensing, Pearson Education, Shanghai Squirrel Classroom Artificial Intelligence Tech, Riiid, Koninklijke Philips, and CAE have made more international filings, with patent applications in at least five different countries or regions. Notably, Shanghai Squirrel Classroom Artificial Intelligence Tech has filed the majority of its AI-related education patents in China.

Table 3 Leading Patent Holders in AI for Education and Their Filing Jurisdictions

No.	Patent Assignees	Rank by Number of Patent Families	Number of Patent Families	Number of Patent Applications in Different Jurisdictions *									
				Total Number of Patent Applications	WO	US	EP	CN	CA	AU	DE	KR	JP	SG
1	International Business Machines Co. (IBM)	1st	**151**	**209**	6	202	0	1	0	0	0	0	0	0
2	Microsoft Technology Licensing LLC	2nd	**45**	**77**	29	37	5	2	2	2	0	0	0	0
3	Pearson Education Inc.	3rd	**42**	**64**	12	47	2	1	1	1	0	0	0	0
4	Shanghai Squirrel Classroom Artificial Intelligence Tech Co. Ltd.	4th	**36**	**40**	2	1	0	34	0	2	1	0	0	0
5	Riiid Inc. and Riiid Labs Inc.	5th	**28**	**41**	12	18	0	1	1	1	0	5	2	1
6	Samsung Electronics Co. Ltd.	6th	**22**	**32**	4	19	9	0	0	0	0	0	0	0
7	Koninklijke Philips NV	7th	**18**	**33**	11	13	7	0	1	1	0	0	0	0
8	Aspen Performance Technologies	8th	**15**	**15**	3	12	0	0	0	0	0	0	0	0
9	CAE Inc.	8th	**15**	**23**	7	8	4	0	3	1	0	0	0	0
10	Tornier Inc.	8th	**15**	**21**	18	0	2	1	0	0	0	0	0	0

* The codes for country or regional patent offices: WO (World Intellectual Property Organization), US (United States Patent and Trademark Office; USPTO), EP (European Patent Office; EPO), CN (China National Intellectual Property Administration; CNIPA), CA (Canadian Intellectual Property Office; CIPO), AU (IP Australia), DE (German Patent and Trade Mark Office; DPMA), KR (Korean Intellectual Property Office; KIPO), JP (Japan Patent Office; JPO), and SG (Intellectual Property Office of Singapore; IPOS)

Table 4 presents an analysis of the patent families held by the top ten patent assignees in the AI in education sector. The leading organizations, IBM and Microsoft, are major global technology firms based in the United States. IBM's innovations primarily focus on behavioral and emotional analysis, personalized learning, adaptive content, content generation, and recommendation systems. Additionally, IBM has made significant advancements in integrating virtual reality (VR) and augmented reality (AR) into education. Similarly, Microsoft Technology Licensing has made notable contributions to AI-driven education, particularly in personalized learning, adaptive systems, virtual assistants, and conversational AI.

The third, fourth, and fifth largest patent holders in this domain are Pearson Education, Shanghai Squirrel Classroom Artificial Intelligence Tech, and Riiid—companies specializing in education technology. Pearson Education, headquartered in the United Kingdom, is a leading provider of educational publishing and assessment services (Pearson, n.d.). Its key innovations include personalized and interactive content management and delivery, as well as digital assessment and proctoring. Shanghai Squirrel Classroom Artificial Intelligence Tech, commonly known as Squirrel AI Learning, is a China-based company specializing in AI-driven adaptive learning platforms (Squirrel Ai Learning, n.d.). Its primary innovations encompass

VR and AR applications in education, along with multimedia and interactive teaching tools. Riiid, headquartered in South Korea, has expanded its global footprint through Riiid Labs, a U.S.-based subsidiary (Riiid, n.d.). Its core innovations include personalized learning recommendations, knowledge tracing, and skill assessment.

