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Sustainability in Professional Development: Manifestations and Reliefs of Technology Anxiety among Mandarin Chinese Teachers in the Era of Digital Intelligence

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Abstract

With the rapid development and practical application of digital intelligence technology in many fields of human society, the integration trend of digital intelligence technology with Mandarin Chinese education is inevitable. Digital intelligence technology seems to have also placed a psychological and physical burden on teachers when providing them with convenience. Focusing on the technology anxiety of Mandarin Chinese teachers, this research discussed the manifestations and generation of their technology anxiety in the era of digital intelligence through in-depth interviews with 25 Mandarin Chinese teachers and classroom observations. The results indicated that the technology anxiety of Mandarin Chinese teachers manifested as cognitive dilemma anxiety caused by the distorted cognition of technology and technology iteration, technology-induced obstacle anxiety caused by invisible technology obstacles and the reform of teaching empowered by technology, career development anxiety caused by the weak renewal of teachers' technology knowledge and skills and deviation of intelligent education expectations, and ethical security anxiety caused by anomie of artificial intelligence and technology risk prevention and management. This irrational psychological state was the result of interactions between Mandarin Chinese teachers and technology influenced by a series of cognitive, emotional, and social factors. On the basis of this, the following suggestions for relieving such anxiety include exploring and adopting diverse measures to help teachers hold positive technology cognition and value-evaluation viewpoints, taking the cultivation of intelligent education knowledge and practical ability as the core to improve teachers' intelligent education literacy, exploring a new model of human–machine collaborative education and bringing teachers' professional advantages to full play in the era of digital intelligence, and providing guidance for intelligent education technology to instruct teachers to correctly understand and address ethical security problems derived from technology.

Keywords: mandarin chinese teacher; the era of digital intelligence; technology anxiety; professional development

Introduction

The era of digital intelligence refers to the era in which people acquire, analyze, and use a large amount of data through intelligent means such as AI, blockchains, and big data with the support of information technology [1]. The continuous development and application of digital intelligence technology have impacted many fields of human society, and the integration trend of digital intelligence technology and Mandarin Chinese education is irreversible. In 2021, the Center for Language Education and Cooperation issued the Action Plan for International Chinese Online Education (2021-2025), which noted that "accelerating the construction of a new Mandarin Chinese education format with new information technologies as the internal support, leading the modernization of Mandarin Chinese online education as the goal, and promoting the renewal of educational concepts, model change, and system reconstruction as the purpose [2]." In the field of Mandarin Chinese education, the integration of digital intelligence technology and Mandarin Chinese education has gradually become a popular research topic. Related studies have focused on the following two parts: on the one hand, researchers have macroscopically explored the overall development and promotion of Mandarin Chinese education reform empowered by digital intelligence technology [3,4]; on the other hand, researchers have microscopically discussed new requirements for the construction of Chinese education resources, mandarin Chinese teachers' literacy, and the reform of teaching concepts and models in the era of digital intelligence [5-7]. Academic research has not clearly discussed the topic of Mandarin Chinese teachers'

technology anxiety in the era of digital intelligence. Research in the field of teacher education has shown that digital intelligence technology has caused some teachers to have different degrees of technology anxiety [8-14]. Therefore, this research focused on the technology anxiety of Mandarin Chinese teachers and aimed to answer the following questions:

RQ1: What are the manifestations of Mandarin Chinese teachers' technology anxiety in the age of digital intelligence?

RQ2: What are the inducers of Mandarin Chinese teachers' technology anxiety, and how do they affect teachers?

RQ3: How can we relieve the technology anxiety of Mandarin Chinese teachers in the age of digital intelligence?

Interpretation of the Core Concept

As a product of the information and communication age, technology anxiety is coeval and accompanied by technology, presenting different characteristics in different stages and under different conditions. Previous studies have used terms such as computer phobia [15,16], computer anxiety [9,17,18], technology anxiety [11-14], techno-stress [10,12,19,20] or technophobia [21,22] when working on this topic. In 1981, Jay put forward the concept of computer phobia for the first time and defined it from three aspects, namely, refusing to talk about computers in behavior, having emotional anxiety and fear of computers, being hostile to computers in attitudes, or having the idea of damaging computers [15]. In 1985, Cambre & Cook defined computer anxiety as people's fear and anxiety when thinking about using or actually using computers [17]. The prominent feature of this anxiety is that "people have excessive timidity in using computers, negative comments against computers and information science, attempts to reduce the amount of time spent using computers, and even the avoidance of computers in the place where they are located [18]". "It is clearly explained above that computer phobia or anxiety refers to a mixture of negative feelings such as fear, worry, stress or anxiety invoked by the use of computers. Unlike computer phobia or anxiety, technology anxiety, stress or phobia refer to the psychological state of users when they use all technological hardware and/or software, whereas computer phobia or anxiety focus more on the psychological characteristics of users when they use computers. Early in 1984, Brod defined techno-stress as "a modern disease of adaptation caused by an inability to cope with the new computer technologies in a healthy manner. It manifests itself in two distinct and related ways: in the struggle to accept computer technology and in the more specialized form of overidentification with computer technology [20]." The term techno-phobia is defined as "an irrational fear or anxiety caused by side effects of advanced technologies or fear, dislike, or discomfort by using modern technologies and complex technical devices (especially computers) [21]." Similarly, the term technology anxiety refers to all the apprehension, fear or negative reactions toward technology, or resistance to technology [23].

By analyzing and comparing all these terms, it can be clearly noted that technology anxiety usually manifests as stress, fear, apprehension or worry aroused by the use or even the anticipated use of technology (especially computers). These negative feelings can then translate into avoidance behavior, where users avoid using new technologies or minimize their interaction with them [24]. With the advent of the era of digital intelligence, digital intelligence technologies such as intelligent auxiliary systems, intelligent robots, virtual reality and augmented reality have continuously developed and enriched various fields of human society, resulting in new patterns of learning and life. Therefore, the characteristics of technology anxiety in the digital intelligence era have also changed. In the field of education, although digital intelligence technology plays an important role in promoting the reform of educational models and improving teachers' teaching efficiency, with the deep integration of digital intelligence technology and education and teaching, teachers' technology anxiety has become increasingly prominent. The aim of this research is to identify and understand the manifestations of technology anxiety among Mandarin Chinese teachers as well as the strategies used to relieve such anxiety to secure sustainable professional development for these teachers in the era of digital intelligence.

