Artificial Intelligence in Education: Enhancing Teacher Professional Development and Classroom Efficiency

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Abstract:

The integration of Artificial Intelligence (AI) in education has the potential to revolutionise teacher professional development, enhancing their ability to foster student learning and improve classroom efficiency. This efficiency involves teachers optimizing their time and efforts to meet school and student needs, all while maintaining educational quality and reducing stress. In formalized teacher development systems, AI aids teachers in becoming more proficient and effective. It offers feedback on teaching practices, providing insights and resources like tutorials, lesson plans, and differentiation strategies that enhance lesson planning. Furthermore, AI addresses rising workloads, alleviating stress and burnout among teachers and administrators. There are opportunities for continuous growth through AI, even beyond initial teacher training. (R. Kshirsagar et al., 2022)(Schiff, 2021)

Keywords: Artificial Intelligence, Education, Teacher professional development, classroom efficiency.

1. Introduction

Education systems worldwide strive to equip learners with the knowledge, aptitudes, and competencies to thrive in a fast-changing, complex world. Governments and international organizations such as UNESCO, the OECD, and the World Bank regard the ability of teachers and trainers to nurture requisite lifelong learning skills among students as key to meeting global learning hub challenges. Hence, professional development for teachers is increasingly recognized as essential (R. Kshirsagar et al., 2022).

Artificial Intelligence (AI) offers the potential to enhance teacher professional development and classroom practices, arguably the most critical influence on student learning outcomes. AI tools help teachers continuously appraise their teaching capabilities and identify knowledge or skill

gaps, while providing just-in-time personalized supplementary content to address shortcomings. Accordingly, educators can improve individual teaching performance without requiring formal qualifications, enabling new entrants to quickly acquire necessary knowledge and skills. A growing body of evidence suggests that teachers are rethinking their instructional practices, adopting more equitable and formative assessment approaches, monitoring attendance closely, and accelerating feedback, all of which contribute to better time management (Schiff, 2021).

2. Theoretical Foundations of AI in Education

The term professional development (PD) refers broadly to a variety of learning opportunities for educators. Both continued education and informal mentoring contribute to teacher knowledge and practice (R. Kshirsagar et al., 2022). Contextual factors—individual, classroom, school—exert influence on how new insights gain traction in classrooms. López-Urrutia and Gairín hold that "professional development combining training on subject matter and pedagogy has more successful results" (Schiff, 2021). Instructional activities support effective learning in groups of three.

A teacher-oriented approach emphasizes classroom efficiency—the extent to which instruction leads to intended learning. Repetition and systematic review sustain short-term retention, while adequate time and protection against interference improve longer-term recall (Tian et al., 2024). Classroom management strategies predict improved student behaviour. Formal assessments also help establish progress.

2.1. Concepts of Professional Development in Teaching

The conceptualization of professional development is essential for assessing how information and communication technologies (ICTs) can enhance educators' learning and improve students' outcomes. Glickman, Gordon, and Ross-Gordon (2001, p. 36) outline four main assumptions: 1. Professional development aims to improve student learning. 2. More effective development is necessary for educational reform and better student results. 3. The nature of professional development has evolved significantly. 4. Learning is lifelong and occurs in various settings, meaning professional development is a continuous process. There is no single definition of professional development, but terms like inservicing and workshops are commonly used. Adelman (2007) identifies three philosophical approaches: technical, humanistic, and pragmatic. Kagan (2000) highlights professional development as an ongoing process supporting teachers' growth throughout their careers. Teachers seek personalized approaches relevant to their specific contexts. Increasing emphasis on ICTs in teacher development shows that only about 20% of educators can utilize new ICT tools. The availability of diverse ICT tools affects the pedagogical models teachers adopt, enhancing their pedagogical knowledge and benefiting the learning community. (R. Kshirsagar et al., 2022)

