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ASSESSING DIGITAL TEACHING COMPETENCE: AN APPROACH FOR INTERNATIONAL CHINESE TEACHERS BASED ON DEEP LEARNING ALGORITHMS

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Abstract. Digital Teaching Competency (DTC) is an important skill in the professional development of international Chinese language teachers. This study developed a new deep learning-based assessment model of DTC for international Chinese language teachers. To build this model, the researchers first collected data on DTC from 221 international Chinese language teachers at different levels in 26 countries to ensure that these sample data are representative; secondly, clustering and feature dimensionality reduction techniques were used to preprocess the data and constructed the Siamese architectural model; and finally, the researchers confirmed through experimental validation and expert evaluations that the model has a high accuracy rate of 96.33%. The innovation of this model is to use the traditional three-level network as an improved constructed digital twin network, so as to extract some features that are more accurate and to characterize those features that are most predictive. The improved network is able to extract all the inputs globally and also locally that are of most interest to the user/researcher, the final prediction results are weighted, and those weighted results are used as the final prediction output of the model. This model not only provides systematic and adaptive support for improving teachers' DTC, but through the comprehensive result output, it can provide targeted improvement strategies for teachers to improve their DTC.

Key words: International Chinese teachers, professional development, digital teaching competence, assessment models, deep learning

1. Introduction. Due to advancements in information technology and the penetration of artificial intelligence research, online teaching has become one of the most important pedagogical methods for international Chinese language education [51, 19]. In the context of language education, digital teaching competence (DTC) has emerged as a crucial competency for teachers to acquire, emphasizing the need for effective methods to develop digital competence globally [37]. Assessment, as the primary method of evaluating teachers' competency, helps Chinese as foreign language (CFL) teachers improve their DTC and teaching effectiveness [61]. There has been little research on the digital competence of international Chinese teachers, and the current situation necessitates the development of more convenient and efficient methods of assessing DTC. However, existing research has highlighted the challenges that Chinese language teachers face in achieving high levels of proficiency in DTC and the lack of standard assessment methods available [54]. Teacher assessment does not exist in isolation from other aspects of the education system and must be considered alongside student development goals, curriculum objectives, and professional development [1]. Traditional evaluation methods rely on weights determined by experts to calculate competence scores, but these weights are neither flexible nor dynamic [7]. Furthermore, in teaching practice, the weights of dimensions such as student difference and teaching environment are supposed to be adjusted, which can be expensive when each adjustment necessitates a single expert decision.

It is undeniable that the education system faces challenges in the development and assessment of DTC, and more attention should be paid to these areas [12]. Artificial intelligence has the potential to achieve complex goals [46]. Intelligent algorithms are useful in teacher education because they reconfigure teaching practice and

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teachers' ideological construction [41]. Based on this, intelligent algorithms can be applied to teacher evaluations and personalize guidance during ongoing evaluations [22]. Deep learning algorithms are particularly effective in constructing machine learning models and improving classification or prediction accuracy. In this context, our research team has made a meaningful attempt to apply the algorithm technology to the field of international Chinese teachers [53]. By leveraging deep learning algorithms and training data, intelligent systems can learn valuable features, resulting in higher prediction accuracy of teachers' abilities [35]. Notably, these predictions only require the appropriate parameter settings, as the machine autonomously learns to assign weight to each dimension based on input [21]. However, limited studies have investigated the relationship between technology and DTC assessmentv [13]. To achieve sustainable development for international Chinese teachers, continuous innovations and algorithm design are necessary. From the perspective of technology, the question of how to assist teachers in effectively mastering digital teaching skills and accessing their digital competence in Chinese teaching has emerged as a primary concern [42].

Based on these issues, the authors of this paper conducted research on DTC for international Chinese teachers using deep learning algorithms. The first part provides a brief introduction to the evaluation of DTC for international Chinese teachers and outlines the research design. The second part presents an overview of domestic and international research on DTC and its assessment, summarising current research gaps. The third part designs a model for assessing DTC in international Chinese teachers, utilizing deep learning algorithms to address the shortcomings of traditional assessment methods. The fourth part analyses the constructed DTC model for international Chinese teachers in this study and validates its accuracy through experiments. The novelty of this paper lies in the use of algorithmic construction for a new evaluation approach. Considering the complexity of the classroom teaching environment, the author proposes a data-driven evaluation method based on deep learning.

