

ORIGINAL ARTICLE

What qualities do teachers need in the era of artificial intelligence: Analysis based on international experience

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ABSTRACT

The new generation of artificial intelligence (AI) technology has led to systematic and revolutionary changes in the field of education. As a key element in the process of education and teaching in the intelligent era, the development of teachers' AI literacy level cannot be ignored. Countries around the world are actively developing teachers' AI literacy to cope with the development trend of intelligent education, and have issued a series of policies and guidelines to regulate its development. Based on this, this paper starts from the relevant policies and practical actions of teachers' AI literacy in various countries, and analyzes the urgent requirements of AI education for teachers' AI literacy from the aspects of teachers' consciousness and attitude, curriculum development, teaching development, teaching management, teacher development and AI ethics. Finally, the article clarifies the necessary qualities of teachers in the era of AI, and puts forward the development path of teachers' AI literacy in view of the above six aspects, in order to provide a reference for the professional development of teachers in the intelligent era.

Key words: artificial intelligence, digital literacy, policy analysis, teacher development

INTRODUCTION

Digital education is an important foundation for China to build an educational power, and it is also a powerful measure to cope with social changes in the digital age. In the process of digital transformation of education, artificial intelligence (AI) has played an important role in promoting it. The deep integration of various AI technologies with education and teaching links is profoundly changing the traditional education pattern. Many countries and regions have begun to incorporate AI into national strategies, actively organize and carry out AI learning campaigns, and develop artificial intelligence education (AIED). As the first resource of education development and the core element in the process of

education and teaching (Cao, 2022), the cultivation and development of teachers' AI literacy has become an important prerequisite and key link for the efficient use of AI technology to carry out education and teaching, develop AIED and respond to the new round of education reform in the digital age. At present, a number of policies in China have mentioned the development of teachers' AI literacy, but the research on AI literacy is still not deep enough and systematic, the conceptual elements have not been unified, lacking clear and systematic training concepts and mechanisms, and there is a huge "digital intelligence gap" in intelligent teaching (Wang, 2022). Therefore, this study establishes an analytical framework of teacher awareness and attitude, curriculum development, teaching development,


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teaching management, teacher development, AI ethics, sorts out and analyzes the experience of developing teachers' AI literacy internationally, including relevant policies and practical actions, clarifies the context and direction of the development of teachers' AI literacy in the intelligent era, and puts forward suggestions on the cultivation and development of teachers' AI literacy in China in the future.

THE BACKGROUND OF THE DEVELOPMENT OF AI LITERACY

Goldman Sachs has predicted that automation can replace up to 300 million jobs (Toh, 2023). At the same time, it also brings more creative and challenging employment opportunities, which puts forward higher requirements for the cultivation of the labor force: the labor force in the AI era must be committed to completing more productive tasks. As a systematic project, the top level of AIED is an application, that is, to cultivate a high-quality labor force with AI literacy and master AI skills. Behind it, it must go through a progressive process from enlightenment cognition, thinking training, and hands-on practice to integration and innovation (Jia, 2023). As a key factor in the process of cultivating a high-quality labor force of AI, teachers first need to have AI ability and literacy to teach students how to use AI to complete work, promote personal development and improve employment competitiveness.

CONNOTATION AND COMPOSITION OF AI LITERACY

United Nations Educational, Scientific, and Cultural Organization (UNESCO) mentioned teachers' digital literacy in the third edition of "Information and Communication Technology (ICT) Competency Framework for Teachers" (UNESCO, 2018) in 2018, which is not contradictory to the AI literacy of this study. The two support and promote each other and together constitute the ability of teachers to use technology effectively in the modern educational environment. Specifically, digital literacy and AI literacy can be understood as the relationship between foundation and progression: digital literacy involves the understanding and application of various digital technologies, including the acquisition, understanding, creation of relevant knowledge and the use of digital tools. As an important representative of contemporary digital technology, AI technology is reshaping the educational environment, and AI literacy is based on digital literacy. It further focuses on the mainstream technology of AI and pays more attention to the knowledge and skills in the field of AI technology. Therefore, from the teachers' perspective of AI, a more specific literacy is needed to describe consciousness, attitude and ability: AI literacy,

that is, teachers' ability to understand and use AI technology in the field of education, including the basic understanding of AI technology, the ability to apply AI technology to promote teaching and learning, and the ability to evaluate and criticize the application of AI in education.