2.2. Classroom Efficiency and Learner Outcomes

Global efforts to enhance education emphasize the need for greater investment in teacher education and development. Many countries adopt systemic approaches to teacher education,

recognizing teaching as a complex, context-dependent activity. A notable initiative is the creation of a collaborative web-based platform promoting reflective practice, knowledge-sharing, and collegial support. This platform connects teachers to an online community for peer discussions, sharing resources, and reflecting on their teaching. Based on a solid framework of teacher development and data from a pilot project, the paper outlines design decisions and future proposals. AI tools help teachers assess their practice, plan lessons, and find instructional materials, enriching the coherence of learning experiences. Access to more tools often leads to formative feedback. Analytical support focuses on various aspects of written and oral work. Planning time remains a critical issue for educators globally. AI technologies significantly impact classroom practices, affecting professional development and teacher education. Understanding the balance among these elements is vital for grasping AI's evolving role in education. This framework highlights options in the educational ecosystem and underscores the importance of pedagogy in creating learning opportunities through reforms, technology integration, or AI adoption. (R. Kshirsagar et al., 2022)

3. AI Tools and Their Roles in Teacher Development

AI tools supporting diagnostic reflection, adaptive content, and automated feedback enhance teacher development in various contexts, echoing the learning theory accepted by educational reformists and the emphasis on adaptation and guidance by constructivist leaders. Such tools identify teachers' strengths through classroom video analysis and generate tailored recommendations aligning with empirical evidence connecting specific improvements to desired outcomes (R. Kshirsagar et al., 2022). AI offers personalized guidance without replacing human interaction, unlocking professional growth opportunities beyond prevailing pathways grounded in collaborative peer engagement and singular course participation.

Diagnostic and Reflective Tools for Professional Growth

Through concise, AI-generated descriptions of classroom videos, teachers grasp their strengths and receive personalized suggestions for developing professionalism and enhancing practices, especially those correlated with impactful learner outcomes. With these recommendations derived from global educational research, autonomous growth in line with institutional objectives becomes attainable; various formats accommodate specific contexts.

Adaptive Content and Lesson Planning Support

AI-facilitated instructional material generation assists lesson preparation, liberating time for planning and design activities and accommodating diverse educational needs across countries. The adaptability of such assistance is particularly relevant, aligning with constructivist leaders' prioritization of learner-specific needs (Schiff, 2021).

Automated Feedback and Assessment for Educators

3.1. Diagnostic and Reflective Tools for Professional Growth

Professional development through a process of self-diagnosis followed by reflection is part of the journey that teachers undertake throughout their careers.

Professional development can be described as a process of self-diagnosis followed by reflection, which teachers embark on throughout their careers. By comparing their actual practices to the best known or recommended practices to which they aspire, educators—in collaboration with peers or individually—can assess their own strengths and pinpoint areas that would benefit from further training or learning (G. Moursund, 2006). Despite being well-documented, in the literature this particular form of professional development has not been consistently recognised. Several AI-assisted tools complementing such a development path are emerging.

3.2. Adaptive Content and Lesson Planning Support

AI-powered support tools can generate teaching resources and lesson plans tailored to local contexts and specific student needs, offering significant advantages in education. However, creating these resources requires considerable pedagogical expertise and is often time-consuming. Ongoing research aims to improve automation in lesson planning, ensuring alignment with learning objectives and relevant materials. Despite advancements, effective socio-political lesson plans often necessitate customization. While teachers increasingly modify AI-generated content, these tools assist in selecting suitable learning objectives and strategies for various student groups. Future developments are expected to enhance planning for educational activities, lesson rubrics, and the application of generated content to monitor progress and promote collaboration. (Bredeweg & Kragten, 2022)(E. August & Tsaima, 2021)

3.3. Automated Feedback and Assessment for Educators

Teachers have little time for meeting their own instructional needs in the high-volume demands of classroom preparation and management (Schiff, 2021). Task-oriented AI has the potential to provide immediate and automated feedback on the design of lessons, assignments, assessments, and other instructional materials. Educators can use these rapid "quality checks" to reflect on and apply improvements. In an era where classroom observation is rare due to logistical and cultural constraints, such AI-based feedback serves to fill an essential vacuum.

