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Artificial Intelligence for Classroom Teaching – Novel Applications, Challenges and Practical Review

Yicheng Xiao

Institute of Education, University College London, London, WC1E 6BT, United Kingdom

Abstract: This article provides an organized overview and discussion on the use of AI for classroom teaching from an empirical perspective instead of reviewing opinions only. Combined witha study of case reports on AIuse in real classrooms, the review findsfour main modes of usage: didactical feedback and teaching collaboration, virtual classrooms, and big data analytics. The main problems can be grouped into three categories – technology integration, teaching practice, and subject adaptation. The resultsindicate that a successful implementation of AI in education needs to align technology, pedagogy, and institutional support, although these resultsshould be considered tentative given that most work is based on small-scale case studies and the rapidly changing nature of AI technology. The reviewpresents an organized basis for future empirical research, but itmust acknowledge that drawing broad inferences from published works and examples can also lead us astray.

Keywords: Artificial Intelligence in Education, Classroom Teaching, Literature Review, Application Models, Implementation Challenges.

1. Introduction

Education's digital and smart revolution has become an international focus area. As artificial intelligence is one of the most powerful engines for this revolution, it is transforming teaching, learning, assessment, and management of education in various ways. Face-to-face classroom learning has advantages for knowledge transmission, yet it lacks the capability to address individualised learning needs and promote higher-order thinking skills such as creativity and innovation. Artificial intelligence (AI) applications, including ITSs, learning analytics, and educational data mining,-offer new ways of addressing such a long-running tension between standardization and personalization in education [1].

Yet there are significant obstacles to integrating artificial intelligence in the classroom, including lack of infrastructure, teacher adaptation problems, resource allocation problems and potential issues with algorithmic fairness and user's data security. The goal of this article is to: (1) provide a thorough survey and classification of current models for deploying AI into classroom instruction; (2) synthesize reported problems in technical, pedagogical, and disciplinary aspects; and (3) provide systematic suggestions based on the analyzed papers and cases.

Research Questions: This review answers three questions: (1) Which model of using AI to support classroom teaching is reported? (2) What implementation problems have been repeatedly encountered in various settings? (3) What seems to be the basis for success with these technologies, according to the cases reported in the literature?

2. Methodology

2.1. Research Design

In this paper, a systematic literature review approach and inductive thematic coding of reported implementations were used to analyze the existing evidence. This methodological approach is consistent with that recommended for reviewing educational technologies (e.g.,, stressing the need for openness about how sources are selected and analyses conducted [2].

2.2. Search Strategy and Source Selection

The following inclusion criteria were applied: (b) English language; (c) focus on the use of AI technologies in K–12 educational settings; and (d) reporting of original research findings or a detailed case study. Studies were excluded if they were strictly conceptual in nature with no reference to any actual deployment of such ideas, as well as those that dealt solely with post-secondary education and not K-12 learning environments. This first screening resulted in 187 citations, of which 35 met the inclusion criteria after title, abstract, and full-text screening.

2.3. Case Selection and Data Sources

esides scientific articles, for the purpose of this review, published implementations reported in the open literature were also considered, including reports from schools running pilots, as well as published use-cases on the platforms' websites; cases were chosen for which there was information available about their implementation: (a) detailed presentation of the AI tool(s) and class setting; (b) reported effects on observed results. The case study is not used to generalize findings, consistent with the exploratory nature of this review. Primary data were not collected, and no new data are presented herein: only published information is used.

2.4. Analytical Framework

The analysis consisted of three steps: (1) coding the literature as well as the case studies to identify how applications have been modeled, what difficulties in applying the models had arisen, and what results were published. Second, each item was labeled with one of the following three categories: technological implementation (technology), teaching practice (roles of the teacher, pedagogy, adaptation of students) and subject adaptation (characteristics of disciplinary knowledge); third, themes were synthesized from the sources, identifying patterns and gaps.