Research methods and data collection

In a qualitative study, research design should be a reflexive process operating through every stage of a project [25]; the activities of collecting and analyzing data, developing and modifying theory, elaborating or refocusing the research questions, and identifying and addressing validity threats are usually performed more or less simultaneously, each influencing all of the others [26]. That is, the researcher may need to modify or reconsider the research design in response to new changes or developments during the process of actual

study. Therefore, it is more appropriate to use qualitative methods to explore the manifestations and generation of Mandarin Chinese teachers' technology anxiety. In addition, semi structured in-depth interviews are the most common and frequently used data collection technique in qualitative studies [27]. This research aimed to obtain detailed information regarding Mandarin Chinese teachers' thoughts, feelings and beliefs related to technology integration in education by adopting a qualitative methodology and conducting semi structured interviews. More specifically, the research mainly consisted of three stages. The first stage was the presurvey stage, in which the researcher collected data through a general interview and then analyzed them. The second stage was the qualitative stage, which involved developing a formal in-depth interview guide, conducting the interviews and analyzing the data. The third stage included discussions and conclusions in which the researcher proposed certain suggestions for relieving technology anxiety.

Identifying the Participants

Strategies for sampling are usually influenced by the purpose and questions of the study. Quantitative studies emphasize the representativeness of large samples, whereas qualitative studies seek a detailed and in-depth understanding of each individual. Therefore, a purposeful sampling method was used in this study. According to the International Standards for Professional Competence of Mandarin Chinese Teachers, the digital literacy and competency structure, and evaluation standards of Mandarin Chinese teachers in related studies, factors such as years of teaching, professional titles, teaching targets and places, 25 Mandarin Chinese teachers were selected as participants, including 3 associate professors, 11 lecturers, 6 doctoral students and 5 with no titles, with the duration of teaching ranging from 5~15 years. Table 1 shows the demographic profile of the interviewees.

Table 1: Demographic profile of the interviewees (N=25)

Numbering	Gender	Nationality	Years of Teaching	Professional Title	Teaching Target	Teaching Place
T1	Female	China	5	Doctoral student	Primary and secondary schools and adults	United States; Indonesia
T2	Male	China	12	lecturer	Primary and secondary schools and universities	China; Cambodia; Georgia
T3	Female	Mongolia	6	lecturer	Primary and secondary schools	Mongolia
T4	Female	China	13	Associate Professor	University	China
T5	Female	China	11	lecturer	University	China
T6	Female	China	13	Associate Professor	University	China
T7	Female	China	7	Null	Primary and secondary schools and universities	Ireland; Kenya
T8	Male	Vietnam	7	Doctoral student	University	Vietnam
T9	Female	China	12	lecturer	University	China
T10	Male	China	10	lecturer	Primary and secondary schools and universities	China; South Africa
T11	Female	China	6	lecturer	University	China
T12	Male	France	8	lecturer	Primary and secondary schools and universities	France
T13	Male	China	7	Doctoral student	Primary and secondary schools and universities	Botswana; Ukraine; China
T14	Female	China	11	Associate Professor	University	China
T15	Female	China	8	Doctoral student	Primary and secondary schools and universities	Georgia; Uzbekistan
T16	Male	Tanzania	5	Doctoral student	University	Tanzania
T17	Female	China	6	Null	Primary and secondary schools and universities	Mozambique; Tanzania
T18	Female	China	15	lecturer	University	China

T19	Female	China	8	Null	Primary and secondary schools	United States; China
T20	Male	China	12	lecturer	University	China
T21	Female	China	9	Null	Primary and secondary schools and universities	United States; Australia
T22	Female	China	8	Null	Primary and secondary schools and universities	South Korea; United States
T23	Male	China	7	lecturer	Primary and secondary schools and universities	Thailand; China; Madagascar
T24	Female	China	10	lecturer	University	South Korea; China
T25	Male	Afghanistan	7	Doctoral student	University	Afghanistan

Instrument and Measures

Before all the interviews, the researcher carefully informed all the participants about the aim and purpose of the research. Other issues, including reducing the risk of potential harm, protecting the interviewee's privacy, and reducing the risk of exploitation, were also taken into consideration. On the basis of the researcher's self-cognition and understanding, closely following the theme of "difficulties and needs of Mandarin Chinese teachers' educational application of technology in the era of digital intelligence", the researcher first developed a preinter view outline and interviewed 10 Mandarin Chinese teachers who were not the sample for formal study in advance to gain a basic understanding of the awareness, attitudes, knowledge and skill performance of Mandarin Chinese teachers' technology application in teaching, as well as the difficulties and actual needs of technology application. Then, according to the results of the preinter view and related technology anxiety scales [28,29], the researcher compiled a formal interview outline and invited five doctoral students majoring in Mandarin Chinese education to modify the outline or propose suggestions for improvements. The interviews focused on Mandarin Chinese teachers' perceived usefulness and ease of use of technology (e.g., do you think that digital intelligence technologies such as intelligent learning guidance systems and intelligent robots will gradually replace human teachers?), the correlation between technology and language education (e.g., Are you concerned about the development and trend of cutting-edge technologies in the field of Mandarin Chinese education?), teachers' self-evaluations of technology capacity (e.g., How often do you apply information technology in language teaching?), emotional status during the application of technology (e.g., When using intelligent teaching equipment, do you worry about damage or difficulty in controlling the equipment?). As the iterative nature of qualitative research in which data collection and analysis coincide may result in altering the guiding questions, questions that are not effective at eliciting the necessary information can be dropped and replaced with new ones [30]. The researcher, therefore, made some adjustments to the original research questions according to the progress of the interviews.