AI-supported assessment of educators can extend fully formed materials, generate scenarios for co-design, or improve batch collections—strengthening existing efforts around teacher collaboration, equity, engagement, and participation. In addition, instructions, questions, and prompts can be automatically assessed for fidelity and viability in relation to various dimensions and frameworks, while estimates of cognitive demand and Bloom's taxonomy levels can highlight alignment with learning intention and elaborated goals.

4. Impacts on Classroom Practice

Generative artificial intelligence can enhance classroom practices by aiding planning, instructional design, and reducing administrative burdens. AI tools help educators choose suitable learning objectives, activation strategies, and assessments, while providing prompts for lesson structure. Automated lesson outlines and intro materials can be generated through computer-supported textual analysis. AI matches teaching resources to learning objectives and adjusts materials for various cognitive levels, offering feedback on lesson gaps. Additionally, AI

can recommend materials tailored to learner profiles or suggest modifications for better accessibility. Analyzed teaching data helps identify features of quality instruction, such as content relevance and pacing. As curriculum demands grow, AI can reduce administrative tasks, allowing more time for teaching and feedback. (R. Kshirsagar et al., 2022)

4.1. Planning and Instructional Design

Since the mid-2010s, ChatGPT-like tools have gained prominence globally, performing various tasks in text and speech that could transform online communication and information access. AI-enhanced education provides timely, personalized training and assessment for teachers and learners, increasing efficiency. It is integral to the Higher Education version of Creative Commons' OER—Open Educational Resources—and the National Educational Technology Plan (NTP), which leverages AI for managing educational and career networks. AI-enabled systems aid in the unbiased selection of professional development programs, addressing significant obstacles to sustainable growth. AI-assisted feedback enhances learning efficiency and quality, offering personalized invitations to institutional courses and recommending free external online programs, making education more systematic and accessible. Professional teaching standards are divided into three domains or twelve aspects that promote in-service growth. A key focus area is upgrading higher education institutions to embed legally recognized educational qualifications. AI-supported instructional assistance guides educators toward responsible, competent formal recognition through incentives. (R. Kshirsagar et al., 2022)(G. Moursund, 2006)

4.2. Differentiation and Inclusive Teaching

In instructional planning, there is significant variability in the depth and variety of learning experiences offered to student learners who possess diagnostic information. Each lesson is typically designed to foster learner interactions with essential competencies a limited number of times, completing all planned experiences enables the teacher to monitor learner uptake of the relevant competencies (R. Kshirsagar et al., 2022). Some student learners enthusiastically engage with the planned opportunities, while others require additional instructional experiences before they demonstrate sufficient proficiency (Guo et al., 2021). AI Tools can proactively suggest strategies enabling educators to design lessons with an explicit focus on differentiated coverage of the essential competencies. Adaptive support focused on differentiated coverage can also alleviate the longer planning time often required for lessons that feature tailored learning experiences either for the entire class, small groups, or individual students.

4.3. Time Management and Administrative Tasks

Effective teaching necessitates a supportive environment that fosters knowledge and skills among diverse learners. Educators meticulously select and prepare lesson content, specifying learning objectives, creating rich models, and developing instructional materials. Designing new lessons requires substantial pedagogical expertise and time, whereas refining existing content mainly involves minor adaptations. Providing advanced explanations requires teacher involvement, especially for learners with complex misunderstandings beyond AI support, such as

misconceptions about causal dependencies. In these cases, dialogue aids in recognizing and adjusting misconceptions tailored to individual needs. Additionally, teachers play a crucial role in administrative tasks and classroom management. Responsibilities, such as welcoming students, creating a positive atmosphere, encouraging participation, and maintaining engagement, remain with educators, even with the help of real-time analytics to identify at-risk pupils. Interpreting this data and formulating responses are firmly within the educator's duties. (Bredeweg & Kragten, 2022)(R. Kshirsagar et al., 2022)

5. Implementation Frameworks

Supporting effective AI-enhanced professional development and classroom efficiency requires coherent and collaborative governance and decision-making among key stakeholders (Tian et al., 2024). Such frameworks safeguard data privacy, uphold ethical standards, advance equity and inclusion, and chart pathways for workforce development and progress monitoring. Teachers can find AI skill pathways that accommodate situational contexts and target pivotal competencies for enhanced professional growth (Aliabadi et al., 2023).