2. Related Works.

2.1. Digital Teaching Competence. Digital teaching competence (DTC) is derived from digital competence (DC), which focuses on the acquisition of digital competence in the context of tools and technologies rather than a pedagogical model [14, 43]. DTC refers to the skills, competencies, and knowledge that teachers should master and develop in order to improve their teaching quality and efficiency in the classroom. In general, DTC can be defined as a set of knowledge, skills, or strategies used by teachers to address educational issues and challenges posed by society in the information age [39]. Krumsvik [23] defines DTC as "the teacher proficiency in using information and communications technology (ICT) in a professional context with good pedagogic-didactic judgement and awareness of its implications for learning strategies and the digital Bildung of pupils and research is primarily concerned with investigating the factors that influence DTC in order to improve it for teachers." Age, gender, teaching experience, and level of education are among these factors [4, 15, 38]. Other studies have focused on influencing factors such as teachers' perspectives on technology and ethical safety [11]. Furthermore, teachers' individual characteristics, particularly motivation and self-efficacy, have received a lot of attention [16].

However, most current research is disconnected from the study's context and focuses on a specific teacher competency while ignoring the impact of the larger environment [36]. Changes in education caused by AI have resulted in the growth of online distance learning, particularly in foreign language teaching [62]. It is therefore essential to investigate teachers' DTC. As technology advances, concepts around teaching competencies continually evolve, making it imperative to prioritize the development of technologies and solutions that fully support the education industry and thus lead to widespread improvements in education [24]. Research is increasingly exploring the relationship between technology and teachers, highlighting the need for more real-time support from AI mentors to determine when students require human assistance, assess the impact of their own help, and manage student motivation [17]. Tondeur [47] emphasizes the importance of preparing the next generation of teachers for the integration of technology into education. Therefore, the evaluation of DTC should consider a variety of technological aspects. However, how to apply new technologies, particularly AI, in education remains a grey area [25], requiring teachers to be prepared to introduce advanced technology into education. Hence, teacher education plays a critical role in preparing teachers for the future [32].

2.2. Assessment of DTC. Teachers' self-assessment provides the majority of feedback on teacher competence [10], and current DTC assessment is based on a number of frameworks. The European Framework for Digital Competence of Educators is the most commonly used assessment method, with a large number of empirical studies demonstrating its reliability [6]. Currently, the majority of DTC research in language teaching focuses on quantitative studies, employing instruments such as questionnaires for self-assessment, or expert judgments [65, 64]. However, self-assessment is frequently regarded as less accurate [16], and expert-based rubrics can be time-consuming. Although various frameworks have been used to assess teachers' DTC, their use in language teaching research has been limited [29]. According to Chinese scholars' research, there was no research framework on DTC for international Chinese teachers, and most scholars focused solely on theoretical aspects. Xu [20], for example, previously discussed the meaning, evaluation system, and cultivation of digital competence for teachers in a CFL context, which primarily focused on theoretical aspects with little attention paid to DTC in teaching practice. Lin [52]developed a DTC assessment system for international Chinese teachers at various levels of competence based on the Belt and Road initiative. Furthermore, Liu [54] proposed an assessment index for international Chinese teachers' DTC based on a survey of 205 working Chinese teachers. Furthermore, the proliferation of online teaching in Chinese language education has necessitated stricter DTC requirements [52]. The framework has made theoretical contributions to the evaluation of international Chinese teachers' DTC, but further empirical research support or promotion is needed.

In previous studies, algorithms have been utilized to assess teacher competence [44]. Fuzzy clustering algorithms have emerged as a more scientific, reasonable, and straightforward teaching evaluation method. However, the accuracy of these methods depends on the sensitivity of the initial data, and the clusters produced may not always be meaningful or accurate [53]. Bayesian algorithms, on the other hand, are faster, but have lower accuracy and are unable to effectively apply their findings to new datasets [44]. Decision trees are advantageous in that they provide interpretability and can effectively handle high-dimensional data. However, they are susceptible to overfitting and may not generalize well to new data [44]. Random forests, by contrast, can avoid overfitting, process quickly, and handle high-dimensional data, but have poor interpretability and may not always yield the most accurate predictions [34]. These studies have created a new perspective, linking DTC assessment with AI, but they also reflect that the application of AI technology in the field is not mature enough, and algorithms need to be improved in follow-up research.