Data analysis

The interviews were conducted individually through WeChat, Zoom or face-to-face methods. A total of 25 pieces of recorded material that lasted 938 minutes were obtained from the interviews, with the longest one lasting 57 minutes and the shortest one lasting 33 minutes. The data collected were analyzed through a series of steps, which started by reviewing and transcribing the data, applying descriptive codes to the data, condensing and categorizing the data to identify patterns, and then phrasing and verifying the results via the software NVivo12. In addition, twenty pieces of the materials were randomly selected as research coding data, and another five were reserved for the final theoretical saturation test. For descriptive coding, the researcher adopted the grounded theory approach via a mixture of both software-assisted and manual methods. The grounded theory approach is commonly used for analysis strategies. It relies on using codes to tag segments from text material and then sorting the segments with similar content into separate categories, thereby distilling categories into major themes [31]. During the process of open coding, which focuses on research questions, the researcher first defined and tagged the original sentences through repeated comparison, induction and integration with an open attitude. Then, combined with the original data, the researcher integrated and conceptualized the tagged sentences, thereby phrasing related concepts. Finally, together with the original data and classroom observations, which provided clear insight into teachers' actual experience and emotional status when applying educational technology in teaching, the researcher analyzed and

compared the concepts formed in the last phase to identify the initial category. Table 2 shows an example of open coding. During the process of axial and selective coding, on the basis of the results of open coding, continuous comparisons and analyses were performed to clarify the relationships between initial categories and form the main categories. Then, on the basis of the initial categories and main categories, a number of core categories with leading meanings are formed. Finally, the researcher explored and phrased the story line of the research and then explained the results by constructing a theoretical model. Table 3 shows an example of axial and selective coding.

Table 2: Examples of Open Coding

Original Statements	Labels	Conception	Initial Category
I myself lack technology capacity, so sometimes I don't dare to use the technology equipment in the classroom, for fear of damaging it. (T9)	Lack of technical capacity, being afraid to use smart devices and worried about damage to the equipment	Lack of capacity hinders technology application practice	Avoid or reduce the use of technology
In XX (country), our teaching branch is located in a remote primary school, and there are only chalks, blackboards, and teaching tables in the classroom. Actually, you don't have any chance to use technical tools at all. (T12)	Lack of digital teaching environment hinders the use of technical tools	Teaching environment limits the frequency of technology use	Lack of technology use environment

Table 3: Examples of axial and selective coding

Initial Category	Main Category	Core Category	Typical Relationship
Avoid or reduce the use of technology	Insufficient internal capacity	Cognitive dilemma anxiety	Manifestations of mandarin Chinese teachers' technology anxiety in the era of digital intelligence
Lack of technology use environment	Lack of external opportunities		
Teachers and students' improper mining, utilization and preservation of data and information	Worries about information transparency	Ethical security anxiety	
Teachers and students rely too much on technology and lack independent thinking	Technology dependence and virtual addiction risk		
Deep integration of intelligent technology and education	Technology iteration	Technical factors	Influencing factors of technology anxiety of mandarin Chinese teachers in the era of digital intelligence
Technical tools do not match mandarin Chinese education	Technology adaptability		
Negative influence of technology cognition of teacher group	Group influence	Environmental factors	
Lack of training and guidance on new technical knowledge and skills	Training and guidance		

In this research, semi structured in-depth interviews were used to collect data, scenario analysis and category analysis of qualitative studies were used as methods, NVivo12 software was used as the coding tool, and data from class teaching observations were supplemented. Focusing on the theme of Mandarin Chinese teachers' technology anxiety in the era of digital intelligence, the researcher dug deep into and mined the data to construct a theoretical configuration through a bottom-up approach. According to the questions and aims of the research, the researcher continuously analyzed and compared the concepts, initial categories, main categories and core categories and reported that the core of all these items formed in the coding and analysis was the formation of Mandarin Chinese teachers' technology anxiety; then, the story line was defined as "the formation mechanism of Mandarin Chinese teachers' technology anxiety". The results indicated that Mandarin Chinese teachers suffer from technology anxiety due to both internal and external factors. The internal capacity, comprising technology capacity, perceptions of technology, cognition of technology, cognition of technology risk and technology self-efficacy, played a decisive role in leading to the formation of teachers' technology anxiety. External

factors, including technology-related factors, environment-related factors, and student-related factors, were the precipitating factors that accelerated the formation of such anxiety. Cognitive dilemma anxiety, technology-induced obstacle anxiety, career development anxiety, and ethical security anxiety were the main manifestations of Mandarin Chinese teachers' technology anxiety. On the basis of the typical relationship and analysis, the researcher took the organism—teacher—as the core and constructed a "Factor-Organization-Anxiety Manifestation" (FOAM) model, as shown in Figure 1.