5.1. Stakeholder Roles and Governance

Teaching professionals, schools, and education authorities are vital in AI-assisted professional development planning. School and district administrators make decisions based on research and expert advice to choose effective tools. Teachers and school leaders provide feedback, identify training opportunities, and share use cases. Education authorities are mandated to select relevant tools that align with educational goals and standards on data protection, privacy, equity, and access. AI can enhance professional development in teaching, improving classroom processes and student outcomes. Educators face rising demands and often express frustration over time-consuming tasks that hinder classroom work, a burden AI can ease. It helps adapt lesson materials for different age groups or pupil configurations. The way AI applications are designed and integrated can significantly influence pedagogy and assessment. Therefore, the choice of tools, implementation, and context are crucial for effective professional development. AI can improve classroom efficiency and allow for exploration of new teaching methods. (Schiff, 2021)

5.2. Data Privacy, Ethics, and Equity

The deployment of AI tools in education raises important ethical concerns, including transparency. For AI to successfully assist professionals, users should understand its contributions, risks, and limitations. Tools developed for teacher training typically do not specify organizational data retention policies (Yu & Yu, 2023) , a major hurdle for adoption.

Privacy is also paramount. It encompasses protecting information such as email addresses and personal characteristics to prevent harm and ensure security. As AI systems gain sophistication, personal privacy threatens to erode. For instance, intricate data analysis of ostensibly anonymized student responses could reconstruct identities and discern sensitive characteristics, including socio-economic status, ethnicity, and disability. Such revelations may occasionally

contravene institutional transparency policies and provoke discrimination concerns. These issues highlight the growing salience of privacy concerns in education.

Equity is a further consideration. Chatbots are widely used for communication and information dissemination, but education systems must determine whether learners can engage within these knowledge networks. Ensure systems do not reference, repurpose, or glean further insights about the educational context from their interactions.

5.3. Professional Development Pathways and Competencies

AI-assisted professional development of teachers has the potential to complement and enhance the skills acquired through initial training, thereby addressing the evolving needs of educators (Schiff, 2021). From understanding students' goals and developing pedagogically beneficial assessments to managing classroom discussions, a host of topics gain prominence as teachers gather experience over time. A common goal is to engage learners according to their individual starting points, abilities, and aspirations, and to pursue their goals in a way that fosters learning. Only with thorough exposure to inquiry-based learning can teachers adequately inspire students possessing distinct backgrounds, needs, goals, and interests.

Moreover, formal professional development pathways rooted in teaching, learning, and education analysis enable teachers to advance from novice to expert and to follow a variety of development paths aligned with their specializations (Aliabadi et al., 2023). Competencies for initial training of educators and for their continuous development have emerged as a new focus of educational research. Development can also extend toward strengthening teachers' identities, which affect their initial choices of specializations and guide decisions to adapt outputs or explore alternative disciplines.

6. Case Studies and Empirical Evidence

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Case Studies and Empirical Evidence

K-12 Contexts

A case study investigated the impact of AI tools on teachers' professional development in a K-12 pilot project (Tian et al., 2024). The technology-enabled environment emphasised long-term, continuous input and support, coupling (1) a data analytics platform measuring instructional quality with (2) a software tool automatically generating granular feedback. Teachers received both programme-wide evaluations and personalised recommendations. Findings revealed improved practice and reflection across 19 subjects. AI-supported prompt engineering also helped colleagues design classroom observation rubrics and pedagogical advice. A comprehensive analysis of teachers' feedback through text mining further encouraged thematic discourse and signalled readiness for a large-scale rollout.