Table 4 Leading Patent Holders in AI for Education and Their Patent Family Insights

No.	Organization Name	Organization Description	Business Sector	Country of Headquarters	Number of Patent Families	Delineation of Patent Families
1	**International Business Machines Co. (IBM)**	A multinational technology company offering hardware, software, and consulting services.	Information Technology	United States	**151**	Behavioral and Emotional Analysis (51 patent families) Personalized Learning and Adaptive Content (18 patent families) Content Generation and Recommendation (18 patent families) Question Answering and Knowledge Systems (15 patent families) Automated Assessment and Grading (14 patent families) Language Learning and Speech Enhancement (10 patent families) Gaze Tracking and Attention Analysis (7 patent families) Virtual and Augmented Reality in Education (7 patent families) Collaborative and Social Learning (7 patent families) Neurofeedback and Cognitive Monitoring (4 patent families)
2	**Microsoft Technology Licensing LLC**	A subsidiary of Microsoft Corporation responsible for managing its technology licensing.	Information Technology	United States	**45**	Personalized Learning and Adaptive Systems (12 patent families) Virtual Assistants and Conversational AI (11 patent families) AI-Driven Content Creation and Management (10 patent families) Real-Time Feedback and Assessment (8 patent families) Gamification and Engagement Tools (4 patent families)
3	**Pearson Education Inc.**	A leading education publishing and assessment service provider.	Education	United Kingdom	**42**	Personalized Content Management and Delivery (14 patent families) Digital Assessment and Proctoring (11 patent families) Predictive Analytics and Adaptive Learning (10 patent families) Handwriting and Visual Analysis (4 patent families) Network and User Positioning (3 patent families)
4	**Shanghai Squirrel Classroom Artificial Intelligence Tech Co. Ltd.**	Also known as Squirrel AI Learning, it specializes in AI-driven adaptive learning platforms.	Education Technology	China	**36**	Virtual Reality and Augmented Reality in Education (9 patent families) Multimedia and Interactive Teaching Tools (9 patent families) Personalized Content Management and Delivery (6 patent families) Automated Question Generation & Assessment (4 patent families) Language Learning and Speech Recognition (4 patent families) Remote and Online Learning Platforms (4 patent families)
5	**Riiid Inc. and Riiid Labs Inc.**	Companies focusing on AI-based education solutions, offering personalized learning experiences.	Education Technology	South Korea and United States	**28**	Personalized Learning Recommendations (10 patent families) Knowledge Tracing and Skill Assessment (7 patent families) AI-Powered Tutoring and Interfaces (3 patent families) Content Evaluation and Correct Answer Prediction (2 patent families) Vocabulary and Language Learning (2 patent families) API-Based AI Prediction Services (2 patent families) Pre-Training AI Models for Educational Predictions (1 patent families) User Data Analysis and Diagnostic Question Sets (1 patent families)
6	**Samsung Electronics Co. Ltd.**	A world leader in consumer electronics, telecommunications, and semiconductors.	Electronics	South Korea	**22**	Learning Assistance and Content Analysis (9 patent families) Health and Fitness Education (6 patent families) Augmented Reality (AR) and Wearable Devices (3 patent families) Virtual Audience and Interaction (1 patent families) Cognitive Assessment Based on User Content (1 patent families) Simulation and Autonomous Systems (1 patent families) Device Synchronization and Collaboration (1 patent families)
7	**Koninklijke Philips NV**	Commonly known as Philips, it operates in health technology, focusing on diagnostic imaging, patient monitoring, and personal health.	Health Technology	Netherlands	**18**	Behavioral and Cognitive Assistance (6 patent families) Personalized Learning and Coaching (5 patent families) Healthcare and Medical Training (4 patent families) Engagement and Interaction Analysis (3 patent families)
8	**Aspen Performance Technologies**	A company specializing in performance management and optimization solutions.	Technology	United States	**15**	Symbol Sequence Manipulation (12 patent families) Pattern Recognition and Search Tasks (2 patent families) Orthographic and Numerical Tasks (1 patent families)
9	**CAE Inc.**	A global leader in training for the civil aviation, defense, and healthcare sectors.	Training and Simulation	Canada	**15**	Simulation and Virtual Training Environments (9 patent families) Adaptive Learning Systems (4 patent families) Biometric and Cognitive Load Analysis (1 patent families) Psychometric Data and Performance Prediction (1 patent families)
10	**Tornier Inc.**	A medical device company specializing in joint replacement and soft tissue repair.	Medical Devices	France and United States	**15**	Mixed Reality for Surgical Education and Training (10 patent families) Extended Reality for Visualization and Monitoring (2 patent families) Neural Networks for Diagnosis and Recommendation (2 patent families)

