人工智能与未来教育国际前沿研究专栏 | 韦恩·霍姆斯 孙梦 袁莉：《人工智能与教育：本质探析和未来挑战》

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重新思考人工智能给教育带来的冲击和影响

——人工智能与未来教育国际前沿研究专栏导读

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作者简介

科林·德·拉·伊格拉（Colin de la Higuera），法国南特大学联合国教科文组织开放教育资源和人工智能教席，教授

人工智能教育包含两个方面的内容，一是人工智能在教育中的应用，二是提高人工智能素养。当前，如何面向未来培养下一代年轻人，已经成为这个时代各国政府的一个紧迫议题。可以肯定的是，虽然我们尚未掌握人工智能社会必备的数字技能，但全世界的教育系统都在迅速对此采取相关的行动。无论是从技术层面，还是从人类发展层面，人们都应该拥有以开发、实施和使用人工智能技术为核心的知识、技能和价值观。

专栏文章《人工智能与教育：本质探析和未来挑战》由英国伦敦大学学院副教授韦恩·霍姆斯（Wayne Holmes）等人撰写。韦恩·霍姆斯长期从事学习科学与教育技术创新等方面的研究，是关注人工智能与教育问题的国际知名学者之一。多年来， 他从批判性研究视角探讨人工智能教育的伦理问题及对社会的影响和冲击，已经出版了多本探讨人工智能与教育关系的专著。其中包括《人工智能教育中的伦理：实践、挑战和争议》（2022）、《人权、民主和法治视域下的人工智能教育》（2022）、《人工智能在教育中的伦理：走向社区的框架》（2021）等。他是多个国际组织的专家，也是联合国教科文组织新成立的国际人工智能研究中心（IRCAI）的主要发起人之一。

文章主要回顾了韦恩·霍姆斯在过去几年中提出并一直在坚持的关键思想，并探索了不同类型的人工智能技术应用。他的结论得到了广泛认同，即我们应该警惕炒作，人工智能对教育所产生的作用可能并不是我们想象的那样！更重要的是，作者认为，“如果人工智能能够对教育产生影响，那么人工智能产业就将拥有对教育的话语权……”而这并不是我们所希望看到的。很多国际权威组织也在不断强调人工智能应用于教育的相关问题，如欧洲委员会强调了人的权利问题，联合国教科文组织则强调了伦理规则等问题。

韦恩·霍姆斯等人在文章中提出“要确保同时教授人工智能技术和人文两个方面的内容。”这一观点非常重要，因为在大多数学校系统里，科学和人文是分开教授的。文章还提出“人工智能在教育中的应用大部分采用了相当原始的教学方法，而且经常把重点放在自动化这些陈旧的教学方法，而不是推动教学创新”等观点，从不同角度探析了人工智能教育的本质。

当前，很多人工智能教育研究是以解决方案为导向而不是以问题为导向、以取代教师为目标而非赋能教师，并且人工智能教学往往只关注人工智能的技术层面，而将人文的因素排除在外。文章从人工智能的定义以及人工智能与教育的关系出发，为读者了解人工智能教育提供了一个很好的切入点。文章还围绕人工智能教育与教学法，伦理，儿童权益，个性化，节约教师时间，智能、效能和影响，技术解方主义，教育商业化，殖民主义，信任等十个方面，思考人工智能教育表象下存在的问题，将启发更多人在此基础上继续探索新的想法，并对该领域的研究重点有更加深刻的理解和思考。

引用格式

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人工智能与教育：本质探析和未来挑战

韦恩·霍姆斯　孙梦　袁莉

摘要：当前，虽然有研究人员认为人工智能将重塑教育，关于人工智能教育的研究也日益受到关注和重视，但是人工智能在教育中的应用仍存在“炒作”现象，一些乐观看法还亟待商榷，一些关键问题还需要探析和解决。为此，文章首先探讨了人工智能的定义，提出人工智能本质上应同时考虑其技术维度和人的维度；然后进一步分析人工智能与教育的关系，并从人工智能教育与教学法，伦理，儿童权益，个性化，节约教师时间，智能、效能和影响，技术解方主义，教育商业化，殖民主义，信任等十个方面，思考人工智能教育表象下存在的问题。据此提出，虽然人们已经意识到教育中人工智能伦理和人本主义等问题的重要性，但由于人工智能的发展方向受科技巨头企业的控制，这些问题的解决还有很长的路要走。文章希望通过对人工智能教育本质的探讨，促使更多研究者和实践者不只关注人工智能教育的表面价值，更要去发现、思考和应对正在出现和仍然未知的挑战。

关键词：人工智能；人工智能教育；人工智能素养；人工智能伦理；未来挑战

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一、引言

人工智能在教育中的应用已被认为是一种“在全球传播优质教育的全新方式”[1]。著名人工智能专家李开复等人在《AI 2041：预见10个未来新世界》（AI 2041: Ten Visions for Our Future）一书中提出：“我们知道今天教育的缺陷，人工智能可以在修复这些缺陷方面发挥重要作用。人工智能将使学习更有效、更吸引人、更有趣……这种共生的、灵活的新教育模式，可以帮助每个学生在人工智能时代发掘自己的潜力”。[2]

当前，很多研究人员认为，人工智能可以为学习者提供个性化和符合学习需求的内容[3]；国际组织也纷纷大力宣称，人工智能将能为学习者提供更大的自主权（如学习内容、方式、时间、地点等）[4]和帮助教师实现更好的教学效果[5]。因此，越来越多的人认为人工智能将改变教育[6]，这种热情也促使人工智能教育（Artificial Intelligence in Education, AIED）成为2020年人工智能三大风险投资领域之一[7]。

然而，当前对于人工智能教育的一些乐观看法在很大程度上是夸大，甚至错误的。人工智能和人工智能教育的巨大潜力仍有待进一步发掘。目前人工智能在教育中的应用存在“炒作”现象，其发展受到诸多关键性限制的问题，也尚未得到充分考量。事实上，关于人工智能教育潜力的种种提法，大多基于理论设想而非源自实证研究[8]。这些设想经常过于简单化，忽视了诸如能动性、教学法、监督、效能、伦理等方面的问题[9-12]。其原因是，现有人工智能教育倾向于解决方案导向而非问题导向，目的是取代教师的职能而非赋能教师。此外，在关于人工智能与教育关系的研究与讨论中，还存在术语不明确的问题，“运用人工智能教学（teaching with AI）”与“教授人工智能知识（teaching about AI）”经常混淆，使得当前关注的焦点仅在于人工智能的技术维度，忽视了教育中

必不可少的人的维度。基于此，本文从人工智能的定义、人工智与教育的关系，以及未来人工智能教育面临的挑战三个方面，对相关问题作延伸讨论。

二、人工智能定义辨析

要厘清人工智能与教育的关系，首先要明晰什么是人工智能。通过网络检索可以发现，有关人工智能的定义在不断发生变化。有观点认为，一些前沿的人工智能应用，一旦变得非常实用和相当普及，往往就不再被贴上人工智能的标签[13]。

对于非计算机领域的研究者来说，由联合国儿童基金会发布的定义值得参考。该定义认为，人工智能是指能够根据人类设定的一系列目标，做出影响现实或虚拟环境的预测、建议或决定的机器系统。人工智能系统直接或间接地与我们互动并影响环境。通常，人工智能系统看起来是自主运行的，并且可以通过对环境的学习来调整自身行为[14]。