The improvement of teachers' AI literacy enhances their adaptability to the characteristics of the intelligent era and enhances their competence in the intelligent era (Rosasa, 2020). It is an important part of teachers' professional development and is crucial for students' comprehensive development. It is of great significance to improve the quality of education and adapt to future educational changes. Fengchun Miao (UNESCO, 2023c), Director of the Information Technology Department of the UNESCO Asia-Pacific Education Bureau, believes that the key areas of the AI teaching ability framework include humanistic values, AI literacy, AI teaching methods, and the use and innovation of AI tools to promote learning. Wong (Wong et al., 2020) believes that AI literacy should include three parts: AI concept, AI application, and AI ethics. The "K-12 AI curricula: a mapping of government-endorsed AI curricula" (UNESCO, 2022) (hereinafter referred to as the "Mapping") released by UNESCO believes that AI literacy includes data literacy and algorithm literacy. With the popularization of AI technology in life, learning and work, AI literacy has attracted more and more scholars' attention. When cultivating teachers' AI literacy, it is necessary to comprehensively consider the above key elements.

EXPERIENCE ANALYSIS

Through the analysis of the existing policy literature, it can be found that there are no relevant policies specifically aimed at teachers' AI ability and literacy, which are usually presented as part of the more macro AIED policy guidelines and AI policy guidelines, and are not mandatory, and only the European Union's (EU's) "AI Act" stipulates the use of AI in the form of law. Australia has published the "Australian Framework for Generative AI in Schools", which provides guidance for policymakers, schools, teachers, students, and others on the correct use of generative AI tools from six aspects: Teaching and Learning, Human and Social Well-being, Transparency, Fairness, Accountability, Privacy, Security, and Safety (Department of Education-Australian Government & Australian, 2023). Diao and Hu (Diao & Hu, 2022) believe that teachers' AI literacy is reflected in the process of education and teaching, including curriculum development, curriculum teaching, professional knowledge, research and development. Therefore, from the six aspects of consciousness and attitude, curriculum development, teaching development,

teaching management, teacher development and AI ethics, this study combs the relevant policy literature and practical action of teachers' AI literacy in the international scope, as shown in Figure 1.



Figure 1. Policy and practice analysis framework chart. AI, artificial intelligence.

Consciousness and cognition

"Beijing Consensus on AI and Education" (Ministry of Education of the People's Republic of China, 2019) is the first document to provide guidance and suggestions for the scientific application of AI technology to implement the 2030 Education Agenda, it fully focuses on teachers' awareness and attitude toward educational reform of AI technology, that is, to cultivate the values and skills needed for life and work in the era of AI. Teachers should be aware of the systematic and long-term changes in the labor market caused by AI, actively adapt to the new needs of AI literacy and basic skills caused by AI, and make changes in the level of consciousness, attitude and values. Digital Promise, a non-profit organization in the US, regularly talks with advanced AIED experts and publishes relevant AI reports, providing teachers with a variety of training courses and learning resources, helping teachers understand and apply AI technology, and providing teachers with sufficient information support by promoting the development and promotion of AI tools and resources (Digital Promise, 2023). As a publication in the field of educational technology, the vision of "Getting Smart" is to help teachers understand more general concepts of AI, and the educational resource library created provides help for teachers to make better use of AI technology to carry out teaching. The UK Department of Education found in a survey study

(GOV.UK, 2024) that nearly 40% of teachers are using generative AI in their daily teaching, and its adoption rate among teachers is rapidly increasing. Some respondents indicated that Gen AI has become an essential tool in their daily work, and this trend is becoming increasingly common among their peers.