Samsung Electronics, based in South Korea, is a worldwide leader in consumer electronics, telecommunications, and semiconductors (Samsung, n.d.). The company prioritizes

innovations in learning assistance, content analysis, and healthcare technologies, including health and fitness education, augmented reality (AR), and wearable devices. Philips, officially known as Koninklijke Philips and based in the Netherlands, is a key player in health technology (Philips, n.d.). Its advancements focus on behavioral and cognitive assistance, personalized learning and coaching, as well as medical training and healthcare solutions. Aspen Performance Technologies, a U.S.-based company, specializes in performance management and optimization solutions (AspenTech, n.d.). Its technological developments include symbol sequence manipulation, pattern recognition, and search tasks. CAE, headquartered in Canada, is a leading provider of training solutions for civil aviation, defense, and healthcare industries (CAE, n.d.). Its primary innovations include simulation-based virtual training environments and adaptive learning systems. Originally established in France, Tornier was a medical device company that merged with the U.S.-based Wright Medical Group in 2015 (GlobeNewswire, 2015). In 2020, Wright Medical was acquired by Stryker Corporation (Stryker, 2020), also based in the U.S. Tornier's innovations include mixed reality (MR) applications for surgical education and training, along with extended reality (XR) solutions for visualization and monitoring.

DISCUSSION & CONCLUSION

This analysis of patent data from 2014 to 2023 reveals a notable expansion in AI applications within the education sector. Over the decade, AI-related patent filings surged nearly eightfold, mirroring the broader trend of rapid technological progress and AI integration across industries. While patents specifically focused on AI-driven education also experienced a threefold increase, this remains a specialized niche within the broader landscape of AI innovation. This rapid surge in AI-related patents in education aligns with the academic publication trends observed in the study by Jain and Raghuram (2023).

One significant finding is the concentrated efforts of major technology firms and education-focused companies in securing AI in education patents. IBM, Microsoft, Pearson Education, Shanghai Squirrel Classroom Artificial Intelligence Tech, and Riiid emerge as key players driving innovation in AI-driven education solutions. Their contributions span various technological advancements, including personalized learning systems, adaptive content delivery, virtual assistants, and educational experiences through AR and VR. This underscores the strategic importance of AI in enhancing educational methodologies, improving learning outcomes, and addressing diverse learner needs.

The geographical distribution of patent filings further highlights the strategic priorities of leading organizations. While companies, such as Aspen Performance Technologies, primarily focus on domestic patent filings, others—such as Riiid, Microsoft, and Pearson Education—have adopted more international strategies. Moreover, industry diversification within AI in education patents is evident, with companies from various sectors—including healthcare technology (Philips), consumer electronics (Samsung), and training solutions (CAE)—actively innovating in this space. Their focus on integrating AI into specialized training programs, cognitive assistance, and simulation-based learning reflects the expanding applications of AI in professional and vocational education beyond traditional academic settings.

This study contributes to the understanding of technological evolution in AI-driven education by mapping the trajectory of patent filings over the past decade. The results offer valuable insights into innovation patterns, key industry players, and regional focus areas. This research serves as a useful resource for policymakers, educators, inventors, and business leaders. By understanding these trends, stakeholders can better prepare for technological disruptions, optimize resource allocation, and formulate strategies for the effective integration of AI in educational settings. Additionally, the findings can inform investment decisions for businesses

looking to enter or grow within the AI-driven education sector, shedding light on emerging opportunities and potential challenges.

AI has the potential to transform education and support Sustainable Development Goal 4, which seeks to provide inclusive, equitable, and quality learning opportunities for all; however, challenges related to data privacy, algorithmic bias, and accessibility require a multidisciplinary approach for responsible implementation (Porayska-Pomsta et al., 2023). Developing regulatory guidelines and incorporating AI ethics into education systems can help address these concerns (Kamalov et al., 2023). To promote ethical AI adoption in education, Yan and Liu (2024) introduced a six-step framework emphasizing fairness, transparency, and human-centered development. Their approach includes selecting appropriate AI models, ensuring high-quality and ethically sourced data, refining AI behavior through structured learning, using reinforcement learning for continuous improvement, aligning AI systems with long-term ethical principles focused on human well-being, and maintaining feedback mechanisms to protect privacy and fairness (Yan & Liu, 2024). AI policies should also consider cultural diversity to promote fairness and inclusivity rather than applying uniform solutions (Yusuf et al., 2024). Future research should investigate the long-term impact of AI-driven educational tools on learning outcomes and teaching methods while strengthening regulatory measures and ethical guidelines. A responsible approach to AI implementation will help ensure equitable access to its benefits across different educational settings.

REFERENCES

AspenTech. (n.d.). *About Us*. Retrieved from https://www.aspentech.com/en/about-aspentech.