该定义的重要性可以从三个方面来理解[11]。首先，该定义适应了基于数据驱动的人工智能技术的发展（如人工神经网络和深度学习），但又不依赖于数据；其次，该定义涵盖了基于规则或符号的人工智能，以及未来可能出现的任何新的人工智能范式（如“神经符号”人工智能）[15]；最后，该定义强调人工智能系统必然依赖于人类的目标，其核心是考虑到人类在人工智能开发流程所有阶段的关键作用，即人工智能系统有时“看起来是自主运行的”，而不是假设它们“确实是自主运行的”。

实际上，该定义也存在一定的缺陷，“学习”这一要素在人工智能系统中的意义并不大。学习需要意识或能动性，而在现在和可预见的未来，机器系统并不具备这一能力[16]。虽然人工智能叙事者经常使用拟人化的术语来描述机器系统，如“智能”“学习”“识别”等，但这并不能改变上述事实。总之，在试图理解人工智能的真正含义时，我们要认识到它既不神奇，也不具备人类的智慧[17]；跳出思维定势来看，人工智能甚至不是人工的，也不是智能的，其背后实际是人在执行任务，只不过系统看起来像是自主运行的[18]。

需要承认的是，近年来基于“机器学习”的人工智能，尤其是“人工神经网络”研究，取得了巨大的进展。人工神经网络的灵感来自于人类大脑的结构和功能，包括神经元和突触，并且以大量数据为基础来确定模式和得出推论[19]。人工神经网络已经在诸如人类语言之间的自动翻译[20]、蛋白质折叠预测[21]、生成类人文本的大型语言（如“GPT-3”）[22]等方面取得了成功应用。

然而，在取得这些进展的同时，人工智能也经常受到过度宣传和夸大其辞的影响[23]。例如，人工智能系统可能会非常脆弱，有时对路标的一个小改变就会妨碍人工智能图像系统对它的识别[24]；人工智能产生的结果也可能会因为训练数据集或驱动算法的偏差而出现偏差[25]；在人类面临严重的新冠疫情传播的时候，人工智能也未能如预期一样发挥作用[26-29]；人工智能语言模型也经常会生成一些无意义的文本[30][31]等。

需要指出的是，尽管当前人工智能有其技术背景和受技术主导，但也不应该只是纯技术术语。相反，人工智能是一种复杂的社会技术生成物，需要被理解为复杂的社会过程的产物[32]。也就是说，在研究人工智能时，必须同时考虑共生关系中人的维度和技术的维度。

三、人工智能与教育的关系

人工智能与教育之间的关系可以归纳为人工智能在教育中的应用和面向人工智能素养提升的教育。人工智能在教育中的应用涉及在教学和学习中使用人工智能辅助工具，包括利用人工智能支持学习者、教师和教育行政管理者（如招聘、课程表和学习管理）[33]。面向人工智能素养提升的教育涉及提高所有年龄段公民（从初等教育到终身学习者）及其教师的人工智能知识和技能，既包括人工智能的技术维度，即人工智能的相关技术，如机器学习、自然语言处理等；也包括人工智能的人的维度，即确保所有公民为人工智能对生活可能产生的影响做好准备，帮助他们了解人工智能伦理、数据偏见、监控，以及对就业的潜在影响等问题。可见，只有充分理解人工智能的本质，即技术和人两个维度，才能具备人工智能素养。

（一）人工智能教育应用

在过去的40年里，多数人工智能教育研究的重点都聚焦于支持学习者的人工智能，即自动化教师的职能，从而使学习者能够不依赖于教师进行学习。然而，现有的人工智能教育大部分采用了相当原始的教学方法，而且经常把重点放在自动化这些陈旧的教学方法，而不是推动教学创新。例如，人工智能经常被用于辅助传统考试，却很少被用于设计创新的方法来评估和认证学习。尽管如此，支持学习者的人工智能已经在主流教育中流行起来，并发展出了各种各样的应用。最近有研究依据可用性（从成熟的商业应用到获取投资的设想）对其进行了分类[11]，主要包括：智能辅导系统、人工智能学习应用（如翻译软件、作业解答）、人工智能模拟仿真（如增强现实、基于游戏的学习）、支持特殊学习者的人工智能、自动化论文写作、聊天机器人、自动化形成性评价、学习网络配置、基于对话的辅导系统、探索性学习环境以及人工智能终身学习助手。

随着人工智能对社会各个领域发展的冲击，世界各地获得数百万美元投资的人工智能教育公司数量不断上升，由此证明全球对于支持学习者的人工智能的需求在持续增长[8][33][34]。然而，现有支持人工智能工具有效性的证据，大多源自基于限定条件下的短期研究[35-37]。排除营销手段和政策制定者表达的愿景，目前尚未有足够证据表明在资源充足的教室中，广泛使用人工智能的合理性。因此，在缺乏强有力独立研究证据的情况下[8]，人工智能将显著改善学习者学习方式这一说法[4]，显得过于理想化或具有一定猜测性[8][33]。

与此同时，很少有研究关注支持教师的人工智能（除了常见的仪表盘[38]）。近期逐渐有一些研究和个别商业产品开始关注这一方面[11]，如抄袭检测、学习资源智能管理、课堂监控、自动化总结性评价、人工智能教学、评估助手以及课堂编排等。支持教育行政管理的人工智能研究也在起步[11]，包括招生、课程规划、日程安排、课程表、学校安全、识别辍学和有风险的学生以及电子监考等。

（二）人工智能素养

虽然只有少数学习者会因为想成为人工智能设计者或开发者而学习人工智能，但鼓励和支持所有公民具备一定水平的人工智能素养，是未来社会的必然要求。无论是从技术角度还是从人的角度，公民都应该拥有以开发、实施和使用人工智能技术为核心的知识、技能和价值观。世界公民需要了解人工智能可能会产生的影响，包括能做什么、不能做什么，何时有用、何时应该受到质疑，还要引导人工智能为公众利益服务。[8]

人工智能素养通常被认为是信息技术素养或数字素养的延伸，包括：数据素养，即理解人工智能如何收集、清理、处理和分析数据的能力；算法素养，即理解人工智能算法如何识别数据中的模式（Patterns）和关联（Connections）的能力[39]。然而，人工智能在本质上与大多数数字技术不同，人工智能素养也不能仅限于技术部分。换言之，人工智能素养应该包括人工智能的技术和人的维度，即人工智能的运作方式（技能和技术）和对人的影响（认知、隐私、能动性等）[33]。

总之，尽管人工智能技术的教学很重要，但也不应忽视采用自动化决策背后的人、权力和政治动机。强调人工智能素养的人的维度，是要让每个人都能够了解与人工智能共存意味着什么，以及如何在最大限度地利用人工智能提供优势的同时，保护人的行为或尊严不受任何不当影响。因此，应该帮助年轻人了解人工智能、自动化，尤其是自动化决策将如何影响他们的社会待遇。换句话说，如果年轻人想要像精通数学一样精通人工智能，就需要了解其有意或无意接触的人工智能是否公平地对待了他们。[40]

通常的观点是，信息技术相关教师负责教授信息技术或提高学生数字素养。但事实证明，只有通过鼓励不同学科（从科学到人文、艺术）的所有教师，与学生一起探索人工智能在其学科领域的潜在用途、益处、影响、挑战、风险等议题，才能真正实现人工智能素养的培养和提升。例如，基于人工智能已经被用于自动生成数字图像、诗歌和故事的案例，相关学科教师（如艺术和文学教师）可以提问学生——如果机器可以具有创造性行为，那么人的价值又将如何体现？