The second study explored educational AI tools facilitating professional growth and impact on advancement level (R. Kshirsagar et al., 2022). Teachers indicated strong gains via earlier

development instruments, while university graduates perceived a ceiling effect; intensive workshop series subsequently addressed policy changes, student-centred activities, and new learning formats. To sustain these initiatives after pilot completion, administrators encouraged staff to document innovative techniques in peer-reviewed journals and apply for additional funding. These cases highlight effective teacher professional development, yet warrant caution about attributing success solely to AI.

Higher Education Contexts

A case study in higher education examined how the Hybrid Intelligence System for Teacher Development (HISTED) improved educators' instructional practice (Bredeweg & Kragten, 2022). The web-based platform supports institutions in gathering evidence for upholding teaching quality, stimulating collaboration and knowledge exchange, optimising curriculum design, and offering timely feedback. With four interconnected subsystems targeting self-assessment, activity design, material selection, and content delivery, the system streamlines the professionalisation process.

Vocational and Adult Education Contexts

Policymakers, researchers, and practitioners in vocational and adult education frequently recognise AI's potential to foster professional growth, yet few studies document specific developments. A recent investigation identified requirements and challenges for creating a hybrid intelligence application enhancing systems thinking while remaining responsive to diverse stakeholder needs. Following a participatory design approach, conceptual architecture and operational prototypes were iteratively refined.

6.1. K-12 Contexts

Much literature on instructional quality highlights classroom observations as an effective method for professional development, providing constructive feedback for teachers to improve instructional practices. Feedback typically comes from administrators, peers, or coaches who observe lessons. The effectiveness of this feedback often hinges on the observer's expertise, and observers may lack the ability to monitor every teacher frequently due to time constraints. Computer-assisted analysis of recorded lessons is proposed as a viable solution, offering valuable insights into instructional quality. Such analyses, enhanced by machine learning and natural language processing, can evaluate various observable features, including questions and lesson structure. Teachers need to blend subject-matter knowledge with skills to create engaging lessons. Reusing lessons can save time, but developing new ones demands significant expertise and effort, which templates can alleviate. Moreover, teachers must address learning processes and clarify misconceptions through dialogue. These tasks require extensive time investment. Classroom management is essential, including welcoming students and maintaining engagement. Learning analytics can identify students needing support, but teachers are responsible for interpretation and intervention. (Tian et al., 2024)(Bredeweg & Kragten, 2022)

6.2. Higher Education Contexts

Educational contexts significantly affect the integration of Artificial Intelligence (AI) in teaching. Resources for teacher development, classroom practices, and challenges reported in literature differ across educational sectors. Three cases show AI's current and potential impact in higher education. At a large public university, the shift to hybrid and online formats due to COVID-19 led to the creation of a teaching toolkit that aids course design. This toolkit includes resources on pedagogy, video production, assessment, learning activities, and technology tools to meet diverse teaching needs. Its development involved literature insights and expert interviews clarifying complex concepts. Tools like BeLatina, ChatGPT, and Canva emerged rapidly, allowing safe exploration of generative text and image models. AI facilitated the generation and revision of structured materials and instructions. At the University of Illinois, the transition to distance learning for challenging computer science courses presented ongoing difficulties. Instruction transitioned to effective in-class, hybrid, and online models aided by Open Educational Resources (OER) for affordability and accessibility. Despite time demands, personalized support on quantitative reasoning topics was attainable, with ChatGPT enhancing efficiency by clarifying topics and improving solutions for quizzes while identifying programming pitfalls. MOOC-style education at this university faces scale challenges, resulting in passive student engagement. To combat this, teacher-centered methods like in-person meetups and digital office hours improve interaction. AI-powered tutoring systems and social-emotional engagement tools provide opportunities for quality enhancements in large-scale pedagogical settings. (Schiff, 2021)

6.3. Vocational and Adult Education Contexts

Modern education involves incorporation of artificial intelligence, learning analytics (LA), and other technological innovations, yet education systems, methodologies, and institutions have not been sufficiently studied to address new educational challenges. This situation presents a gap of pedagogical knowledge and skills to inform policy initiatives. Such knowledge and skills are fundamental to education strategy formulated through interdisciplinary collaboration of pedagogy, economics, computing, and policy experts (Schiff, 2021).