The 35 included studies were coded to identify recurring themes (Sections 3 & 4). For the in-depth discussion in

Section 5, 10 representative cases were purposively selected from the 35 for their rich descriptive detail and disciplinary diversity. This two-level approach-broad coding for framework construction, focused case analysis for mechanistic illustration-follows standard practice in exploratory reviews of emerging technologies.

2.5. Limitations of This Review

This review recognizes the following potential limitations in its methods:(i) search of the published literature potentially introducing a selection bias for positive results;(b) studies are often poorly designed in terms of evaluation methodology; (c) advances in artificial intelligence make results obsolete rapidly;.(d) geographic concentration of the reviewed literature (mostly from North America, Europe, or East Asia), limiting generality. We address these limitations later in Sec. 7.

3. Application Models of AI in Classroom Teaching

Based on a synthesis of the reviewed literature [3], four distinct application models emerge. These approaches are compatible with one another and commonly operate side by side in real-world settings.

3.1. Precision-Oriented Teaching Support Model

The intelligent tutoring system (ITS) uses artificial intelligence's ability for information management and analysis to offer personalized teaching advice. In previous studies [4], it is often implemented as an adaptive learning system that considers student response, time on task, and error pattern in order to adapt the content level, order, and format in real time; automatic scoring of objective and semisubjective answers; early warning identification of at-risk students; and individualized recommendation of a learning path. The results reported on some case studies indicate that it can be possible to improve the precision of teaching, although effects differ greatly depending on the context [5].

3.2. Collaborative Teaching Process Model

Rather than using AI as an isolated tool, the proposed model regards AI as an agent involved in the process of teachers and students, enabling human-machine cooperative relations . Examples of implementation found in the literature are AI as a conversation partner for teaching languages with situational dialogues and pronunciation correction, as a scaffolding tool in project-based learning for resource recommendations and timeline management, and as a discussion facilitator with speech recognition to analyse participation equity. What distinguishes them is the bi-directional information flow between human and machine, to support but not replace the teacher's own judgment [6].

3.3. Immersive Learning Environment Model

The proposed system uses VR, AR and digital twin technology for creating a simulated, interactive teaching environment [7]. The main building blocks of these systems as found in the literature are high-fidelity scenario simulation (e.g., virtual labs, time travel applications), natural modalities (gestural and motion-based input, vocalization), and multimodal feedback fusion. Examples have been reported for safely conducting dangerous chemistry demonstrations, virtual dissections, historical immersion, and job training with expensive equipment. Context-based learning is stressed by the model, including the ability to ground abstract knowledge in specific circumstances, and the production of a high degree of engagement.

3.4. Data-Driven Teaching Decision-Making Model

Here we view education in the classroom setting as an actionable process that can be quantified and improved upon using scientific methods This is done by gathering various types of information about the environment ,procedural, outcome) through Internet of Things (IoT), devices, cameras, LMSs. Learning analytics dashboards offer teachers information including class-wide knowledge mastery heatmaps,time-on-task analysis, and visualization of behavior patterns. Some key attributes include systems perspective (relationships between various aspects of teaching) ,insight creation (making things visible that were not previously visible) and empiricism (moving from an intuitive to a data-driven approach).

4. Implementation Challenges

Among the studies we review, there are three common types of practical issues reported.

4.1. Technical Integration Challenges

The lack of infrastructure is the most common barrier reported in all of the examined papers. The differences found among high- and low-resource institutions are: inconsistent access to broadband connectivity, lack of adequate end-user devices to meet student-to-device ratios, and lack of information technology support staff . These gaps are more than an inconvenience; they are key to the possibility of using AI tools at all in any particular classroom. Without stable access to the Internet and adequate computers, no classroom activity supported by artificial intelligence is feasible, expanding, instead of closing, the information technology gap.