四、未来人工智能教育面临的挑战

值得关注的是，由于存在用于监控、剥夺教师权利和削弱学生能动性的倾向，许多人工智能工具在教育中的应用已经受到广泛质疑[11]。因此，有必要对人工智能教育所面临的深层次问题进行全面剖析，具体包括：教学法，伦理，人权，个性化，节约教师时间，智能、效能和影响，技术解方主义（techno-solutionism），殖民主义，信任等。

（一）人工智能教育与教学法

虽然现有的商业人工智能辅导工具采用了先进的技术，并时常以认知科学为基础，但它们几乎都仅仅体现了简单的教学和学习方法，其本质是根据学生表现灌输预先设定的学习内容，从而避免失败。尽管这些人工智能工具声称可以给每个学生提供不同的建议，但本质上还是基于行为主义或讲授主义理论，并未体现近60多年来教学研究的新发展。长此以往，人工智能将剥夺教育工作者的权力，使他们成为单纯的技术促进者；并削弱学生的能动性，使得他们别无选择，只能做人工智能要求的事情，失去发展自主技能或自我实现的机会。人工智能教育教学工具的典型方法忽视了深度学习[41]、引导式发现学习[42]、有益的失败[43]、基于项目的学习[44]、主动学习[45]等。这种行为主义取向，尤其是填鸭式的方法，将记忆优先于思考，将了解事实优先于批判性参与，最终会损害真正的学习。

（二）人工智能教育与伦理

总体来说，人工智能研究越来越关注伦理问题，并已提出80多项人工智能伦理原则[46]。人工智能教育中的伦理问题对学生、教育工作者、家长和其他利益相关者至关重要，但相关的研究还比较缺乏[9][10][47][48]。事实上，到目前为止，大多数人工智能教育工具的研发，都没有认真考虑在教育中使用人工智能可能带来的伦理后果。虽然欧洲国家开始制定面向教师的指南和规则，以规范人工智能教育伦理发展和技术开发，联合国教科文组织成员也签署了《北京共识》[49]，但尚未有国家和地区真正颁布适当的法规[50]。同时，大多数围绕人工智能教育伦理和学习分析的相关讨论都集中于数据（如偏差、隐私和数据所有权），以及如何分析数据（如公平、透明和信任）等问题。而人工智能教育的伦理不仅仅包括以上问题。也就是说，了解人工智能教育数据和算法的伦理问题是必需的，但不是全部。人工智能教育伦理还需要关注教育和人类发展的伦理问题[10]，如教学法（大多数人工智能教育采用的教学方法是否有道德基础）、知识（什么是知识）、评估（应该评估什么以及如何评估），以及学生和教师的能动性（谁应该掌握“控制”权）[9]等一系列问题。

（三）人工智能教育与儿童权益

近期，欧洲委员会借鉴了联合国《世界人权宣言》（1948年）、欧洲理事会《欧洲人权公约》（1953年）和联合国《儿童权利公约》（1989年），从人权方面探索了人工智能和教育，并发布了相关报告[40]。该报告详细讨论了人工智能教育工具面临的关键问题：①人类尊严的权利：教学、评估和认证不应委托给人工智能系统。②自主权：儿童应享有避免被进行个体描述、被规定学习路径，并保护他们的发展和未来生活的权利。③被倾听的权利：儿童应享有不接触人工智能系统的权利，且不会对他们的教育产生负面影响。④不受歧视的权利：所有儿童都应享有从技术使用中受益的机会，而不仅仅是那些有负担能力的社会经济群体。⑤数据隐私和数据保护的权利：儿童应享有在没有直接利益的情况下，其数据不被汇总和用于商业目的的权利。⑥透明度和可解释性的权利：儿童和他们的父母应该能够理解和质疑人工智能教育系统做出的任何决定。

（四）人工智能教育与个性化

李开复等人提出，也许人工智能在教育领域的最大机会是个性化学习。个性化的人工智能导师可以被分配给每个学生，不像真人教师要考虑整个课堂，虚拟教师可以给予每个学生特别关注，无论是解决特定的发音问题、练习乘法还是写文章。人工智能教师会注意到哪些知识会让学生的瞳孔放大、哪些知识会让学生的眼皮下垂。它可以推断出一种教几何的方法，使一个学生学得更快，即便这种方法可能对其他1000名学生无效。而对于一个热爱篮球的学生来说，数学问题可以用自然语言处理技术改写为篮球领域问题。人工智能会根据每个学生的进度给他们布置不同的家庭作业，确保学生在进行下一个主题之前完全掌握前一个主题。[2]

虽然“个性化学习”的含义尚未完全明确[51]，但越来越多的教育工作者认为教育应努力实现个性

虽然“个性化学习”的含义尚未完全明确[52]，但越来越多的教育工作者认为教育应努力实现个性化学习[52]。事实上，“个性化学习”起源于100年前普雷西（Pressey）和斯金纳（Skinner）设计的所谓“教学机器”，即针对每个学生的长处和短处进行学习[53]。出于各种原因，这些机器在当时没有被广泛接受，因此关于个性化学习的讨论也逐渐消失。然而，几十年后，互联网的发展使大规模定制成为可能，也使得个性化学习重新被关注。人们经常会问，如果我们可以在网飞或亚马逊上提供个性化的推荐，为什么不能在教育领域做类似的事情。

关于个性化学习，有研究人员提出这样的比喻：标准的课堂教育就像一辆普通的校车（黄色巴士），所有学生都坐在一起，以相同的速度、相同的方向，前往相同的目的地（汽车站）；而人工智能教育产品更像是网约车车队，每个学生都坐在自己的网约车里，以适合他们个人的速度和方向行驶。然而，这个比喻也未能揭示人工智能教育的本质。虽然一些人工智能工具可以通过学习材料为每个学生提供学习的路径，但这仍然会把所有学生带到一样的固定学习终点。这也表明，当前人工智能教育所提供的个性化学习方法是基于对个性化的表面理解[33]。事实上，真正的个性化是帮助每个学生发掘自己的潜力，自我实现，并增强能动性，但目前很少有人工智能教育工具能够实现。总之，虽然现有人工智能教育工具可以通过学习材料提供相应的个性化学习途径，但大多数都有推动学生同质化的趋势。通过对这类人工智能教育工具的批判性解读，我们应该认识到，这些工具只能确保学生按照既定的目标发展（如通过考试），并为适应既定的社会工作角色作好准备。

（五）人工智能教育与节约教师时间

教育技术界另一个老生常谈却又从未真正实现的愿望是，应用人工智能教育工具节省教育工作者的时间[53]。当然，业界可能会辩解说人工智能与其他教育技术不同，人工智能工具最终将节省教育工作者的时间。虽然多数教师都会喜欢能够代替他们打分的工具，但是任何人工智能系统，都无法提供像人类教育者一样具有深度的解释或准确的分析。同时，人工智能还会忽略教师对学生的了解程度，在阅读学生的作品时，教师给出的个人见解是任何仪表盘都无法给出的。需要进一步思考的是，即使人工智能确实可以在一定程度上节约教师时间，但能否像技术公司所许诺的“提高教学质量”，仍有待进一步探究和证实。