Vocational education, career and technical education, adult education, and workforce development involve the same pedagogical challenge of cultivating aligned skills and attitudes through varied learning contingencies across different subjects, lessons, approaches, and institutions, and educational systems have achieved highly variable success.

7. Challenges and Risks

Artificial intelligence (AI) offers significant opportunities to improve personal and professional lives. However, integrating AI into teaching presents various pedagogical, ethical, and operational challenges. Key issues include bias, transparency, resource constraints, and change management, which impact the effective use of AI for teacher development. While AI has revolutionized fields like finance and agriculture through data-driven insights, skepticism towards AI persists, particularly in education. Educators recognize their role in shaping future generations but may worry about AI tools replacing critical tasks. The education sector might

only adopt a small portion of AI innovations before they alter core principles. Shifting the focus from machine-led to teaching-led AI implementation could reshape educational practices. Teaching is rooted in professional identity, emphasizing personal achievement and respect. If AI manages administrative tasks like lesson planning, teachers may see their responsibilities shift, potentially diminishing aspects of the teaching profession that are currently viewed as credible. (Schiff, 2021)(Mollick & Mollick, 2023)

7.1. Bias, Transparency, and Trust

AI systems for professional development and classroom practices may exacerbate existing biases, affect trustworthiness, and promote transparency. For example, systemic inequities in teacher evaluation affect many countries (Ali Chaudhry et al., 2022). The role of teachers in the classroom and their evaluation procedures differ widely due to historical and cultural issues. Such disparities may influence interpretable and genera4977893-1d5b-4a77-a043-8b566ef1ab2fzable targeted developmental support to teachers, even in an AI-based support system. Trust enhances collaborative construction of collective intelligence; lower trust undermines the efficacy. Trust in AI systems varies across educators' dispositions and teaching contexts. Policy-makers must consider not only content and topics but also influence- and mission-related responses, a broader and more complex relationship than that in existing systems. Enabling teacher agency toward self-improvement is crucial.

7.2. Resource Constraints and Access

Access to hardware, software, infrastructure, and technology often drives how widely agents embrace educational technology. Some forms of professional development are also costly to use, implement, or administer. Members of educational organizations—particularly teacher or faculty associations—may lack resources to take full advantage of some or any AI applications for professional development.

Broadband internet access is also an issue. In the K–12 system, not all classes benefit from sufficient bandwidth (Schiff, 2021). In developing countries, video usage in combination with an open online course delivery system is typically limited due to inadequate access within the home and low levels of digital equipment. Even educational institutions with access to class-tested systems report limitations in software suitable for mixed-mode delivery.

Tackling such significant resource constraints and access issues may seem daunting, and the challenge may remain unaddressed. Nevertheless, preparation enables degree-granting organizations to be proactive rather than reactive.

7.3. Change Management and Professional Identity

The organizational culture within which any technological innovation emerges is centrally important. Teachers reflect a strong commitment to their professional identity. Frequent changes in the educational landscape affect their perception of the nature and purpose of their work. Teachers believe that innovations often demand alterations to their professional identity rather than enhancing it. The quality of technology-enhanced education thus becomes dependent on

governance arrangements, which in turn depend on changing teachers' professional identity (Ángel Negrín-Medina et al., 2022).

AI-enhanced content and planning systems are not considered a threat to teachers and do not diminish their professional identity. By assuming responsibility for specific aspects of planning, AI tools may enable wider consideration of classroom design and support key areas in which manual planning is ineffective, such as differentiation. AI support allows teachers to concentrate on improving instruction and engagement rather than revising existing materials or creating new content. AI-enhanced assessment opens opportunities to identify gaps that are difficult to detect when relying solely on final products.

8. Policy Implications and Future Directions

To harness the potential of AI-enhanced professional development, policy design needs a solid pedagogical foundation that considers stakeholder roles, implementation steps, and expected outputs (Schiff, 2021). A structured professional growth experience is necessary to enable longitudinal studies and the characterisation of AI-enhanced professional development with enough specificity to relate to teachers' needs (RIINA et al., 2020). Parameters for tracking sustained changes in practice, pedagogy, and profession are well-established at tertiary level but not indicated in K-12 contexts. Models with substantial prior professionalisation grow in value under a policy engaging at upper-tier, low-detail abstraction.