Curriculum development

Public institutions in various countries have recognized and provided practical support for the development of AI courses. To date, 11 governments have developed and implemented 14 AI courses. In addition, 7 AI courses in 5 countries are still under development (UNESCO, 2022). Most of these courses are developed by national public institutions and recognized through centralized government guidance. Major stakeholders will also participate. Teachers, scholars and experts will work in the development of AI courses. Some countries will also interview and investigate teachers who implement courses to evaluate AI courses. AI courses can be flexibly integrated into the existing education system in a variety of ways: specialized AI courses: exist as an independent subject category within the curriculum framework, with independent time allocation, teaching materials and resources; subsumed AI courses: Developed in other disciplines, AI is not only the most common subject in information communication or computer science, but also a part of language, mathematics, science or engineering science. For example, South Korea has developed two AI elective courses. One belongs to the mathematics discipline group, and the other is included in the technical family economics discipline group. In order to ensure that the design and implementation of AI courses are supported, many countries have carried out a series of overall planning and adjustment of the resources and personnel capabilities of the education system: various AI courses have put forward higher requirements for the AI literacy of professional teachers, so most AI courses (89%) choose to support the development and implementation of courses by developing resources and training for teachers (UNESCO, 2022).

"Mapping" (UNESCO, 2022) summarizes the development mechanism of AI curriculum in detail: developing AI curriculum in a balanced, multidisciplinary and collaborative way, fully considering the professional suggestions of domestic and foreign industries, subject experts and educational practitioners, and paying special attention to the position of teachers in curriculum development, to ensure the operability of curriculum in practice. In addition, UNESCO encourages the integration of AI courses, incorporates AI courses into the existing curriculum system of the school, and achieves the learning results of learning professional development, mastering AI skills, and

cultivating AI thinking methods in different thematic areas through the development of subject curriculum integration guidelines.

Developed countries in Europe and the United States advocate giving full play to teachers' ability of interdisciplinary teaching and research in the process of using AI technology to develop and integrate courses at the practical level. Whether it is a separate or embedded AI course, teachers should master enough subject knowledge, including science, technology, engineering and mathematics (STEM), cultural research, psychology, political science, law and so on to provide valuable input for the course.

Teaching development

Stuart J. Russell, a professor of computer science at the University of California, Berkeley, believes that if the development of generative AI is constrained and supervised, it can become an ideal assistant for teachers (UNESCO, 2023a). Countries and regions around the world regard the ability to use AI technology to carry out teaching applications and innovation as one of the important aspects of teachers' AI literacy, and the improvement of teachers' AI literacy can effectively improve the effect of AI technology empowerment teaching.

In terms of policy guidance, the Organisation for Economic Co-operation and Development (OECD) strongly supports teachers' use of AI tools and applications to carry out teaching innovation, and believes that teachers' ability to use AI to carry out teaching is very important for cultivating students' ability and skills to adapt to the rapid changes in technology. The 2017 Higher Education Supplement issued by the National Education Technology Plan of the US advocates helping teachers carry out teaching work and develop AI skills and literacy from the dimensions of using technology to change teaching and developing collaborative solutions (Research Institute for International and Comparative Education-Shanghai Normal University, 2022). In "AI and the Future of Teaching and Learning" (Cardona *et al.*, 2023), the US Office of Educational Technology discussed in detail how teachers can use AI to improve their teaching work, carry out teaching planning and reflection and improve the practical application effect of AI. "The challenges and opportunities of AI in education" emphasizes the important role that teachers need to prepare for the new "double-qualified" teaching mode supported by AI technology (UNESCO, 2023b).

In terms of practical support, many organizations have begun to use AI to create teaching resources for teachers, provide technical support for teachers from multiple dimensions such as teaching objectives,

teaching resources, teaching activities, and teaching evaluation, and establish a good teaching ecology. For example, Massachusetts Institute of Technology MIT's "AI Curriculum Day" provides teachers with a complete curriculum and training package designed to help teachers and educators in classroom activities. International Society for Technology in Education (ISTE) is studying the Stretch AI chat robot to carry out auxiliary teaching and provide help for teachers' teaching practice (ISTE, 2024). In addition, companies such as Dell and Amazon Web Services (AWS) have also begun to develop teaching resources for teachers to help teachers carry out new teaching in the intelligent era, improve the skills of using AI to carry out teaching, and help teachers develop AI literacy.

Teaching management

Countries are actively formulating AIED strategies, encouraging the use of AI to reduce paperwork and administrative work, and reapplying the saved time to more effective teaching, which is also one of the important manifestations of teachers' AI literacy.