（六）人工智能教育的智能、效能和影响

首先，许多公司声称其人工智能教育工具是智能的，但事实并非如此：至今没有任何人工智能系统能接近人类的智慧（引人瞩目的GPT-3也不能理解它生成的文本[31]），也没有任何人工智能教育工具能接近人类教育者的智慧。事实上，教育领域人工智能系统所涵盖的范围和能够实现的目标非常有限，有些系统尽管看起来很智能，但距离真正的智能依然任重道远[54]。

其次，发表在《国际人工智能教育杂志》（International Journal of Artificial Intelligence in Education）上的实证研究表明，研究者已经对人工智能教育系统的效能开展了广泛研究，也有许多元分析对此进行了综述[55-57]。然而，这些研究大多由技术开发人员开展，并且大多来自商业组织本身，其学习者数量十分有限，可推广性不强。目前，只有少数研究是独立进行或大规模的[58][59]，而这些研究大多在美国开展，其可迁移性也受到社会文化等因素的限制。

再次，现有的人工智能教育研究，多专注于验证人工智能工具在提升个体学生学习成就方面的作用，很少有研究考虑到人工智能在课堂环境中可能产生的更广泛意义，及其对教师和学生产生的更深远影响。例如，目前许多循证研究都旨在揭示人工智能的技术力量，而尚未触及教育是否需要人工智能的问题[8][60]。

最后，人工智能教育还可能会对人类认知和大脑发育产生潜在影响。儿童的认知结构和能力仍处于发展阶段，关于技术如何影响儿童大脑和认知能力是一个重要且尚待研究的问题，主要包括：技术使用是否导致诸如注意力问题等各种认知或行为后果？技术使用是否与儿童大脑部分区域重构有关？技术使用是否与健康风险有关？如果是，其因果机制可能是什么[61]。这些问题的解决对人工智能教育发展至关重要，值得重点关注。

（七）人工智能教育和技术解方主义

“人工智能教育系统比人类教师表现更好”[56]，这一结论是支撑人工智能教育系统广泛应用的合

理性依据。特别是，由于优质师资不足，一些发展中国家农村地区学生无法获得应有的优质教育，而人工智能教育被认为可以弥补这一缺失[62]。尽管在这种特定的背景下，学生可能会从获得的人工智能教育工具中受益，但也存在很多挑战。一方面，许多农村地区缺乏必要的基础设施（如电力和互联网接入）；另一方面，有些地区有可用的设备，但能够部署、管理和支持所需硬件和软件的人才十分有限。

更重要的是，虽然人工智能教育或许能解决学习者无法接受高质量教育等表面问题，但无法从根本上改变优质师资不足等潜在、长期的，社会发展过程中存在的一些积弊。在实践中，技术提供者往往会根据自身利益来表述“问题”，而由于缺乏利益相关者的广泛参与，教育中更深层的社会和文化问题很难得到改变。正如克拉胡尔科娃（Krahulcova）所指出的那样，“最复杂的现实世界问题需要复杂的现实世界解决方案”[63]，而不是技术解决方案。因此，提升落后地区教育质量的最好办法，应该是专注于教师专业发展和向缺乏经验的课堂教师提供支持，如在全国范围内建立人工智能辅助的同行、教学专家交流平台。因此，人工智能教育未来发展的重点应该是使用技术来支持和赋能教师，而不是取代教师。

（八）人工智能教育与教育商业化

以学习者为中心的人工智能研究已有近40年历史，但近10年间才得以走出实验室，逐渐商业化，并被各国政府借助行政手段大力推广。这一发展现状具有重要影响：首先，虽然人工智能研究最初是在学术界进行，目的是加强教学和学习，然而，在商业机构以创造利润为前提的背景下，学生与人工智能系统的交互，必然会产生关于产品如何设计的技术知识，以及关于产品如何使用的市场知识。我们需要反思，学生是否在不知情的情况下，被用来创造和提供旨在支持企业的商业智能，这是否已取代帮助学生学习和认知发展的本意[40]。其次，商业机构很少分享专有系统及其有效性的信息，限制了社会公众对采购、审查和公共资金问责的权利。最后，大型科技公司所提供的人工智能教育系统和工具不仅在塑造个体学习者，并且也在影响国家政策和治理，即“它们可以按照自己的标准来决定什么是知识。知识就是或将是，那些能够或可以通过计算方式程序化的东西”[64]。简而言之，这种以人工智能教育为借口，从而隐匿地将教育商业化的做法，也反映了复杂的现实和意识形态问题。

（九）人工智能教育与殖民主义

人工智能教育科技公司在全球范围内销售其产品，也助长了所谓的人工智能教育殖民主义：发达国家的公司将人工智能教育工具出售到发展中国家，造成了国家之间权力的不对等。在这种情况下，“数字技术成为延续过去种族和殖民形态的一种方式”[65]。事实上，来自发达国家的人工智能教育研究长期以来占据压倒性优势，但其很少在解决文化多样性或地方政策、实践问题方面作出有意义的贡献[66]。

人工智能教育殖民主义可以表现为，发展中国家采用了某个人工智能教育工具，其数据和资本被提取，为发达国家公司带来市场和经济收益[67]。它可能始于个别学校的人工智能教育日常教学实践，然后逐步扩展到整个国家教育系统，最终所有学校都采用单一的产品。甚至，人工智能教育殖民主义并非一定要依赖某种特定的工具，在课堂中训练人工智能教育工具的语言（多为美式英语）都可能会产生影响[68]。而在非英语环境中，使用基于英语训练模型的人工智能教育工具的效果，及其对学生的影响尚未可知[69]。

（十）人工智能教育和信任

旨在支持学习者的人工智能教育的最后一个问题是信任。要想在课堂上更加广泛地应用人工智能工具，必须要让利益相关者，如教师、学生、家长等相信其是有益的，可以促进学习且不会造成任何伤害。当前，涉及信任的对话才刚刚开始，而相关责任往往落在使用者而非开发者身上。例如，最近一项研究总结了影响教师信任人工智能教育工具的八个因素，但所有因素都指向教师，而没有向开发者提出任何使其所开发工具值得被信任的要求[70]。为此，我们建议，未来人工智能教育系统设计应遵循欧洲委员会的《可信任的人工智能伦理指南（2019）》（Ethics Guidelines for Trustworthy AI 2019）[71]。

五、结语

五、结语

本文提出和讨论当前人工智能教育所面临的众多挑战，试图确保教育工作者在教育中使用正确的人工智能类型，以及教授正确的人工智能方法[72]，并非阻止人工智能在教育中的应用。经过多年发展，人工智能的伦理和人本主义挑战开始出现并逐渐受到了重视。然而，由于人工智能的发展方向受科技巨头企业的控制，这些问题的解决还有很长的路要走[73]。与此同时，尽管人工智能教育研究已经有40多年的发展历史，但直到最近，人工智能教育工具才开始真正大规模进入课堂，而人工智能素养也仍存在唯技术维度而忽视人的维度的误区。总之，当前人工智能在教育中的应用和人工智能素养的提高还较为滞后。令人欣慰的是，越来越多的人尝试采用人本主义方式来研究人工智能教育[9][72][74]，开始逐步关注和解决信任、人的能动性和透明度等问题。

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Artificial Intelligence and Education: Digging Beneath the Surface

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Abstract:It has been proposed that artificial intelligence will reshape education, and therefore the research and application of artificial intelligence in education have drawn increasing attention. However, the exaggeration of AI's application in education still exists, and some optimistic conceptions still need reconsideration, and some key issues remain to be discussed and solved. In this case, this paper first discusses the definition of artificial intelligence, and proposes that artificial intelligence should consider both its technical dimension and human dimension. On this basis, the paper further analyzes the relationship between AI and education, and explores the perspectives of AI education and pedagogy, ethics, human rights, personalisation, saving teacher time, intelligence, efficacy and impact, techno-solutionism, commercialisation of education, colonialism, trust, etc., which are digging beneath the surface of artificial intelligence in education. While people are aware of important issues such as AI ethics and humanism in education, the resolution is still a long way off as the direction of AI development is controlled by the tech giants. By discussing the essence of artificial intelligence in education, this paper hopes to encourage more researchers and practitioners not only to pay attention to the surface value of artificial intelligence in education, but also to discover, think about and respond to emerging and still unknown challenges.