Ongoing incorporation of AIEd tools and services into tertiary learning-management and teacher-development systems follows a widely-used, pedagogically-informed, institutional design framework. AI-supported professional development has reached the daily practice of substantial proportions of vocational education and training. More than one major national initiative actively fosters K-12 AIEd deployment to achieve professionalisation through educational and pedagogical research, management or innovation. Teacher demand for classroom management that targets the data of usefulness, assessment, and student-group formation remains unaddressed across any sector.

8.1. Policy Design for AI-Enhanced Professional Development

AI professional development and classroom efficiency necessitate rigorous analysis and structured argumentation, with a clear premise outlined in scholarly literature. The teacher's role is evolving, requiring a professional development model that adapts to contemporary and future needs. Despite the teaching profession's critical influence on education and student outcomes, it often receives inadequate focus in terms of professional development opportunities, which teachers themselves seek more of. Definitions of artificial intelligence (AI) vary in academia, but a common definition describes it as the "study of intelligent agents" that perceive their environment and act to achieve goals. This foundational view of AI is integral to the policy, which advocates for AI-driven professional development for educators. Strategic guidance is essential for school districts and education agencies to successfully implement these initiatives. (Schiff, 2021)(Van Brummelen & Lin, 2020)

8.2. Longitudinal Impacts on Teaching Practice

Teaching professionals and policymakers may wonder how AI tools impact teachers' ideas about pedagogy and educational issues over time. Since the 1800s, pedagogical content knowledge (PCK) has been relevant for understanding the forms of knowledge teachers need. PCK involves teachers' understanding of educational last-mile content delivery (the "Co") within specific disciplinary ways of knowing (the "C"). Regulation theory posits that teachers' ways of thinking about educational ends are crucial and will be examined as a complement to PCK. Salary datasets inform how classroom efficiency affects pedagogical approaches and priorities. Teachers often use efficiency methods proposed at the beginning of their careers and seldom change practices substantially thereafter. Although the underlying view of educational ends remains constant, teachers might orient toward PCK and Co despite their long-established positions (R. Kshirsagar et al., 2022).

8.3. Innovative Models and Research Gaps

AI-enhanced professional development for educators and improved classroom efficiency rely on innovative models and empirical research. The design-based implementation research (DBIR) framework focuses on transforming educational systems through iterative design and research cycles, while the formative design model emphasizes prototype development based on pedagogical insights. Both aid in the design and examination of AI-enhanced teacher development. The Community of Practice and the Concerns-Based Adoption Model further inform this development. The Equity-Focused Adopter Stages Model analyzes educational innovations in context, revealing systemic inequities and focusing on cognitive and instructional implementation aspects. These advancements deepen understanding of AI, teaching, and learning, providing insights into the evolution of educational technologies influenced by AI. (Schiff, 2021)

As AI adoption continues to grow, studios are increasingly integrating the technology into games, from automation to tools that enhance artists' creativity. These bespoke AI tools enable studios to automate repetitive tasks, gain inspiration during the creative routine, and explore new styles, ideas and enhanced feedback. Examples include AI for lighting design, creating skyboxes and horizon line detection; storyboarding and conceptual design assistance that provides color palettes, art styles, 2D/3D prompts, full frames or just silhoettes; quality-checking for assets; and voice acting. AI can also detect performance capture artifacts and support language substitution with lip sync preservation.

How studios define and classify AI tools determines how to best pursue integration and indeed whether or not to adopt AI at all. Several approaches include distinguishing between tools that should be embraced and those that should be considered with caution, component-based classification, method-based classification, and adopting an open exploratory approach without predefined classification. Regardless of approach, additional factors to consider include modelling and interpretation approaches, evaluation, control and supervision, the impact on the production

process, identifying inherent opportunities and risks during exploration, and whether AI is the right choice for the specific problem at hand.

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