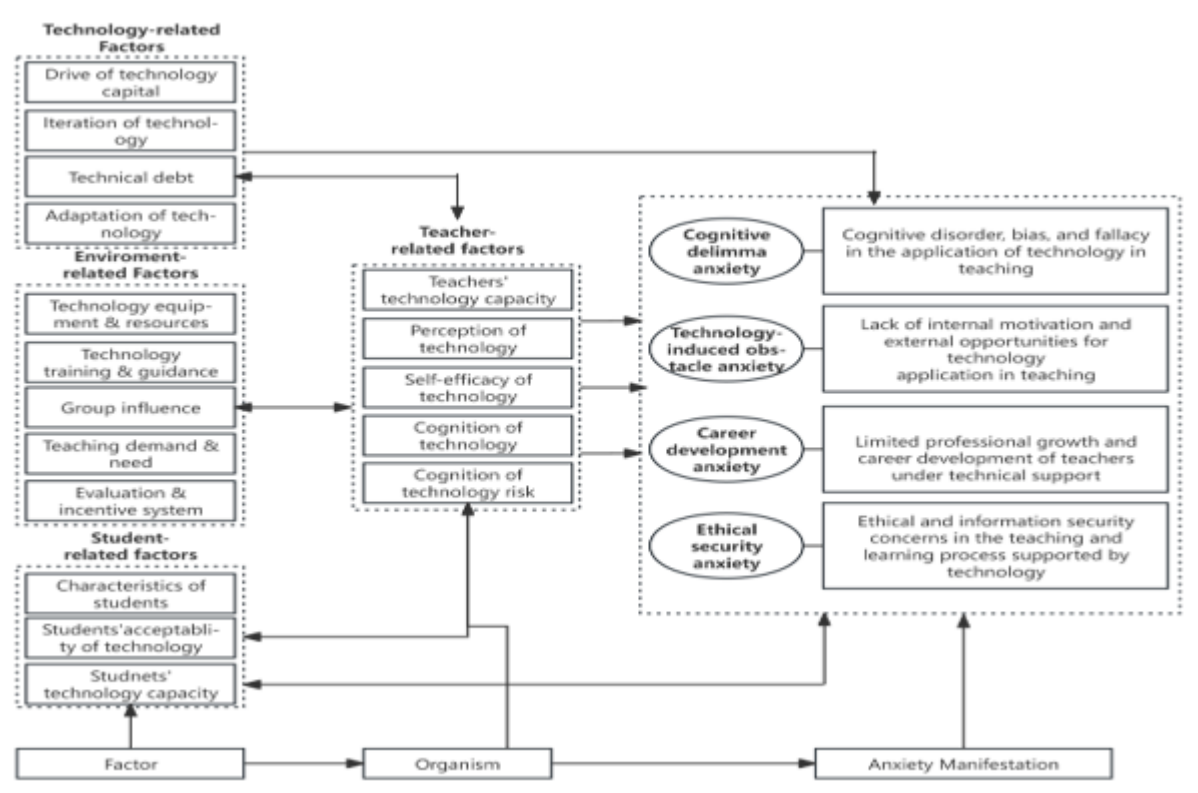

Figure 1: Factor-Organization-Anxiety Manifestation (FOAM) formation mechanism model

Theoretical saturation test

Theoretical saturation is defined as testing the identified categories with new data until no new codes or categories appear, which is a criterion to stop sampling in grounded theory [32]. In this study, 25 Mandarin Chinese teachers were interviewed. After the second round of coding for the remaining five interview texts, no new conceptions, initial categories, main categories or core categories were formed. These findings are consistent with the formation mechanism model of Mandarin Chinese teachers' technology anxiety, which means that the model above is theoretically saturated.

Keywords and Model Interpretation

Technology anxiety indeed takes several forms, and two of the most prominent concerns are as follows: one is that technological progress will cause widespread substitution of machines for labor, leading to technological unemployment and a further increase in inequality in the short run, even with long-term benefits; the other is that there is anxiety over the moral implications of the technological process for human welfare [33]. Studies have demonstrated that technology anxiety can be induced by users' previous computer experience [8], low technology training [34], technology insecurity [35], and technology self-efficacy [36]. Moreover, technology anxiety might increase to a high level due to the rapid development of advanced technology [37]. Accordingly, the psychological manifestations of technology anxiety caused by the deep integration of technology and education are also more complex and diversified.

Manifestations of the Technology Anxiety of Mandarin Chinese Teachers

Cognitive Dilemma Anxiety: Distorted Cognition

The iteration of digital intelligence technology brings unprecedented convenience to Mandarin Chinese education but, at the same time, imposes new requirements on teachers' professional literacy and profoundly affects teachers' cognition of technology.

The cognitive dilemma anxiety of Mandarin Chinese teachers has resulted mainly from their cognitive distortion of digital intelligence technology, which manifests as cognitive dissonance, cognitive bias and/or cognitive fallacy. Cognition dissonance is usually induced and triggered when an individual has two or more kinds of cognition in conflicts, and this affective state with negative emotions and discomfort has a significant effect on the motivation of individuals to resolve the aroused dissonance [38,39]. In response to the question "What is your opinion about online teaching?", interviewee T23 said, "*At first, I thought online teaching could help me reduce the fatigue and time of travel, but later, I found that online teaching was much more exhausting.*" Mandarin Chinese teachers usually had cognitive bias when they perceived the usefulness and ease of use of technology due to the teaching environment and its internal reasons. T3, T12, and T13 noted that digital intelligence technologies had been of little practical value in Mandarin Chinese education because of the imperfect modern teaching equipment in their schools. Moreover, the cognitive fallacy resulting from conclusions based on fallacious reasoning made it easier for Mandarin Chinese teachers to be caught in information cocoons. For example, T13 mentioned that the Mandarin Chinese teachers around him all held the view that digital intelligence technologies did not truly make a difference from Mandarin Chinese teaching and that they would prefer to adopt traditional teaching methods. Teachers with this cognitive distortion are likely to be engulfed in anxiety and fall into information cocoons. On the one hand, information cocoons may narrow the range of teachers' cognition and affect their communication and cognition of the outside world; on the other hand, due to a lack of interaction with the outside world, teachers' thinking may be solidified [40]. In this way, Mandarin Chinese teachers would be inclined to pay much more attention to information oriented toward personal preferences, indulge themselves in such information, and gradually show bias against the perception, understanding, and application of technology, thus being besieged by the cognitive dilemma.

Technology-induced Anxiety: The Denied Opportunity

Digital intelligence technologies offer high efficiency and convenience in Mandarin Chinese education, but they also pose invisible obstacles for some teachers. Researchers believe that people can adopt technologies normally only if they have both internal capacity and external freedom and opportunities; otherwise, there are obstacles and limitations to technology adoption [41-43]. Influenced by the teaching environment and their technology capacity, it is very difficult for most Mandarin Chinese teachers to have both internal capacity and external freedom and opportunities at the same time. Consequently, Mandarin Chinese teachers encountered technology-induced obstacles when applying digital technologies to teaching practices, and technology-induced obstacle anxiety subsequently appeared in response. Specifically, the technology-induced obstacle anxiety of Mandarin Chinese teachers manifested in two aspects: anxiety about their internal technology capacity and anxiety about a lack of external freedom and opportunities for technology adoption. In terms of internal capacity, Mandarin Chinese teachers tended to avoid or reduce the integration of technology and teaching due to their inadequacy of technology capacity and lack of technology application training and technical resources, which led to anxiety about their internal technology capacity. In terms of external freedom and opportunities, whether technological teaching facilities were well equipped, whether students had technology capacity, and whether technologies were well adapted to Mandarin Chinese teaching content placed some limitations on teachers' integration of technology and teaching to a certain extent. It was such a prominent phenomenon in relatively tough teaching areas that Mandarin Chinese teachers were "deprived" of the freedom and opportunities to adopt digital intelligence technologies to support their teaching. For example, Teachers T5, T16, and T25 all mentioned that they were hindered from adopting digital intelligence technologies in Mandarin Chinese teaching due to imperfect technology-assisted facilities in schools where they stayed, limited technology acceptance of their students, and their lack of technology capacity.