Keywords:Artificial intelligence; Artificial intelligence in education; AI literacy; Artificial intelligence ethics; Future challenges

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Artificial Intelligence and Education. Digging beneath the surface.
(based on Holmes et al., 2019, 2022; and Holmes & Tuomi, in press)

The application of Artificial Intelligence (AI) in classrooms is increasingly being fêted as an "*altogether new way of spreading quality education across the world*" (Seldon & Abidoye, 2018, p. 4). According to a leading AI entrepreneur, Kai-Fu Lee (formerly a senior executive at Google, Microsoft, SGI, and Apple):

> We know the flaws of today's education…. AI can play a major part in fixing these flaws…. AI will make learning much more effective, engaging, and fun…. I believe this symbiotic and flexible new education model can… help every student realize his or her potential in the Age of AI. (Lee & Qiufan, 2021, p. 118)

Meanwhile, international organisations are loudly proclaiming that AI will "*give learners greater ownership over what they learn, how they learn, where they learn and when they learn*" (OECD, 2021, p. 3); and that AI "*helps teachers realize impressive outcomes in the classroom*" (IBM, 2018), especially "*given its ability to provide content tailored to students' learning needs*" (World Bank, 2022). In short, so the argument goes, AI will "*transform education*" (OECD, 2020, p. 7). As a consequence of this enthusiasm, AI in education (AIED) was one of the top three AI venture capital investment areas in 2020 (Zhang et al., 2022).

However, the contention here is that much of this optimism is overstated or even misplaced. While the full potential of both AI and AIED remain to be revealed, current applications suffer from much hyperbole and many critical limitations that all too often are not given due consideration. In fact, claims about the potential of AIED tend to be aspirational rather than evidence-based (Miao & Holmes, 2021), and overly-simplistic, forgetting issues such as agency, pedagogy, surveillance, efficacy, and ethics (Holmes et al., 2021; Holmes & Porayska-Pomsta, 2023; Porayska-Pomsta et al., in press). This is often because current approaches tend to be solutions- rather than problems-oriented, and all too often replace teacher functions rather than empower teachers. In addition, the conversation about AI and education (AI&ED) suffers from an imprecise use of terminology, and all too often conflates 'teaching with AI' (AIED) with 'teaching about AI' (AI literacy), which in turn almost always focuses on the technological dimension of AI to the exclusion of the human dimension.

ARTIFICIAL INTELLIGENCE

To begin with, before we can consider its connections with education, it is important to be clear about what we mean by 'Artificial Intelligence' – the problem being that AI is notoriously difficult to define. A quick Internet search will reveal multiple attempts, while what counts as AI constantly changes:

> [A] lot of cutting-edge AI has filtered into general applications, often without being called AI because once something becomes useful enough and common enough it is not labelled AI anymore. (Nick Bostrom cited in CNN, 2006)

For non-computer scientists, the definition provide by UNICEF (which is derived from a definition agreed by the Organisation for Economic Co-operation and Development (OECD) member states) is particularly helpful:

> AI refers to machine-based systems that can, given a set of human-defined objectives, make predictions, recommendations, or decisions that influence real or virtual environments. AI systems interact with us and act on our environment, either directly or indirectly. Often, they appear to operate autonomously, and can adapt their behaviour by learning about the context. (UNICEF, 2021)

As explained elsewhere (Holmes & Porayska-Pomsta, 2023), this definition is preferred for several reasons. First, it does not depend on data, although it does accommodate data-driven AI techniques such as artificial neural networks and deep learning; second, it therefore also includes rule-based or symbolic AI and any new paradigm of AI that might emerge in future years (such as "neuro-symbolic" AI, Z. Susskind et al., 2021); and third, it highlights that AI systems necessarily depend on human objectives and sometimes "appear to operate autonomously", rather than assuming that they do operate autonomously, which is key given the critical role of humans at all stages of the AI development pipeline.

However, inevitably, the UNICEF definition is not perfect. An element that is less helpful is the notion of an AI system "learning" – something that, it might be argued, requires the consciousness or agency that, now and for the foreseeable future, machine-based systems entirely lack (Rehak, 2021). However, the use of anthropomorphic terms to describe these machine-based systems (including "intelligence", "learning", and "recognition", as in "facial recognition") are so part of the AI narrative that, although distracting and unhelpful, they are unlikely to change anytime soon. Finally, when trying to understand what AI really is, it is also important to acknowledge that it is neither magic nor as intelligent as humans (Yoshua Bengio, a leading AI researcher, cited in Press, 2019). In fact, it is not even artificial nor intelligent: "*It is made from natural resources and it is people who are performing the tasks to make the systems appear autonomous*" (Kate Crawford cited in Corbyn, 2021).

Nonetheless, so-called 'machine learning' type of AI, and especially 'artificial neural networks', have made dramatic advances in recent years. Artificial neural networks are inspired by how the human brain is structured and functions, involving neurons and synapses, and usually require huge amounts of data from which to determine patterns and draw inferences (Holmes et al., 2019). Recent artificial neural network successes include automatic translation between human languages (e.g.,

OBTranslate, 2022), figuring out what shapes proteins fold into (Google Deepmind, 2020), and large language models that can generate human like text (e.g., 'GPT-3', Heaven, 2020).

However, alongside these successes, AI often suffers from overselling and hyperbole (Berryhill et al., 2019). For example, AI systems can be brittle: a small change to a road sign can prevent an AI image-recognition system recognising it (Heaven 2019). They can also be biased, because the data on which they are trained is biased, or the algorithms that drive them are biased (Ledford, 2019). Meanwhile, despite the huge expectation, AI made little impact on addressing Covid-19 when the pandemic was at its height (Benaich, 2020; Heaven, 2021; Roberts, 2021; Walleser, 2021); and the AI language models often write nonsense (Hutson, 2021; Marcus & Davis, 2020). Finally, despite its history and dominant voices, AI should not be thought of in purely technical terms. Instead, AI is a complex sociotechnical artefact that needs to be understood as something that is constructed through complex social processes (Eynon & Young, 2021). In other words, when we consider AI, we must consider both the human dimensions and technological dimensions in symbiosis.