"AI and the Future of Teaching and Learning" regards teacher leadership as an important aspect of the in-depth development and research of education in the AI era (Cardona *et al.*, 2023). In the era of AI, teachers' leadership is largely realized with the help of AI technology. Teachers need to skillfully use the application of AI technology in education management, including data analysis, intelligent decision-making assistance, etc, which puts forward higher requirements for teachers' AI literacy.

At present, teachers' use of AI to assist education management is mainly reflected in two aspects: simplifying teaching-independent work and empowering student management. Some colleges and universities, such as Harvard University and the University of Michigan, have integrated generative AI technology into the work of school construction and education management. They require teachers to be able to skillfully use AI technology to build AI tutor assistants in the classroom, help AI tutors clarify the boundary between teaching and administrative tasks, and enable AI tutor assistants to deal with trivial, complicated and irrelevant tasks, which greatly improves the efficiency of teaching management. Many countries have begun to pay attention to the important role of AI in students' mental health education in student management. Taking the United Kingdom as an example, the British government has been actively promoting the innovation and technology application of mental health services. The National Health Service (NHS) and other relevant institutions will also evaluate and recommend related mental health applications and online services. AI is used

to assist teachers in monitoring students' emotional changes and mental health status, and to remind teachers to intervene in time, which greatly improves the effectiveness of teachers' mental health education. This work also improves the ability of teachers to analyze data and use data to assist decision-making.

In practice, the Geekie adaptive learning platform developed by EdTech in Brazil can provide suggestions for educators and help teachers provide interventions to monitor the effectiveness of school education. The United Arab Emirates (UAE) Ministry of Education's official data analysis platform contains courses from more than 1200 schools and more than 70 higher education institutions (Wang et al., 2019).

Teacher development

In terms of policy guidance, as a non-intermediary organization that manages the implementation and evaluation of local and international education interventions, Joint Education Trust's (JET's) validation report on the "Pan-Commonwealth Standards Framework for Teachers and School Leaders" (JET Education Services, 2016) considers that teacher quality is one of the important factors affecting student development. The development of the Pan-British Commonwealth Standard Framework has a positive effect on guiding teachers' professional learning and practical skills. Only by cultivating high-quality teachers can teaching quality and performance be guaranteed. In the study of teachers' professional development, the US Office of Educational Technology (Cardona et al., 2023) found that teachers' attention, use and development of AI educational technology are generally not high, and that cultivating teachers' AI literacy is an effective way to solve this problem. The survey results of the "Mapping" (UNESCO, 2022) show that nearly 90% of the courses have been supported by resource development and teacher training. National training programs, general conferences provided by non-governmental organizations, and summer camp activities are all committed to the improvement of teachers' AI skills. The "Beijing Consensus on AI and Education" advocates dynamic examination and definition of teachers' roles and their required abilities within the framework of teacher policies, strengthening teacher training institutions and formulating appropriate capacity-building programs to support teachers in preparing for effective work in an educational environment rich in AI.

At the level of practical support, from the state to non-governmental organizations, it has become a craze for organizations at all levels to develop teacher competency development courses: the International Association for Educational Technology has developed a 15-hour professional development course for teachers to help

teachers explore AI technology. International Business Machines Corporation (IBM) partnered with McCurry University's Faculty of Education to offer a 16-hour AI teacher learning course on Coursera. The course covers topics such as the history of AI, the comparison of AI and human wisdom, and ethical considerations in the development and application of AI. In 2012, Microsoft developed the "Technology and Teaching" course closely linked to the ICT competency framework for teachers and implemented it in Egypt, Russia and other countries (Duan & Qian, 2023). Different from the vision of government-based curriculum development, enterprises prefer more feasible goals shortly and pay less attention to long-term expectations.