Career development anxiety: the weakening caregiver

With rapid development, digital intelligence technologies have replaced some jobs that only need skillful techniques and repetitive labor. According to McKinsey, 50% of global jobs will be replaced by artificial intelligence in 2045 [44]. Discussions on the substitution of digital intelligence technologies for jobs have caused anxiety and apprehension among many practitioners. Digital intelligence technologies

such as intelligent tutoring systems, personalized learning resource pushes and provisions, intelligent chat bots, and virtual and augmented reality are deeply integrated with education, and teachers' professional independence is imposed by challenges such as the deconstruction of intellectual authority, the weakening of explanations and evaluation rights, and the marginalization of their central position [45,46]. The results of this research indicated that the career development anxiety of Mandarin Chinese teachers manifested as professional survival anxiety, professional growth anxiety, and role-conflicting anxiety. For teaching, digital intelligence technologies could help with automatic exercise design and correction, real-time learning tracking and accurate feedback. For the push and provision of learning resources, digital intelligence technologies could help provide massive amounts of personalized and tailored learning resources. An intelligent tutoring system and chatbot, at the same time, could help with teaching and learning at any time and place, enhance deep interaction between individuals and technologies, and visualize interpretation data. Confronted with the challenges and threats of digital intelligence technologies, it was inevitable for Mandarin Chinese teachers to have career development anxiety, which was interpreted as "*worries that digital intelligence technologies will replace most Mandarin Chinese teachers and that teachers are facing crisis of high unemployment (T10); apprehensions about the slow renewal of Mandarin Chinese teachers' expertise and teaching skills, which hinders the development of profession literacy (T6); and doubts that the role of digital teachers as educators, supporters, collaborators, and instructors will weaken the professional role of Mandarin Chinese teachers in an all-round way (T10).* "Career development anxiety adversely affects the mental health of teachers, which involves emotional pessimism, suspicions and uneasy, and nervousness as specific types of anxiety [47]. The results of this research indeed showed that Mandarin Chinese teachers experiencing such anxiety held a pessimistic view of their professional development.

Ethical Security Anxiety: Invisible Risk

Digital intelligence technologies, which generate artificial intelligence as a breakthrough, empower teaching and learning with high-quality content generation and deep human–computer interaction. However, the application of these algorithm-based recommendation technologies in education has surpassed its instrumental rationality and evolved into an ideological technology with a deep interplay network of capital, value and power competing behind it [48,49]. Digital intelligence technologies, especially generative artificial intelligence, have attracted much more attention and have been widely adopted in the field of education. It is faster and more convenient to obtain information with the help of technologies, but they simultaneously pose certain risks and threats to users. For example, privacy leakage and information exposure result in privacy transparency [50], preferences for algorithm-based recommendation technologies lead to education discrimination [51], technology dependence and virtual addiction cause emotional risks in education, and disputes about the legal personality of intelligent robots as digital humans give rise to education legal risks [52]. All these problems make education-related ethical security risks increasingly prominent in the era of digital intelligence. As some interviewees mentioned, "*Our school bought an informational-based working system developed by a commercial company, and students' profile and family background information, personal experience and learning data are stored in that system. Later, we found that these data were sold to others privately by that company (T13).*" "*I found that some Mandarin Chinese teachers around me use PPTs, which were directly generated by AI tools, rarely made any further modifications, and they relied too much on technologies (T8).*" It can be predicted that the anxiety caused by information security, technology dependence and ethics in teaching will make the manifestations of Mandarin Chinese teachers' technology anxiety more complex and diverse.

The Generation Mechanism of the Technology Anxiety of Mandarin Chinese Teachers

Technology anxiety in the education field arises in the process of interactions between education participants and technology. This psychological state is not achieved overnight but rather is the result of accumulation over time. Mandarin Chinese teachers' technology anxiety arises from the interplay between teachers' psychological cognition, reflection on technology capacity and external inducements, including technology-related factors, environment-related factors and student-related factors.

Teacher-related Factors: The Root of Technology Anxiety

Teacher anxiety can be defined as "a feeling of fear, worry, and uneasiness, usually generalized and unfocused as an overreaction to a situation that is

only subjectively seen as threatening [53]". Teacher anxiety is not only a present negative experience of teachers' professional life but also reflects teachers' contradictory state of future career life. This contradiction, which mandarin Chinese teachers face, results from the complex interaction between teachers' internal factors and other external precipitating factors. Teacher-related factors, referring to internal factors that include technology capacity, perceptions of technology, cognition of technology, cognition of technology risk, and technology self-efficacy, are the core factors in the generation of teachers' technology anxiety. First, Mandarin Chinese teachers' subjective understanding and evaluation of the perceived usefulness and ease of use of technology in language education, namely, technology perceptions and cognition, strongly affects teachers' acceptance and adoption of technology. Teachers' poor acceptance of technology and avoidance or refusal to adopt technology in education naturally caused teachers' technology anxiety. For example, T18 thought, "At *present, the integration of Mandarin Chinese education and technology is at its very beginning stage. In fact, digital technologies have not been well integrated into Mandarin Chinese education, and these technologies do not work well and lack operational efficiency. Mandarin Chinese teachers seem to prefer traditional teaching methods.*" Second, Mandarin Chinese teachers' awareness of the risks induced by intelligence technologies and their technology self-efficacy usually react to teachers' technology adoption behaviors, thereby leading to technology anxiety. Technology self-efficacy can be defined as the belief that people have sufficient and correct abilities and skills to deal with a technological task successfully [54,55]. Research has indicated that users with lower technology self-efficacy are more vulnerable to higher levels of technology anxiety in both the classroom and workplace [56], and technology self-efficacy is considered to be a significant predictor of a user's future academic and career trajectories [57]. As some of the interviewees mentioned, the credibility of digital intelligence technologies, algorithm preference, information transparency and ethical problems caused by technology were among the important obstacles for teachers to adopt technology in teaching. In addition, a relative lack of technology capacity was one of the most important factors resulting in teachers' technology anxiety. As such, a lack of capacity usually leads to a decrease in teachers' self-confidence in technology adoption, which inevitably provokes technology anxiety. T1 mentioned in the narrative that he often unintentionally operated the teaching equipment incorrectly, and his students were always laughing at him because of his poor technology skills. He gradually lost confidence in himself and avoided adopting technology in his teaching.