THE CONNECTIONS BETWEEN AI AND EDUCATION

The connections between AI and education (AI&ED) may be grouped under the 'application' and the 'teaching' of AI in education. The *application* of AI in education, which is often known as 'AIED', involves the use of AI-assisted tools in teaching and learning, and includes the use of AI to support learners, teachers, and administrative systems (such as recruitment, timetabling, and learning management) (Holmes et al., 2019). Meanwhile, the *teaching* of AI in education involves enhancing the AI knowledge and skills of citizens of all ages (from those in primary education through to lifelong learners) and their teachers, of both the technological dimension of AI (covering the techniques of AI, such as machine learning, and technologies of AI, such as natural language processing) and the human dimension of AI (ensuring that all citizens are prepared for the possible impacts of AI on their lives, helping them go beyond the hype in order to understand issues such as AI ethics, data biases, surveillance, and the potential impact on jobs). Achieving a sufficient understanding of both the technological and human dimensions of AI may be considered 'AI literacy'.

AIED

Over the past four decades, most of the AIED research focus has been on learner-supporting AI, which by definition aims to automate teacher functions so that learners can learn independently of teachers. However, much of this adopts a rather primitive approach to pedagogy, and all too often focuses on automating poor pedagogic practices rather than innovation (for example facilitating

examinations rather than devising innovative ways to assess and accredit learning). Nonetheless, the use of learner-supporting AI is fast becoming popular in mainstream education, and has developed to include a wide range of approaches. A recent taxonomy (Holmes & Tuomi, in press) lists, in order of availability (from commercially available to speculation): so-called Intelligent Tutoring Systems (e.g. Spark from Domoscio, 2022), AI-assisted apps (e.g., Photomath, 2022; translation software from SayHi, 2022; and homework-answering apps, Dan, 2021), AI-assisted simulations (e.g., AR, Behmke et al., 2018; VR, McGuire & Alaraj, 2018; and games-based learning, LaPierre, 2021), AI to support learners with disabilities (Alabdulkareem et al., 2022; Anuradha et al., 2010; Barua et al., 2022; Benfatto et al., 2016; and StorySign by Huawei, 2022), automatic essay writing (Sharples, 2022), chatbots (e.g., Hussain, 2017), automatic formative assessment (e.g., Foster, 2019; Metz, 2021), learning network orchestrators (e.g., Lu et al., 2018), dialogue-based tutoring systems (Nye et al., 2014), exploratory learning environments (e.g., Mavrikis et al., 2018), and AI-assisted lifelong learning assistants (Holmes et al., 2019).

The use of learner-supporting AI appears to be growing in classrooms across the world, as evidenced by the many multi-million-dollar-funded AIED companies globally (Holmes et al., 2019; Miao & Holmes, 2021; R. Susskind & Susskind, 2015). However, while the AIED research community has long demonstrated the efficacy of various learner-supporting AI tools, in short studies researched in limited contexts (e.g., Beal et al., 2007; Ma et al., 2014; Vanlehn et al., 2005), there is actually surprisingly little to justify its wide use in well-resourced classrooms, other than the marketing materials and mostly unsubstantiated hopes expressed by many policymakers. Robust, independent evidence remains scarce (Miao & Holmes, 2021), and claims that AI will dramatically improve the way learners learn (e.g., OECD, 2021) remain aspirational or speculative (Holmes et al., 2019; Nemorin, 2021, cited in Miao and Holmes, 2021).

Over the same period, there has been very little focus on AI designed specifically to support teachers (aside from the dashboards that are common in educational technologies, Jivet et al., 2017). More recently, however, there has been some research and one or two commercial products. The Holmes and Tuomi taxonomy (in press) lists plagiarism detection (e.g., Turnitin, 2022), smart curation of learning materials (e.g, Perez-Ortiz, 2020), classroom monitoring (Lieu, 2018; Moriarty-Mclaughlin, 2020; Poulsen et al., 2017), automatic summative assessment (which was tried, then abandoned, by the Australian government, Hendry, 2018), AI teaching and assessment assistants (Guilherme, 2019; Selwyn, 2019), and classroom orchestration (e.g., Song, 2021).

Finally, administration-supporting AI is quietly growing behind the scenes, despite there being limited research in this area. The Holmes and Tuomi taxonomy (in press) lists admissions (Marcinkowski et al., 2020; Pangburn, 2019; Waters & Miikkulainen,

2014), course-planning (e.g., Martinez-Maldonado et al., 2021), scheduling, timetabling (e.g., Lantiv, 2022), school security, identifying 'drop-outs' and 'students at risk' (e.g., R. S. Baker et al., 2020; Lykourentzou et al., 2009), and e-proctoring (Chin, 2020; Henry & Oliver, 2021; Kelley, 2021).

AI literacy

While only a small number of a total population of learners may want or need to learn about AI in order to become AI designers or developers, all citizens should be encouraged and supported to achieve a certain level of AI literacy. They should have the knowledge, skills and values centred on the development, implementation and use of AI technologies, from both a technological and a human perspective:

> *The world's citizens need to understand what the impact of AI might be, what AI can do and what it cannot do, when AI is useful and when its use should be questioned, and how AI might be steered for the public good.* (Miao & Holmes, 2021, p. 6)

AI literacy is usually considered an extension of ICT or digital literacy, and as comprising "*both Data Literacy, or the ability to understand how AI collects, cleans, manipulates, and analyses data, as well as Algorithm Literacy, or the ability to understand how the AI algorithms find patterns and connections in the data*" (Miao & Shiohira, 2022, p. 11). However, given that AI is qualitatively different from most digital technologies, AI literacy cannot be limited only to its technological components. Instead, AI literacy should comprise both the technological and the human dimensions of AI, both how it works (the techniques and the technologies) and what its impact is on people (on human cognition, privacy, agency and so on) (Holmes et al., 2019). In short, teaching about AI's technical components is important but is incomplete without explanations of the people, power and political motivations behind the adoption of automated decision making.

> *The aim of addressing the human dimension of AI literacy is to enable everyone to learn what it means to live with AI and how to take best advantage of what AI offers, while being protected from any undue influences on their agency or human dignity. To begin with, young people should be helped to understand how AI, automation, and especially automated decision making, may affect their treatment in society. In other words, if they are to be literate in AI as they are literate in mathematics, all young people need to understand whether the AI with which they knowingly or unknowingly engage has treated them fairly.* (Holmes et al., 2022, p. 24)

While ICT/digital literacy has usually been the preserve of ICT or computing teachers, a more robust AI literacy might be achieved by encouraging all teachers of all subjects – from the sciences to the humanities and the arts – to explore with their students the potential uses, benefits, impacts, challenges and risks of AI in their subject areas. For example, given that AI might already be used to automatically

generate digital images, poems and stories, art teachers and literature teachers might ask their students: if a machine might be capable of creative acts, what does it mean to be a human?

AI&ED: SOME CHALLENGES

In this final section, noting that many of the types of tool identified in the Holmes and Tuomi taxonomy have been questioned (e.g. for their use of surveillance, for disempowering teachers and undermining student agency), we identify a small number of issues that increasingly and self-evidently need to be carefully and fully addressed. The following discussion is arranged as follows: AIED and pedagogy, ethics, human rights, personalisation, saving teacher time, intelligence, efficacy and impact, techno-solutionism, colonialism and trust.