At present, sentiment recognition and prediction models based on deep learning have achieved performance beyond existing algorithms, as reported by Liu [56]. Zhou [59] proposed a deep learning-based approach for analyzing interactive classrooms and assessing teaching effectiveness, which offers a faster and more accurate recognition of teacher behaviors and assessment of teaching outcomes, resulting in improved efficiency. This highlights the significant potential of deep learning in online teaching assessment and personalized recommendations. Additionally, Ning [2] conducted research on the relationship between behavior and cognition, revealing that deep learning algorithms consistently outperformed other methods, yielding an enhancement in classification accuracy ranging from 2% to 7%. The study by Hussan Munir et al. [58] demonstrated the wide applicability of deep learning algorithms in performance prediction, adaptive learning, and automation, showcasing their exceptional performance. Notably, deep learning can leverage deep neural networks to construct highly accurate prediction models using large volumes of unlabelled and unstructured data, surpassing the limitations of traditional approaches and effectively improving feature learning capabilities [57].

In summary, the majority of studies in this field have centered on assessing the DTC of EFL instructors, with little attention paid to CFL teachers. Moreover, it is worth mentioning that only a small number of articles have employed artificial intelligence algorithms to evaluate teacher DTC, and existing research has certain limitations. Many scholars have highlighted the difficulties that teachers encounter when attempting to enhance DTC. One major obstacle is the disconnect between technology and teaching methods [44]. This clearly underscores the necessity for further exploration and investigation in this particular area. As a result, it is crucial to conduct more in-depth investigations into DTC evaluations for international Chinese teachers.

3. Materials and Research Methods. The current study is comprised of two distinct parts: The first part focuses on the teaching status of international Chinese teachers and utilizes a questionnaire method adapted from DigCompEdu. The second part involves the creation of an algorithmic assessment model using deep learning algorithms, SQL database, and t-SNE technology. The model was fitted using validated data

Table 3.1: Sampling Characteristics

Age	20-25 (25.8%) 25-30 (41.6%) 31-40 (30.3%) > 40 (2.2%)
Country	China (73.8%) Other country (26.2%)
Gender	Female (84.16%) Male (15.84%)
Education Background	Doctor (19.46%) Master (65.61%) Bachelor (14.48%) other (0.45%)
Profession	MTCSOL (73.8%) Pedagogy (15.8%) Literature (5.9%) Language (3.6%) other (0.9%)
Years of Teaching	1-3 (57.01%) 3-5 (14.48%) 5-10 (17.19%) 10-20 (9.95%) > 20 (1.36%)

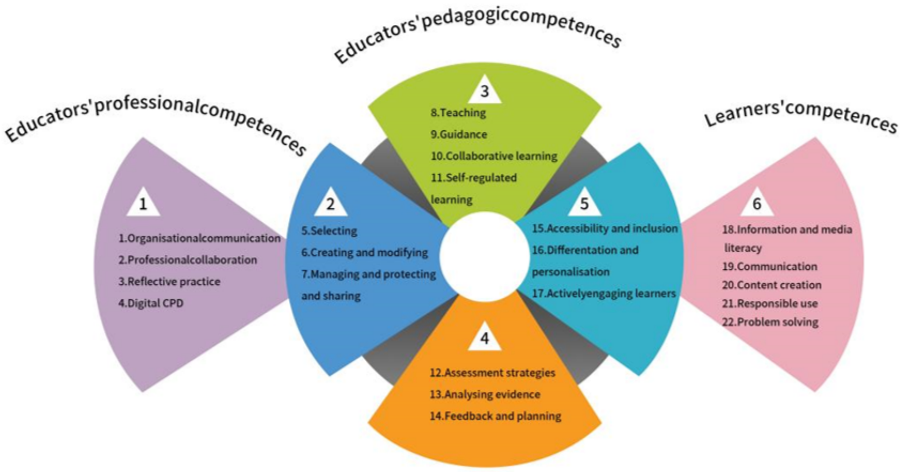

Fig. 3.1: European Framework for the Digital Competence of Educators (DigCompEdu)

obtained from the first part of the questionnaire survey. After multiple iterations, the fit of the model was finalized. Experts were then invited to conduct a second assessment of DTC in order to further improve the model's experimental effect. The primary objectives of this study are as follows:

1. To describe the current state of DTC for international Chinese teachers.
2. To create an algorithmic assessment model for the DTC of international Chinese teachers.
3. To design an experimental study that tests the feasibility of the model.