Technology-related Factors: The Triggers of Technology Anxiety

Teachers' technology anxiety is closely related to technological advances. Technology-related factors, including the drive of technology capital, iteration of technology, technical debt and adaptation of technology, are the triggers of Mandarin Chinese teachers' technology anxiety. First, technology capital is the initial driving force of technology-related factors. Technology capital strongly promotes the deep integration of technology and education. Education technological enterprises hank to develop various educational technologies, and they could not wait to provide services for teaching activities. However, in the process of pursuing more value and strongly promoting iteration of technology, technology capital seems to have overstepped the boundaries of its initials, which hinders the development of educational technologies [58]. In particular, under the influence of the COVID-19 pandemic and other factors, the capital market continues to hype up with the advantages of intelligence technologies, exaggerating or even boasting the great role of intelligence technology integration into education, and they apparently try to create technology anxiety. Second, intelligence technologies have matured in iteration, and such tortuous advancements in technology indicate the ups and downs of the emotional changes of technology users [59,60]. Teachers are no exception in the era of digital intelligence, and they are bound to be impacted by the development of technology, which inevitably leads to teachers' technology anxiety. Faced with various intelligence technologies, such as mushrooms, teachers are already at a loss in terms of technology selection, learning and application. If the problems existing in technology itself cannot be solved well, that is, if the technical debt is becoming heavier or if the adaptation of intelligence technologies to teaching is not good, teachers show no perceptions, desires or capabilities in applying digital intelligence technology to teaching. With the interplay of technology-related factors, teachers' technology anxiety increases sharply. For example, T2

noted, *"I just got familiar with Tencent Conference, and here come ZOOM, Class-in. I believe most of us cannot skillfully cope with them. Teachers use different online platforms, and students are truly facing a great burden."* T13 thought, "*Language education has its particularity, emphasizing communication and interaction between teachers and students, and I have not found a kind of technology that can serve well.*" Additionally, artificial intelligence is moving from weak artificial intelligence to strong artificial intelligence. When artificial intelligence can make decisions by itself and create independently and consciously, teachers' technology anxiety will be further aggravated.

Environment-related Factors: The Catalyst of Technology Anxiety

Environment-related factors are catalysts of the generation of technology anxiety among Mandarin Chinese teachers. Environment-related factors include the material environment, institutional environment and teaching environment, which are reflected mainly in technology equipment and resources, technology training and guidance, group influence, teaching demand and need, and evaluation and incentive systems. First, the shortage of intelligent teaching equipment and resources imposes limitations on the technology application of Mandarin Chinese teachers and accelerated the generation of teachers' technology anxiety. Research has suggested that teachers who work in schools with poor resources usually experience high anxiety levels compared with those who work with more resources [61]. In this research, especially in areas with poor equipment, teachers could only provide oral explanations and take wall chart demonstrations to assist their teaching, and teachers generally experienced panic and apprehension of resources and equipment, thus accelerating the emergence of technology anxiety. For example, Teacher T17 said, "*Every time I prepare for my lessons, I want to show students many beautiful pictures and wonderful videos, but the classroom equipment is too poor to play them at all. I cannot take a laptop and let dozens of students stare at a small screen, which cannot play an auxiliary role at all. When thinking of preparing for lessons, I don't have any motivation.*" Technology training and guidance is an effective way for Mandarin Chinese teachers to improve their capacity to apply digital intelligence technologies, but there are few trainings and guidelines for Mandarin Chinese teachers to improve their knowledge and ability of intelligence technologies. In addition, most Mandarin Chinese teachers do not have many opportunities to be promoted professionally, which results in a lack of impetus and passion to improve their teaching capacity supported by digital intelligence technologies. Moreover, some teachers do not have a better understanding and greater understanding of the integration of digital intelligence technologies and language education, which affects each other in the teacher group. This environment has become the "incubator" for teachers' technology anxiety. As most teachers in the interviews mentioned, they usually taught supported by PPTs and related videos, and they were not clearly aware of the practical ways and methods of integrating digital intelligence into Mandarin Chinese teaching. Another factor within the environment that impacts Mandarin Chinese teachers' technology anxiety is evaluation and incentive systems, which have been found to lead to higher teacher stress and anxiety rates [62,63]. This anxiety brought to the classroom by teachers might lead not only to students' anxiety but also to ineffective teaching practices and environments for teachers.

Student-related Factor: The Booster of Technology Anxiety

Student factors, including students' characteristics, students' acceptability of technology and students' technology capacity, are the boosters of Mandarin Chinese teachers' technology anxiety. Among the students' characteristics, their age and personality were found to be associated with teachers' technology integration. First, as digital natives, referring to people who are accustomed to the use of digital technologies for learning and sharing knowledge [64], younger Mandarin Chinese learners have a better ability to learn and apply digital intelligence technologies, and they are more sensitive to new technologies. In contrast, most Mandarin Chinese teachers were born as digital immigrants, referring to people who do not have a certain ability and applicability of digital intelligence technologies and usually have insufficient ability to learn and apply digital intelligence technologies to teaching. Furthermore, the results suggested that Mandarin Chinese teachers' capacity for digital technology integration barely met the basic needs of classroom presentations. Given that students have strong learning ability and great technology application ability, Mandarin Chinese teachers are usually under increasing pressure, resulting in technology anxiety. Second, facing new intelligence

technologies, some students are interested in new advances, take the initiative and adopt it, whereas others are resistant to it. When teachers are not very skilled in intelligence technologies and when students have different levels of technology acceptability, Mandarin Chinese teachers' technology anxiety obviously increases. In addition, studies have indicated that students' technology capacity plays a positive role in their attitudes toward technology [65], affects their learning outcomes [66], and interacts with teachers' teaching. Students' lack of technology capacity affects teachers' attitudes toward the adoption of technology in their teaching, which, to a certain extent, influences teachers' technology self-efficacy, thus accelerating the generation of their technology anxiety. In summary, as participants in teaching and learning, students' characteristics, acceptance of technology and capacity indeed play a significant role in increasing Mandarin Chinese teachers' technology anxiety.