AIED and Pedagogy

Despite using state-of-the-art technologies and often being grounded in the cognitive sciences (Anderson et al. 1995), almost every existing commercial AI tutoring tool effectively embodies a naïve approach to teaching and learning. The dominant approach involves spoon-feeding pre-specified content, adapted to the individual's achievements, while aiming to avoid failure. In other words, despite suggestions to the contrary, the approach is effectively behaviourist or instructionist, and ignores more than sixty years of pedagogical research and development – and in so doing, they disempower educators (turning them all too often into mere technology facilitators) and undermine student agency (students have no choice but to do what the AI requires, allowing them no opportunity to develop self-regulation skills or to self-actualise). The approach typical of AIED tutoring tools overlooks, for example, deep learning (Entwistle, 2000), guided discovery learning (Gagné & Brown, 1963), productive failure (Kapur, 2008), project-based learning (Kokotsaki et al., 2016), and active learning (Matsushita, 2018). This behaviourist approach, especially the spoon-feeding, prioritises remembering over thinking, and knowing facts over critical engagement, thus undermining robust learning.

AIED and Ethics

For AI in general there has been a growing focus on ethics, resulting in more than eighty sets of ethical AI principles (Jobin et al., 2019). However, despite there being fundamental implications for students, educators, parents, and other stakeholders, relatively little has been published specifically on the ethics of AI in education, notable exceptions being (Adams et al., 2021; Aiken & Epstein, 2000; Holmes et al., 2021; Holmes & Porayska-Pomsta, 2023). In fact, to date, most AIED research and development has happened without serious engagement with the potential ethical consequences (e.g., surveillance) of using AI in education. While, in Europe, there has been a growing interest in developing teacher-oriented guidelines and

regulations for the ethical development and deployment of AI in education, and UNESCO members have agreed the Beijing Consensus (UNESCO, 2019), it remains the case that no appropriate regulations have yet been enacted anywhere in the world (Holmes, Bektik, et al., 2018). In any case, most discussions centred on the ethics of AIED and the related field of learning analytics focus on data (e.g. biases, privacy, and data ownership) and how that data is analysed (e.g. fairness, transparency, and trust). However, the ethics of AIED cannot be reduced to questions about data and computational approaches alone. In other words, investigating the ethics of AIED data and computations is fundamentally necessary but not sufficient. The ethics of AIED also needs to address the ethics of education and human development (Holmes et al., 2021). This raises important questions centred on pedagogy (Is the instructionist pedagogy adopted by most AIED ethically grounded?), knowledge (What counts as knowledge?), assessments (What should be assessed and how?), and student and teacher agency (Who should be "in control"?) (Holmes & Porayska-Pomsta, 2023).

AIED and Human Rights

The Council of Europe has recently explored AI and education in terms of human rights (Holmes et al., 2022), drawing on the UN's Universal Declaration of Human Rights (1948), the European Convention on Human Rights (Council of Europe, 1953), and the UN's Convention on the Rights of the Child (1989). Key issues, that the report discusses in detail, and that many AIED tools clearly challenge, are:

- **Right to human dignity**: teaching, assessment and accreditation should not be delegated to an AI system.
- **Right to autonomy**: children should be afforded the right to avoid being individually profiled, to avoid dictated learning pathways, and to protect their development and future lives.
- **Right to be heard**: children should be afforded the right not to engage with an AI system, without that negatively affecting their education.
- **Right not to suffer from discrimination**: all children should are afforded the opportunity to benefit from the use of technology, not just those from the socio-economic groups who can afford it.
- **Right to data privacy and data protection**: children should be afforded the right for their data not to be aggregated and used for commercial purposes without their direct benefit.
- **Right to transparency and explainability**: children and their parents should be able to understand and challenge any decision made by an AIED system.

AIED and Personalisation

> *Perhaps the greatest opportunity for AI in education is individualized learning…. A personalized AI tutor could be assigned to each student…. Unlike human teachers, who have to consider the whole class, a virtual teacher can pay special attention to each student, whether it is fixing specific pronunciation problems, practicing multiplication, or writing essays. An AI teacher will notice what makes a student's pupils dilate and what makes a student's eyelids droop. It will deduce a way to teach geometry to make one student learn faster, even though that method may fail on a thousand other students. To a student who loves basketball, math problems could be rewritten by NLP in terms of the basketball domain. AI will give a different homework assignment to each student, based on his or her pace, ensuring a given student achieves a full mastery of a topic before moving to the next.*
> (Lee & Qiufan, 2021, p. 118).

The assumption that education systems should strive to personalise learning, despite the meaning of 'personalised learning' remaining unclear (Holmes, Anastopoulou, et al., 2018), increasingly informs the education narrative (UNICEF, 2022). In fact, the development of technologies to 'personalise learning' to the strengths and weaknesses of individual students began almost 100 years ago, with the so-called 'teaching machines' devised by Sidney Pressey and B. F. Skinner (Watters, 2021). For various reasons, these machines failed to be widely accepted, and the 'personalised learning' agenda more or less disappeared. It re-emerged decades later, mainly from Silicon Valley, partly because the Internet made mass customisation possible. A question often posed is, if we can have personalised recommendations on Netflix or Amazon, why can't we do a similar thing in education?

The CEO of a well-funded Chinese AIED corporation once explained it with a metaphor involving school buses and Uber taxis. Standard classroom-based education, he suggested, was like a regular school bus (presumably the big yellow buses that are familiar in the US). All the students are together, travelling at the same speed, in the same direction, and to the same destination (the bus station). His company's AIED offering, however, he argued, was more like a fleet of Uber taxis. Each student is in their own taxi, travelling at a speed and in a direction appropriate to them as an individual. However, it could be counter-argued that the CEO didn't take his own metaphor far enough. While some AI tools might provide each student with their own individual pathway through the materials to be learned (the taxi route), they still take them to the same fixed learning outcomes as everyone else (the bus station). Yet we tend not to get an Uber taxi because it takes us exactly where we want to go. In other words, the personalised pathways offered by much current AIED is a very weak understanding of personalisation (Holmes, 2019). Real personalisation is about helping each individual student to achieve their own

potential, to self-actualise, and to enhance their agency, which is something that few existing AIED tools do. In short, while they might provide adaptive pathways through the materials to be learned, most AIED tools have a tendency to drive the homogenisation of students. A critical interpretation of such AIED tools could suggest that they aim to ensure the students fit in the right box (pass their exams), prepared for their pre-designated role in the world of work.

AIED and Saving Teacher Time

Another claim is that these tools will save educator time, a promise that has again been made about educational technologies for almost a hundred years but has never actually materialised (Watters, 2021). Naturally, AI we are told is different, and AI tools will finally save educator time. While most educators would appreciate a tool that takes care of their marking, this ignores the fact that no AI system is capable of the depth of interpretation or accuracy of analysis that a human educator can give. It also ignores how much an educator learns about a student when they read what the student has written, giving insights that no dashboard will ever give. Even if AI does save educator time, although there's little evidence for that, at what cost to the quality of teaching and learning?

AIED Intelligence, Efficacy and Impact

To begin with, many AI companies claim that their AI education tools are intelligent (after all the word "intelligent" is in the title). But they are not. The reality is that no AI system today comes anywhere close to human intelligence (even the impressive GPT-3 does not understand any of the text that it is generating, Marcus & Davis, 2020), and no AI education tool is anywhere near as intelligent as a human educator. In fact, AI systems in education are extremely limited in what they cover and can achieve. Sometimes, like the Mechanical Turk (Schaffer, 1999), they might *appear* intelligent, but that's a long way from actually *being* intelligent.