The second set of barriers is interoperability issues. The platforms, the tools, and even the data standards offered by various vendors are not compatible with each other nor necessarily with schools' current information systems. This creates data silos-these isolated sets of student information which can't really be shared or used within multiple apps-and therefore, teachers must manage a variety of user interfaces, manually move data from one system to another, and deal with varying representations of students' progression in various AI systems. The lack of seamless integration of learning information limits the extent to which deep big data analysis and individualization can be achieved as promised by AI .

Third, technical validity and black-box algorithms hurt pedagogical legitimacy. The internal logic behind complicated machine intelligence (especially deep learning) is not necessarily visible for the lay person. If an intelligent agent produces a grade on a student's paper or recommends that a student learn something else, the inner reasoning might be hard/impossible to explain to students/parents/administrators. Such opaqueness presents concrete issues with respect to pedagogical feedback: if a teacher can't explain why an AI system evaluated a student's assignment in a particular way, the instructor is not able to

help the learner improve; and finally, algorithmic bias-encoding social/cultural biases that are already embedded in training data-raises a special concern about assessment equity because unexamined biases can be made automatic and scalable, leading to systematic disadvantage of some groups of students [8].

4.2. Teaching Practice Challenges

The teacher's new role is far more complex than many policymakers seem to understand, and it requires an entirely different set of skills for the teacher: teachers may be required to become librarians (p. 69), learning activity planners, data analysts, human-machine team managers, and guides for student socioemotional development . This change will be more than just additive; it requires that the basic purpose of the teaching profession be changed by teachers themselves.

This problem is exacerbated by insufficient training. There needs to be ongoing and structured education-not just a single workshop on technical skills-but in all of the examined papers there is little evidence that this occurs. If they are not well trained, teacher anxiety and identity confusion are often reported as a result; some teachers completely reject the introduction of AI; others practice a performative form of adherence with no real educational value.

A second problem is that pedagogy will not change as fast as technology. Teachers are likely to use the new tools just to give students the same old content in an entirely different format, without allowing them to engage with it and make their own discoveries from it. For example, there have been concerns expressed about AI leading to "drill-and-kill." [9]The interactive whiteboard may be used as a projector instead of a collaboration tool, and learning analytics may be used more as surveillance than teaching enhancement. The imaginative fusion of artificial intelligence with research-based pedagogy – constructivist, inquiry-based, or sociocultural approaches-requires professional knowledge which many teachers have not had a chance to develop

However, student adaptation problems are also consistent. Too much dependence on personalized suggestions might limit the scope of a student's learning path, producing "filter bubbles" and reducing students' exposure to difficult, novel materials; pervasive behavior tracking could lead to performative learning (i.e., trying to please the measures instead of truly learning); privacy concerns resulting from pervasive data capture could harm intrinsic motivation and trust; these types of issues occur at the level of individual learners and are rarely considered as part of a top-down plan for implementing new technologies , yet they matter greatly in actual use cases.

4.3. Subject Adaptation Challenges

Disciplines have profoundly different knowledge characteristics leading to differential AI applicability which is rarely acknowledged in the universalist policy literature. Formal knowledge domains-mathematics,programming, grammar-where rules are explicit, the answer is relatively determinate, and correctness can be objectively defined,AI's guidance, assistance and evaluation capabilities are effective. There have been successful applications of this technology to the areas ofwith intelligent tutoring systems reporting on measurable learning gain.

But for the humanities and arts fields – where information is often open-ended, vague, contextualized, and subjective – current artificial intelligence has its limits. Current AI cannot grasp the nuances of emotions,metaphor, multiple interpretation and creative artistry. In the literature we find that standardised testing is inappropriate to use with tasks like analysing poetry,moral reasoning, or creative writing evaluation. It is futile and possibly deleterious for students' growth to try to map this kind of evaluation on some standard scale.

Furthermore, disciplines which focus on bodily-kinesthetic intelligence (physical education; the performing arts; hands-on vocational training) do not have mature AI support tools available as do the STEM fields. Sensory and motor aspects of learning in such disciplines are difficult to capture or augment with existing technology. The take-away message for both the formal and informal knowledge domains is that we need discipline specific integration approaches instead of off-the-shelf technologies. What might work well in a math class will likely be unsuccessful in either a literature or a PE class.