3.1. Participants. Participants in this study come from 26 countries, with a total of 221, including 163 (73.8%) international Chinese teachers from mainland China and 58 (26.2%) international Chinese teachers from other countries. There are 35 (15.84%) males and 186 (84.16%) females. One (0.45%) is a specialist, and the remaining 32 (14.48%) are undergraduates. 206 (93.2%) have a bachelor's degree in Chinese literature, Chinese language, or TCSL; 10 (4.5%) have a bachelor's degree in English or another foreign language; and 5 (2.2%) have a bachelor's degree.

3.2. Instruments. Since there is no DTC framework specified for international Chinese teachers, this study turned to DigCompEdu as the basis for its questionnaire design. Numerous studies have demonstrated DigCompEdu's practicality and dependability [6]. Many Chinese scholars have also used DigCompEdu to investigate the DTC of international Chinese teachers [20]. DigCompEdu contains 22 entries across three domains as shown in Figure 3.1. We designed a questionnaire with 33 questions, 1-10 for basic information shown in Table 3.1 and 12-33 for scale questions Table 4.2 using a 6-point Likert scale (1=strongly disagree, 6=strongly agree). Five TCSL experts were consulted about the quality of the questionnaire in this study. The questionnaire was revised and tested for reliability after receiving expert feedback.

3.3. Data Collection and Analysis. The International Chinese Teachers' DTC Survey utilized a snowball method to collect data. This involved identifying and recruiting potential participants who were international Chinese teachers currently teaching (in-service) and who had utilized digital teaching tools in their teaching process. An electronic questionnaire was developed with the help of experts, based on the DigCompEdu, which has been shown to have excellent reliability and validity $Cronbachs\alpha = 0.97, KMO = 0.94$. A total of 232 teachers who agreed to participate in the study were selected and sent electronic questionnaires via Questionnaire Star, a web-based user survey tool used to collect data. To comply with GDPR guidelines, the questionnaire was anonymous [8]. After careful screening by experts and consideration of factors, such as the data collection environment and participants' levels of enthusiasm, the authors selected 221 groups of high-quality data. The questionnaire-reclaiming efficiency was 95%, which ensured the effectiveness of the study. The collected questionnaires were entered into SPSS26.0 for analysis of the original data.

3.4. Methods. DL (Deep Learning) [50] is a sub-field of Artificial Intelligence (AI), which uses neural networks to learn from data and make predictions. Deep learning has unique advantages over traditional methods, such as intelligence and robustness. It can automatically screen data without the need for manual extraction, making it convenient and fast. Additionally, it can extract potential features of data, providing valuable insights. It has been applied to a wide range of fields, including natural language processing, computer vision, and speech recognition, and has demonstrated satisfactory performance in a wide range of tasks. Deep learning has recently been used in educational research, including studies of teacher performance. Therefore, we use deep learning to extract the competency distribution of teachers, establish an assessment model, and predict their DTC. The prediction process in deep learning includes four steps:

1. Data preprocessing: During this stage, the raw data is transformed into a format that can be understood by the neural network. This may involve techniques such as normalization and scaling to prepare the data for input into the model,
2. Model building: The neural network models are built based on specific problems at hand. This includes choosing the appropriate architecture and configuring the parameters of the model to optimize its performance,
3. Training: The optimization algorithm is used to train the model on the dataset to adjust the parameters of the model and improve its accuracy. During the training process, the model learns to recognize patterns in the data and make predictions based on those patterns.
4. Prediction: Once the model is trained, it can be used to make predictions about new data. The input data is fed into the model, which produces an output that represents its prediction. According to the characteristics of deep learning, there are six steps in the development of DTC assessment model in this study.

3.4.1. Step 1: Database → Name TDSet. The primary data was collected through a questionnaire survey. A highly advanced and maintainable database utilizing SQL has been constructed to ensure scalability and facilitate future research on the assessment of digital competency among teachers. This database, named TDSet, serves as a benchmark for subsequent studies due to the validity of our data collection methods and the reliability of our data sources. The collected data has been stored in the SQL database (Figure 3.2) for convenient expansion.

Figure 3.2 depicts the detailed data recorded in the SQL, where each row corresponds to the scores of specific DTC items, and the distribution of data in each row is visualized on the right. The distribution characteristics of the data are used to inform both the teacher competence classification criteria and the data processing methods.