AI ethics

The supervision and governance of AI has received extensive attention. The *Recommendation on the Ethics of Artificial Intelligence* issued by UNESCO advocates the application of AI technology to teaching, teacher training and other activities responsibly and ethically, fully assessing the impact of the application of AI technology on students and teachers, protecting the rights and interests of teachers and students, and avoiding risks. The OECD has proposed a classification framework (OECD, AI, 2022) for AI to help teachers clarify and explore the issues of what AI can do it and how to do in the field of education. The "AI Act" divides the AI application scenarios of education and vocational training into high-risk levels, and believes that only when certain mandatory needs are met can they enter the European market. The bill has made comprehensive provisions on the safe use and ethical norms of AI technology, limiting the potential risks and adverse effects of AI education applications. In 2020, Nord Anglia School Network created an ethical framework for AIED, which sets corresponding standards for nine ethical goals, helping educators measure how to effectively use AI to help learners benefit, while also preventing the risks of the technology. Arizona State University has issued the "Digital Trust Guidelines for Generative AI Use" (Artificial Intelligence, 2023), which outlines a range of considerations for teachers using generative AI in the educational context, including intellectual property and personal privacy. By using an ASU-approved tool, teachers will benefit from the data privacy protections and cybersecurity terms ASU has agreed to, as well as the risk mitigations ASU has put in place 30.

At the practical level, in order to ensure the safety of AI technology, many countries and regions will first design AI sandboxes to carry out exploratory interactive experiments on a small scale, and also formulate risk management measures when creating the environment, testing in the real teaching environment, and then

promote it on a large scale after testing the effect. The UK encourages educators to work with computer scientists, data analysts and ethicists to discuss the ethical issues of AI in education. These projects have improved teachers' awareness and ability in AI ethics (Shen et al., 2023). In addition, the Russell Group University in the UK has also implemented an AIED framework within the university, but the regulatory level has only stayed on the surface.

STRATEGIES FOR CULTIVATING TEACHERS' AI LITERACY

Teachers play an increasingly important role in the intelligence era. AI will not replace teachers, but teachers who use AI will replace those who do not (Yu, 2018). Therefore, it is of great significance for our country to refer to, summarize, and draw on the AI literacy policies and implementation actions for teachers issued by various countries and regions.

Change teachers' awareness and attitude, and integrate AI literacy into national teacher standards

UNESCO has released three editions of the "ICT Competency Framework for Teachers" which has been affecting the development of teacher standards in the field of education around the world. The guidance of policies related to teachers' AI literacy is the key to the development of teachers' AI literacy. The guidance of AI literacy policies for teachers is the key to transforming short-term project-driven initiatives into long-term career planning (Han, 2023). At present, there is only one version of the standard for primary and secondary school teachers in China: "Primary and Secondary School AI Teacher Competency Standard (Trial)". The general standards for all stages and types of teachers have not yet been issued, which leads to the lack of attention of teachers to the opportunities and challenges brought by AI. Integrating AI literacy into the national standard framework such as certification and evaluation can effectively guide teachers to correctly understand, accept and apply AI education applications from the ideological level, and improve the internal driving force of teachers' development.

Create a new ecology for curriculum collaborative development

Relevant curriculum development ability is one of the important parts of teachers' AI literacy, which reflects whether teachers can use their own AI knowledge for creative application. In China, AI-related courses are developed with national public institutions as the main body. Teachers, scholars and experts will also participate in the development of the courses. People with different backgrounds form a development team. Teachers'

participation in curriculum development ensures the operability of the curriculum in practice. Communication and collaboration with other developers can help teachers understand the latest AI technology, enrich their understanding of AI-assisted teaching, effectively integrate AI technology into the curriculum, and select the best teaching methods. Through the interdisciplinary collaborative curriculum development ecology, teachers can improve their AI literacy from both theoretical and practical levels.

Build an AI resource library to support course teaching

Research has found that there are differences in the information technology teaching capabilities of teachers in our country, with a low level of application of teaching resources and an unclear supportive role in teaching (Han & Ge, 2018). By referring to the international experience in developing teachers' AI literacy, it is recommended to establish an AI resource library to support course teaching: Carry out evidence-based resource development, provide information for resources through demand analysis before building related resources, and then incorporate them into the resource library after trial qualification; realize the sharing of development resources, provide practical suggestions for teachers to carry out personalized teaching through the online and offline digital teaching resource supply service system, and integrate the matching and application of resources into the context of applying AI to solve practical problems. For example, teachers can build their own AI teaching assistants in the classroom, help teachers match or develop appropriate teaching resources, and provide teachers with teaching ideas.