Conclusions and suggestions

General Conclusions

In conclusion, this paper yielded important insights into Mandarin Chinese teachers' technology anxiety. This research, which is simultaneously constrained by teachers' cognitive dissonance and barriers to technology adaptation, involves both the drive of technology capital and the iteration of technology and is impeded by a lack of technology resources and equipment and invisible technology risk, mandarin Chinese teachers are influenced by all these factors, and their technology anxiety is triggered and aggravated in the era of digital intelligence. Bernstein (1983) noted that long-term serious anxiety not only affects teachers' physical health but also adversely affects teachers' teaching behavior and that anxiety might be the root of many teaching problems [67]. Gardner and Leak (1994) reported that anxiety not only made it difficult for teachers to work happily and achieve sustainable career development but also led to teachers' aversion to teaching jobs [68]. The results of this research indicated that the technology anxiety of Mandarin Chinese teachers, on the one hand, affected their beliefs about the ability to adopt digital technologies in teaching and their beliefs about the time and effort to adopt digital technologies; on the other hand, technology anxiety might cause avoidance or acceptance issues for new technologies. Technology anxiety is not only a manifestation of teachers' irrational psychological state but also a negative experience in teachers' daily teaching jobs, which seriously hinders the professional growth and career development of Mandarin Chinese teachers. Moreover, technology anxiety with psychological burnout as a symptom has become an important factor affecting Mandarin Chinese teachers' mental health. Therefore, on the basis of the realistic manifestations and generation logic of Mandarin Chinese teachers' technology anxiety, this paper proposes the following suggestions for relieving teachers' technology anxiety.

Suggestions for Teachers' Professional Development

Helping teachers hold positive technology cognition and value evaluation viewpoints

The emergence of Mandarin Chinese teachers' technology anxiety in the era of digital intelligence, to a certain extent, was due to teachers' lack of digital intelligence technology self-efficacy, teachers' lack of awareness and expectations of changing their roles in the era of digital intelligence, and the fuzziness of the effectiveness of digital intelligence technologies applied in education. Therefore, to relieve the technology anxiety of Mandarin Chinese teachers, we should focus not only on cultivating digital intelligence technology self-efficacy but also on alleviating the impact of role changes and enhancing teachers' technology cognition. We should also concentrate on evaluating the value of the application of digital intelligence technologies in Mandarin Chinese education to help teachers reflect on the effectiveness of digital intelligence technologies applied in the Mandarin Chinese teaching context. On the one hand, intelligent equipment-based teaching competitions should be carried out to stimulate Mandarin Chinese teachers to actively learn digital intelligence technologies, improve technology self-efficacy, and enhance their faith and confidence in the adoption of digital intelligence technologies in Mandarin Chinese teaching. The government, schools, enterprises, and other relevant parties should organize lectures and forums given by scholars and experts in the field of digital intelligence technologies to increase publicity to help Mandarin Chinese teachers fully understand the role of digital intelligence technologies in education and adopt technologies correctly. All possible parties should guide Mandarin Chinese teachers in understanding their teacher leadership role in digital intelligence

technologies and education adoption of such technologies and help teachers clarify the persistence and expectations of subjectivity in the role of teachers in the era of digital intelligence. On the other hand, all possible parties should jointly build a teaching monitoring system for the integration of digital intelligence technology and Mandarin Chinese courses to assess the effectiveness of teaching supported by digital intelligence technologies to reinforce teachers' perceptions and recognition of the application value of technologies applied in teaching. Mandarin Chinese teachers should be encouraged to collect students' learning data in multiple ways and record the whole process by using digital intelligence technologies, including artificial intelligence and big data; visually present and interpret learning data; and understand the practical value of evaluating digital intelligence technologies. In addition, schools and other relevant parties can use digital intelligence technologies to mine multidimensional data such as teachers' teaching behavior, teaching processes, teaching results, students' learning performance and learning results; assess the effectiveness of teaching supported by digital intelligence technologies on the basis of data evidence; help teachers understand the difficulties and actual needs of digital intelligence technology in Mandarin Chinese teaching applications; and help teachers reflect on how to apply digital intelligence technologies in contextual teaching.

Improving teachers' intelligent education literacy

As the behavior subject of technology anxiety, teachers' psychology, cognition and behavior habits are the decisive factors in the generation of technology anxiety. Therefore, cultivating and improving teachers' intelligent education literacy is the key point for alleviating Mandarin Chinese teachers' technology anxiety. With the development of knowledge, competency, thinking, and cultural values as the core supporting points of intelligent education literacy, teachers utilize educational artificial intelligence to inspire creative design and promote creative application and generation in the teaching and learning process [69]. First, constructing the basic knowledge system of intelligent education, including theoretical knowledge, practical knowledge and technical knowledge [70], should be the foundation and premise of cultivating Mandarin Chinese teachers' intelligent education literacy. Second, owing to the contextualization of Mandarin Chinese teachers' technology anxiety, the cultivation of teachers' intelligent education literacy should focus on contextual teaching practices, promote the deep integration of digital intelligence technologies and Mandarin Chinese teaching, and enhance teachers' digital intelligence teaching capacity, thus alleviating teachers' anxiety about the integration of digital intelligence technologies in Mandarin Chinese teaching. Finally, improving Mandarin Chinese teachers' intelligent education literacy is a systematic task that needs multiagent cooperation. Specifically, relevant parties should establish standards for the intelligent education literacy of Mandarin Chinese teachers to standardize and lead the practice of intelligent education of Mandarin Chinese teachers and guide the cultivation and training of the intelligent education literacy of Mandarin Chinese teachers. Intelligent education literacy has been incorporated into the preservice Mandarin Chinese teacher training curriculum system, and intelligent education literacy has been integrated into the post service Mandarin Chinese teacher training program to establish an integrated development system for the preservice and post service training of Mandarin Chinese teachers' intelligent education literacy. Mandarin Chinese education institutions, including Confucius Institutes, should provide a good digital and intelligent teaching environment for teachers and provide courses and learning resources related to intelligent education literacy, communication and application platforms and system support. The intellectual support of intelligent education research teams, the technical support of artificial intelligence enterprises, and the organizational support of professional development groups should be integrated to provide a diverse basis for improving teachers' intelligent education literacy [70]. In the era of artificial intelligence, teachers should implement strategies for lifelong learning, although they are affected by financial problems, educational policies and learner profiles [71]. Teachers should pay attention to the new progress and new trends in Mandarin Chinese education empowered by digital intelligence technologies, learn new technical knowledge and skills, explore paths and methods of integrating digital intelligence technologies and Mandarin Chinese teaching, focus on improving their ability to teach empowered by intelligent technology and integrate evidence-based practices in education [72]. Teachers accumulate experience during the application of digital intelligence technology in

teaching practice and enhance their capacity to teach empowered by digital intelligence technologies.