3.4.2. Step 2: DTC level classification criteria. The study included a 22-question survey designed to assess DTC comprehensively, yielding 221 high-quality and meaningful data points. In order to more accurately assess and predict teachers' proficiency, it is proposed that, instead of using the total score as the sole criterion for determining DTC, each teacher be labeled into one of five levels based on their individual scores (see Table 3.2). The problem was converted from a regression task to a classification task using this method. Experiments revealed that, using techniques such as clustering and feature dimensionality reduction, the new grading criteria could clearly visualize the distribution characteristics of data within different categories. Secondly, the one-hot

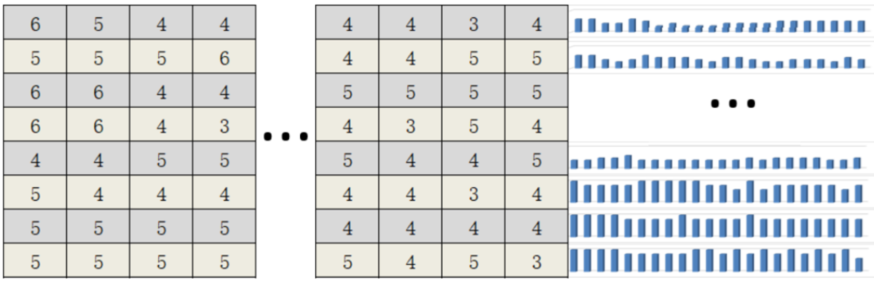

Fig. 3.2: A sample data image

Table 3.2: Digital Teaching Competence Level Classification Criteria

Score	**Level**	**One-hot Encoding**
(114,132]	A	[1,0,0,0,0]
(96,114]	B	[0,1,0,0,0]
(78,96]	C	[0,0,1,0,0]
(60,78]	D	[0,0,0,1,0]
(42,60]	E	[0,0,0,0,1]

encoding technique was used, which can handle discontinuous numerical features and expands the feature space to make data preparation for model training easier.

3.4.3. Step 3: Data analysis and downscaling. In supervised learning, the quality of the data plays a crucial role in determining the effectiveness of the model. Assessing the quality of the data is a valuable task that requires advanced techniques for data classification and analysis. To achieve a comprehensive understanding of the collected data, t-SNE (t-Distributed Stochastic Neighbor Embedding) was employed for visualizing the data. This technique is particularly useful in identifying the variations between different clusters of data and assessing the quality of the data collection process. This technique excels at detecting differences between data clusters and assessing the quality of the data collection process. The algorithm was demonstrated in the main process of t-SNE by using the Algorithm 1.

Algorithm 1: t-SNE

Input: The collected data
Output: Sample data of different categories
while *low-dimensional representation has not converged* **do** Set the number of categories;
Initialize the low-dimensional representation;
Compute the pairwise similarities between all data points in the high-dimensional space;
Minimize the divergence;
end while

3.4.4. Step 4: Data transformation and pre-processing. In order to predict and evaluate DTC using neural networks in this study, the data must be translated into a format that makes network training easier. The platform Pytorch [55] was used to create deep learning models. By converting the data to decimal values in the (0, 1) range, normalization aims to make the data processing easier. The pseudocode is shown in Algorithm 2.

3.4.5. Step 5: Data Modeling. This study demonstrates that the extraction of local features is a more effective and meaningful approach. To achieve this, a Siamese architecture [26] was employed for model

Algorithm 2: Normalize the Data

Input: The collected data
Output: The normalized data
for *each data point in the feature vector* **do** Get the maximum and minimum values of the vector;
Normalize the data point: $x_i = \frac{x_i - \mathrm{Min}}{\mathrm{Max} - \mathrm{Min}}$;
end for