5. Synthesis and Recommendations

5.1. Toward Systemic Integration

Successful use of AI in the studies reviewed seems to hinge on congruence along at least three axes: technology, pedagogy, andand institutional policy [10]. Technology should be reliable, interoperable, and pedagogically aligned with open standards and humancentered design. Pedagogy requires continued investment into teacher professional learning and student digital literacy. Institutional policy should set data ethics standards,design novel curriculums and assessment tools, and distribute resources fairly. Literature indicates that techno-centric interventions lacking the required pedagogy and organisational support are bound to fail.

5.2. Recommendations for Practice

Recommendations derived by synthesising results of papers considered in this review include the following: i) prepare infrastructures first for deploying AI systems;(b) create teacher PDs addressing pedagogical integration rather than technical operation;(c) define standards for data privacy, algorithmic transparency, etc.; (d) test artificial intelligence interventions on a limited set of subjects with the most robust evidence of efficacy (e.g.,mathematics) before moving into other areas which have not been as extensively researched yet; (e) measure the effects of an implementation of AI by a variety of outcomes, such as academic improvements or satisfaction levels for students and teachers.

6. Limitations of This Review

There are a number of limitations to this review which we must explicitly acknowledge: Firstly, most of the work in our review is comprised of small scale cases and pilots;large-scale randomized control trials are rare in AI edutainment research. Therefore, the quality of evidence to support reported results is usually low,and effectsizes should beinter pretedca utiously. Secondly, most of these reported instances that we reviewed are conducted in well-equipped learning environments and thus their applicability may not be extended to poorly equipped ones with lack of facilities etc.r e most severe. T hird , t he pace o f d evelopment i n a rtificial i ntelligence (AI) -especially in g enerative A I s ince 2023 -is such that r esults from older studies may no longer apply or emergent problems. Fourt h, there is the potential for publication bias to be in favour of positive findings, since negative and null findings

tend not to be published Fifth ,this review did not carry out formal quality assessment of included studies, meaning that findings from methodologically weaker studies are treated equivalently to those from stronger designs. Sixth, geographic concentration in reviewed sources (North America, Europe, East Asia) limits applicability to other regions with different educational systems and resource constraints. Seventh, discipline-specific findings are tentative given the limited number ofstudies examining subject-area differences systematically. Future empirical research should address these gaps through larger-scale, longitudinal, and more geographically diverse study designs.

7. Conclusion

In this paper, we have reviewed the literature and reported some cases aiming at discovering four patterns for applying artificial intelligence in class instruction– precision-oriented assistance,collaborative workflows, immersion, and analytics-and the three classes of implementation issues: technical,pedagogical, and subject adaptation levels. While these results are still preliminary, they do suggest that a system-level match between technology,pedagogy , and institutional support in addition to technology capability.

These results do not prove but suggest that AI tools can be useful for educational purposes inside classrooms. They are however limited because most studies have a very local scope,rapid technological change, and geographic concentration of existing research. Our key tension found here is between technological possibility and educational appropriateness: AI can do many things in classrooms,but if it does so, when (and how) is also an empirically open question.

Future directions of study will need to involve (i) large-scale longitudinal measurements of longterm learning performance;(a) comparison in different geographical and resource settings; (b) thorough investigation on disciplinary integration approaches;.(d) analysis of PD frameworks for supporting pedagogy change; (e) use of generative-AI technologies in the classroom,, who provide a more recent survey .

The promise of artificial intelligence for schools will not be its algorithmic accuracy or its hardware complexity-but rather if it makes teachers better],supports student learning, and sustains the basic educational mission of developing whole humans. The realization of that promise depends on collaboration between technologists,practitioners, policy makers, and researchersâ and, critically, openness to change practices as the evidence builds up.

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