CAE. (n.d.). *About CAE*. Retrieved from https://www.cae.com/about-cae.

Eaton, J., & Kortum, S. (1996). Trade in ideas: Patenting and productivity in the OECD. *Journal of International Economics, 40*(3-4), 251-278.

European Patent Office. (n.d.). *Patent families*. Retrieved from https://www.epo.org/en/searching-for-patents/helpful-resources/first-time-here/patent-families.

GlobeNewswire. (2015). *Wright Medical and Tornier Complete Merger and Create Premier High-Growth Extremities-Biologics Company*. Retrieved from https://www.globenewswire.com/news-release/2015/10/01/772729/0/en/Wright-Medical-and-Tornier-Complete-Merger-and-Create-Premier-High-Growth-Extremities-Biologics-Company.html.

Henry, M. K. (2024). *International patent protection: Developing a global strategy*. Henry Law. Retrieved from https://henry.law/blog/international-patent-protection-developing-global-strategy/.

Jain, K., & Raghuram, J. N. V. (2023). Unlocking potential: The impact of AI on education technology. *Multidisciplinary Reviews, 7*(3), 2024049.

Kamalov, F., Santandreu Calonge, D., & Gurrib, I. (2023). New era of artificial intelligence in education: Towards a sustainable multifaceted revolution. *Sustainability, 15*(16), 12451.

Khan, S. D., Kumar, A., Anil, B. C., Solar, E. C., Eswarareddy, S., & Surbakti, H. (2023). Artificial intelligence in education: Enhancing learning experiences and personalization. *Journal of Informatics Education and Research, 3*(2), 545-553.

Leusin, M. E., Günther, J., Jindra, B., & Moehrle, M. G. (2020). Patenting patterns in artificial intelligence: Identifying national and international breeding grounds. *World Patent Information, 62*, 1-13.

Owoc, M. L., Sawicka, A., & Weichbroth, P. (2021). *Artificial intelligence technologies in education: Benefits, challenges and strategies of implementation*. Retrieved from https://arxiv.org/abs/2102.09365.

Pearson. (n.d.). *Our Company*. Retrieved from https://plc.pearson.com/en-GB/company.

Philips. (n.d.). *About Us*. Retrieved from https://www.philips.com/global.

Porayska-Pomsta, K., Holmes, W., & Nemorin, S. (2023). The ethics of AI in education. In B. du Boulay, A. Mitrovic, & K. Yacef (Eds.), *Handbook of artificial intelligence in education* (pp. 573-607). Edward Elgar Publishing.

Riiid. (n.d.). *About*. Retrieved from https://riiid.com/about.

Russell, S., & Norvig, P. (2021). *Artificial intelligence: A modern approach*. 4th ed. Pearson.

Samsung. (n.d.). *About Us*. Retrieved from https://www.samsung.com/us/about-us/our-business/.

Squirrel Ai Learning. (n.d.). *About*. Retrieved from https://squirrelai.com/#/company/about.

Stevnsborg, N., & van Pottelsberghe, B. (2007). Patenting procedures and filing strategies. In D. Guellec & B. van Pottelsberghe (Eds.), *The economics of the European patent system* (pp. 155-183). Oxford University Press.

Stryker. (2020). *Stryker completes acquisition of Wright Medical*. Retrieved from https://www.stryker.com/th/en/about/news/2020/stryker-completes-acquisition-of-wright-medical.html.

USPTO. (2025). *Classification Resources*. Retrieved from https://www.uspto.gov/web/patents/classification/cpc/html/cpc-G09B.html#G09B.

Wang, S., Wang, F., Zhu, Z., Wang, J., Tran, T., & Du, Z. (2024). Artificial intelligence in education: A systematic literature review. *Expert Systems with Applications, 252*, 124167.

WIPO. (2019). *WIPO Technology Trends 2019 - Artificial intelligence*. Retrieved from https://www.wipo.int/publications/en/details.jsp?id=4386.

WIPO. (n.d.). *Protecting your Inventions Abroad: Frequently Asked Questions about the Patent Cooperation Treaty (PCT)*. Retrieved from https://www.wipo.int/pct/en/faqs/faqs.html.

Yan, Y., & Liu, H. (2024). *Ethical framework for AI education based on large language models*. Education and Information Technologies.

Yusuf, A., Pervin, N., & Román-González, M. (2024). Generative AI and the future of higher education: A threat to academic integrity or reformation?. Evidence from multicultural perspectives. *International Journal of Educational Technology in Higher Education, 21*(21).

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