Build a one-stop platform for teaching management

The construction of an integrated teaching management platform can reduce the administrative burden and help teachers better realize the intelligentization of learning progress tracking, student performance management, teaching evaluation and feedback. By analyzing and mining teaching data, teachers can improve data-driven teaching ability and decision-making ability. For example, the AI system can analyze the teaching content of teachers and the learning needs of students, and formulate personalized learning paths for students. Teachers can also analyze these data and adjust teaching strategies to improve teachers' AI literacy in the process of teaching management.

Promote teacher training and professional development

Teacher training is one of the important and effective ways to develop AI literacy. However, in the survey of

"2022 AI Education Blue Book", it is found that Chinese teachers generally recognize the value of AI education, but they are also hindered by the immaturity of related products and the lack of systematic training. Among the 28,782 teachers interviewed, a small number of teachers have not heard of AI, and most of the teachers interviewed think that they only have a general grasp of AI professional knowledge and related tools (Tencent News, 2023). Therefore, it is necessary to promote the professional training and development of teachers. AI technology can be used to formulate personalized capacity-building programs for different roles and attributes of teachers in China. For example, teachers, as designers and guides of education and teaching, need to focus on developing the ability to integrate AI technology into teaching and innovation; as lifelong learners, we need to focus on the development of teachers' professional learning and innovation ability. In the process of using AI technology, the internal driving force of teachers' development of AI literacy is generated to realize the tracking support for teachers.

Focus on the ethical issues

Huai Jinpeng, Minister of Education, mentioned in the second meeting of the 14th National People's Congress: to increase the standardization of AI ethics and data privacy protection, and actively participate in the world's rules on the relationship between AI and education and ethics (Ministry of Education of the People's Republic of China, 2024). Ethical issues run through the whole process of AI education. Therefore, it is necessary to clarify the scope of rights and obligations given to teachers by AI. Schools and educational institutions can establish an ethical review mechanism, provide teachers with special AI ethics training, and public discussion of real AI ethics cases to improve teachers' judgment and processing ability in the face of AI ethical issues. In addition, teachers should fully exercise the right to formulate standards for ethical issues of AI and participate in practical activities. For example, teachers can integrate AI ethics education into the curriculum; at the same time, it consciously abides by the AI ethical guidelines, fully ensuring that the personal information of learners is strictly protected when AI is used, and the data collected in the process of interacting with AI to acquire knowledge is not misappropriated and leaked.

CONCLUSIONS

No education system can surpass the quality of its teachers. The World Economic Forum has predicted that in the fourth industrial revolution, teachers need to adapt to AI and machine technology in order to successfully transform and better face future innovation (Wang et al., 2019). High-quality teachers in the intelligent era have become the main force in promoting

AIED. As the core content and prerequisite of the digital transformation of education (Han et al., 2022), the professional development of teachers is an urgent problem to be solved. The cultivation and development of teachers' AI literacy can effectively realize the professional development of teachers and improve the quality of teachers, which can help teachers release the full potential of technology and empower AI-based education and teaching (Diao et al., 2023), to cultivate new talents in the AI era, build a more flexible and open education system, and promote the modernization of education. Therefore, this study constructs a policy and practice analysis framework from the aspects of teacher awareness and attitude, curriculum development, teaching development, teaching management, teacher development, AI ethics, etc., systematically sorts out the relevant policies and practices of AI education in the international context, and holds that teachers in the era of AI should have the knowledge system of AI, be proficient in AI technology, master the ability of AI to solve problems and innovate teaching, and be familiar with the ethical norms of AI.

By analyzing the international development experience, it is found that the experience of the development of teachers' AI literacy in China can be used for reference: from the six aspects of teachers' consciousness and attitude, curriculum coordination and development ecology, AI resource library, one-stop platform of teaching management, teacher training and development, and ethical issues. Provide suggestions for the development of teachers' AI literacy in China. While enriching the theory of teachers' professional development supported by AI technology, it provides a reference for the construction of high-quality teachers in China.

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Author contributions

Zhang SM: Conceptualization, Writing—Original draft, Resources. Diao JF: Methodology, Writing—Review and Editing. Ma XY: Investigation, Resources. Tang XQ: Investigation, Resources. Ding X: Supervision, Project administration and Funding acquisition. All authors have read and approved the final version.

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Ethical approval

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Conflict of interest

The author has no conflicts of interest to declare.

Data availability statement

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