Exploring man–machine collaboration and giving full play to teachers' professional advantages

Digital intelligence technologies reshape the education process, change the education model and continuously improve the quality of education. However, it should be noted that the essence of technology reshaping education is technology reshaping "the technology for education [73]", not education itself. In other words, despite the deepening integration of digital intelligence technologies and education, teachers are still the key factors of education and teaching and play a greater leading role. Facing the infinite extension of the teaching process and domain empowered by digital intelligence technologies, Mandarin Chinese teachers are worried about their career development prospects and even fear and panic about the educational changes brought about by digital intelligence technologies to a certain extent. As the core participants in Mandarin Chinese education, teachers should actively explore a new mode of man–machine collaboration in educating people and give full play to teachers' professional advantages in the era of digital intelligence. First, teachers should clarify their leadership role in digital intelligence technologies and education adoption of such technologies. The deep integration of digital intelligence technologies and Mandarin Chinese education promotes the transformation of intelligent Mandarin Chinese education, helps with the high-speed sharing of decision-making and the intelligent generation of educational decision-making [74], which requires Mandarin Chinese teachers to play their leading and exemplary role in using digital intelligence technology to lead digital intelligence Chinese education, analyze and solve digital teaching problems, integrate and build digital teaching resources and feedback teaching processes, and clarify their leading role in intelligent Chinese education. Second, teachers need to clarify their role as a guide for "teaching them to fish". The wide application of digital intelligence technologies accelerates the transformation of learning methods to autonomous, inquiry, interdisciplinary and intelligent methods and enables students' choice of learning content, learning methods, learning resources and learning depth. At this time, Mandarin Chinese teachers need to give full play to the role of "teaching them to fish", not only to increase students' awareness and ability to engage in autonomous learning but also to improve students' ability to identify and use information and guide students to master scientific learning methods to cultivate their ability to learn through the use of digital intelligence technologies. Finally, rooted in the advantages of human nature, Mandarin Chinese teachers should maintain educational value. Teachers' advantages are reflected in their complex emotions and profound thoughts, consciousness and ability to consciously guide students, self-awareness and ability to integrate instrumental rationality and value rationality [46]. Under the mode of man–machine collaboration, teachers should stick to the essence of education, give full play to the positive value influence of digital intelligence technology, and cultivate students' innovative consciousness and ability. Teachers not only play the role of "teachers" in imparting knowledge and skills but also play the role of "teachers" in educating people by virtue to realize man–machine collaboration and coeducation in adhering to educational values and emotional interactions.

Instructing teachers to understand and address safety ethics problems

We have not considered the consequences of the artificial intelligence technology revolution, which may create a mechanized world that is not bound by social ethics and norms but is completely driven by data and algorithms [75]. With the wide application of digital intelligence technology in the field of Mandarin Chinese education, digital intelligence technologies not only optimize the teaching and learning process and improve its efficiency but also lead to information leakage and privacy transparency among teachers and students and even the risk of degrading teachers and students. Therefore, it is necessary to improve the ethics of intelligent educational technology, prevent the distortion and alienation of educational technology application, and relieve the technology anxiety of Mandarin Chinese teachers. First, relevant parties should organize experts and scholars in the fields of digital intelligence technology and Chinese education as soon as possible to design and implement the application regulations of digital intelligence technology in Chinese education by evaluating and adjusting existing data protection laws, network security regulations and related laws in response to the problems derived from the application of digital intelligence technologies. Second, digital intelligence technology developers

and technology service providers should clarify the purpose and specifications of digital intelligence technology education applications by providing information such as trusted data and models, nondiscriminatory content generation, generated content identification, security and privacy regulations, and monitoring and reporting technology abuse. Finally, users of digital intelligence technology, including institutions and individuals, should constantly enhance their ability to apply digital intelligence technology correctly and reasonably in education, teaching and research. Institutions, schools and research institutions should take measures to promote teachers' effective use of digital intelligence technology to assist in teaching. For example, they should strictly examine the algorithm, data and output of technology; protect the rights and interests of users; and evaluate and solve the far-reaching impact of the application of digital intelligence technologies on critical thinking and creativity. At the same time, training and continuous guidance for teachers and researchers should be provided. Teachers should persist in lifelong learning, improve their technology literacy, constantly innovate and apply new technologies, improve their technical cognition and understanding, and help improve students' ability to use digital intelligence technology to assist learning to alleviate technology anxiety. For example, teachers can continuously improve their technical perceptions and risk awareness by participating in professional training, forums and discussions. Teachers set learning examples and guide students to make correct and rational use of digital intelligence technology for independent exploratory learning.

Declarations

Author contributions

Conceptualization, K.T., H.H.M. and Y.N.W.; methodology, K.T. and H.H.M.; software, K.T. and Y.N.W.; formal analysis, K.T., H.H.M. and Y.N.W.; resources, K.T. and H.H.M.; data curation, K.T. and Y.N.W.; writing-original draft preparation, K.T. and Y.N.W.; writing review and editing, K.T. and H.H.M. visualization, K.T. and Y.N.W.; supervision, K.T. and H.H.M.; funding acquisition, K.T. All authors have read and agreed to the published version of the manuscript.

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Institutional Review Board Statement

This research study was conducted in accordance with the ethical standards of the Helsinki Declaration. The Zhejiang Normal University Institutional Review Board (ZJNUIRB) usually exempts educational research from the requirement of ethical approval.

Informed Consent Statement

Informed consent was obtained from all the subjects involved in the study.

Conflicts of interest

The authors declare that they have no conflicts of interest.

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