Nonetheless, as evidenced by the International Journal of Artificial Intelligence in Education, academic researchers have conducted hundreds if not thousands of studies into the efficacy of various AIED systems. Many of these studies have been synthesised in numerous metanalyses and meta-metanalyses (du Boulay, 2016; Kulik & Fletcher, 2015; Ma et al., 2014). However, the vast majority of the original studies were conducted by the developers (increasingly from commercial organisations) of the particular technology being studied, and most often with relatively small numbers of learners, thus reducing their generalisability. In only a few instances have the studies been independently conducted and/or at large scale (Pane et al., 2013; Roschelle et al., 2017), and most of those that were, were undertaken in the USA, limiting their transferability to other countries.

However, AIED research is that it also has almost always focused on the efficacy of the AI tool to enhance individual student's academic achievements in the narrow

domain addressed by the tool. Very rarely does the research consider the wider *implications* of AI in classroom settings and its broader *impact* on teachers and students: "*Much of what exists now as "evidence-based" is mostly related to how AI can work in education in a technical capacity without pausing to ask and comprehensively answer the question of whether AI is needed in education at all*" (Nemorin, 2021, cited in Miao and Holmes, 2021, p.26)

One important potential impact of AIED is on human cognition and brain development. There are several outstanding questions with regards the impact of technology on children's brains and cognition – which is especially important because children's cognitive structures and capabilities are by definition still in development. These questions include whether using technology is the cause of various cognitive/behavioural outcomes such as attention problems, whether the use of technology is implicated in restructuring parts of children's brains, whether there are real health risks associated with technology use, and if so what the causal mechanisms might be (Gottschalk, 2019). These questions are also likely to be critical for AIED, suggesting the need for a new research focus.

AIED and Techno-solutionism

The conclusion that "AIED systems perform better than… human teachers" (du Boulay, 2016, p. 11) has been used to justify their increasingly wide deployment around the world. In particular, it has been argued that AIED might effectively fill the void in contexts such as rural areas in developing countries where there are insufficient experienced or qualified teachers necessary to provide learners with the quality education that is their human right (XPRIZE, 2015). However, while the immediate cohort in such a context might benefit from being given access to an AIED tool, there are many challenges.

To begin with, many rural areas do not yet have the necessary infrastructure (electricity and access to the Internet); and even when it is available, rarely are there the skilled support staff needed for the deployment, management and support of the required hardware and software. However, most importantly, AIED in such contexts might address the apparent symptoms of the problem (learners not receiving a quality education) but it does not address the underlying and long-term socio-political causes (the lack of experienced and qualified teachers). In practice, the way in which 'problems' are articulated often depends on the interests of the technology providers, and the deeper social and cultural factors are rarely addressed as they are difficult to change without the broad participation of stakeholders. As Krahulcova notes, rather than technological solutions, "*most complex real-world problems require complex real-world solutions*" (2021). Accordingly, the problem is probably best addressed by focusing on the professional development and support offered to the inexperienced classroom teachers – which might be supported by appropriate AI, perhaps by establishing AI-

assisted networks of colleagues and pedagogy experts across the country. The emphasis is again on augmentation: using the technology to support rather than replace teachers.

AIED Commercialisation of Education

While learner-focused AI has been the subject of research for around forty years, almost a decade ago it "escaped" from the research labs to be developed into commercial products by a growing number of multi-million-dollar-funded AIED companies. It is mostly these products that are being implemented in schools around the world, frequently by government (local and national) agencies. This is important for several reasons. First, while the original research is undertaken in academia with the explicit aim of enhancing teaching and learning, today's commercial organisations by definition focus on generating profits (even a mission to 'do good' is a commercial strategy): "*Given that the children's interactions with these AI systems generate both technical knowledge about how the product works and market knowledge about how the product is used, are children in classrooms around the world being recruited by stealth to create and supply business intelligence designed to support the corporations' bottom lines – and is this being prioritised over the child's learning and cognitive development?*" (Holmes et al., 2022, p. 24). Second, commercial organisations rarely share information about their proprietary systems and their effectiveness, limiting interoperability while disadvantaging civil society with regards procurement, scrutiny and accountability for the public purse. Third, commercial AIED organisations are not only shaping individual learners but are also beginning to influence governance and national policies: "*they will impose their standards on what counts as knowledge at all. Knowledge is, or will be, what is or can be formalised in a computational way*" (M. J. Baker, 2000, p. 127). In short, this commercialisation of education by stealth, through an AIED back door, is fraught with both practical and ideological issues.

AIED Colonialism

AIED corporations are increasingly selling their AIED tools globally, creating what has been called an AIED colonialism: global north companies exporting their AIED tools into contexts in the global south, creating asymmetries in power across and between nations. All too often "*digital technologies function in ways that perpetuate the racial and colonial formations of the past*" (Zembylas, 2021, p. 1). This is only exacerbated by the fact that the overwhelming balance of AIED research is also carried out in the global north, and rarely addresses cultural diversity or local policies and practices in any meaningful way (Blanchard, 2015).

AIED colonialism might involve the adoption of AIED tools created in one context in other places, leading to market and economic gains for the global north corporations, with the extraction of local data and capital out of the host country

(Nemorin et al., 2022). These gains and extractions may begin with individual schools embedding AIED tools into teachers' everyday practices before expanding to draw in entire state education systems in which single products are adopted across all schools. However, AIED colonialism might not necessarily depend on specific tools being imported into global south countries. More subtly, it might simply involve the language in which most classroom AIED tends to be trained – mainly American English (Cotterell et al., 2020). In any case, the impact of the English-trained models used by AIED tools in non-English contexts and on the children who use them remains unknown (Naismith & Juffs, 2021).

AIED and Trust

A final issue to be mentioned here, in the context of learner-supporting AI, is that of trust. If AI tools are to become even more widely used in classrooms, it is essential that teachers, learners, parents and other stakeholders can trust that they will be beneficial – that they will enhance learning and not cause any harm. In fact, conversations about stakeholder trust in AI tools designed for classrooms are only just beginning. However, all too often the onus is placed on the classroom stakeholders (to trust the learner-supporting AI tools) rather than on the providers (to provide learner-supporting AI tools that are trustworthy). For example, a recent paper proposed eight factors that influence teachers' trust in adopting AI-based educational tools, all of which focus on the teachers, and none of which require the AI developers to make their tools trustworthy (Nazaretsky et al. 2021). In short, the European Commission's Ethics Guidelines for Trustworthy AI (2019) should be applied to AIED systems too.

CONCLUDING THOUGHTS

Identifying these numerous challenges should not be seen as an attempt to prevent the application or teaching of AI in educational contexts, but instead as an attempt to help ensure that it is the *right kind* of AI that is applied in education and the *right approach* to AI that is taught (Holmes, 2020). For AI in general, it took many years before its ethical and humanistic challenges began to emerge and began to be addressed. However, with BigTech controlling AI developments and thus much of the direction of travel, it is clear that there remains a long way to go (Bender et al., 2021). In parallel, although the AIED research community is itself more than forty years old, it is only in the past few years that AIED tools have begun to enter classrooms in any serious way, while the teaching of AI remains stuck in a technological cul-de-sac. In short, AI&ED, the application and teaching of AI in education, remains way behind. However, as we have noted, refreshingly there are increasing attempts to engage with a humanistic approach to AI&ED (e.g., Holmes et al., 2022; Holmes & Porayska-Pomsta, 2023; Tuomi, 2018), with issues such as

surveillance, human agency, and transparency, to name just three, beginning to be surfaced and addressed. Hopefully, this paper's short dig below the surface will encourage others not to take current AI&ED at its face value, but to identify, engage with, and address the emerging challenges – especially those that today remain unknown.

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