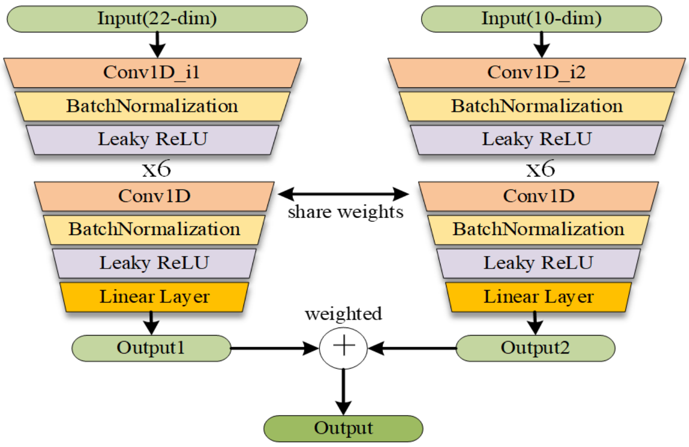

Fig. 3.3: The main structure of the Digital Competence Forecasting Network

construction, which is capable of enhancing both local and global feature extraction. In this approach, the input was divided into two parts - one comprising all the data and the other including more significant indicators and test items, which were identified through expert guidance or interviews. To construct the DTC prediction network (as shown in Figure 3.3), a two-input model was used. The first input consisted of the scores of 22 test items, and the second input of manually filtered scores for 10 essential questions related to Assessment, Empowering Learners, Teaching and Learning. This method helped to extract rich feature data from both local and global sources. For feature extraction, input was first passed through a 1D convolutional layer, followed by a batch layer, and a non-linear activation function. 6-layers of convolutional layers with shared weights were then applied, and a classifier was used to classify the extracted features into their respective types. Finally, the two inputs were weighted for output, with weights defined as 0.8 and 0.2 respectively to maintain integrity for the global features.

The formula used for classification is as follows. The model applies the following equation.

$$out(N_i, C_{out_j}) = bias(C_{out_j}) + \sum_{k=0}^{C_{in}-1} weigth(C_{out_j}, k)a^* \ input(N_i, k) \tag{3.1}$$

Inside C_{in} and C_{out} are the dimensions of input channel and output channel in a Conv1D layer. Bias is utilized to adjust neuron sensitivity and primarily serves to characterize the various neighborhoods within input features. It aids in training the response to input signals and contributes significantly to subsequent classification operations. Batch Normalization is an optimization technique for neural networks, ensuring that input feature variation remains within an appropriate range. This allows input values to smoothly traverse the sensitive part of the excitation function. The activation function is of utmost importance in neural networks as it enables effective utilization of multiple layers. Non-linear activation functions are essential because, without them, multiple linear layers would behave similarly to a single layer, thereby limiting the network's ability to learn from data and handle complex tasks. Additionally, the activation function helps regulate network output by suppressing irrelevant values and amplifying crucial ones. In this study, the LeakyReLU activation function [5] is adopted as the network's activation function. It assists in eliminating unnecessary values, promoting network convergence, and preserving feature integrity. To achieve this, a negative slope parameter of 0.05 is employed. The following represents the corresponding form.

$$LeakyReLU(x) = \begin{cases} x, \quad ifx \geq 0 \\ negative\_slope.x, \text{ otherwise} \end{cases} \tag{3.2}$$

3.4.6. Step 6: Training Details. To accelerate network training, a $GTX1660TI6GB$ with CUDA core was used to train the deep network model. Adam optimizer was additionally used to make network optimization more efficient. The estimation steps for the Adam optimizer are as follows.

$$g_t = \bigtriangledown \widehat{L}(\Theta t) \tag{3.3}$$

$$\begin{cases} m_t = \beta_1 m_{t-1} + (1+\beta)g_t \\ v_t = \beta_2 v_{t-1} + (1+\beta_2)g_t^2 \end{cases} \tag{3.4}$$

$$\begin{cases} \widehat{m_t} = \frac{m_t}{1-B_1^t} \\ \widehat{v_t} = \frac{v_t}{1-B_2^t} \end{cases} \tag{3.5}$$

$$\theta_{t+1} = \theta_t + \frac{\eta}{\sqrt{\widehat{v}} + \epsilon}\widehat{m^t} \tag{3.6}$$

The first term gradient g_t is the loss function biased against v_t. The second term is the first-order moment estimate and the second-order moment estimate of the gradient at moment t in the momentum situation. The third term is the first-order moment estimate and second-order moment estimate after using bias correction. The last item is the weight update step. To better quantify the distance metric between the predicted values and the labels, a cross-entropy loss function was used in the training process [31], as follows.

$$H(p,q) = -\sum_{i=1}^{n} p(x_i)log(q(x_i)) \tag{3.7}$$

The cross-entropy loss function measures the variability between two probability distributions. In the above equation, $P(x)$ represents the true distribution of the sample and $q(x)$ represents the distribution predicted by the model.

4. Results.

4.1. The Status Quo of DTC of international Chinese teachers.

4.1.1. Descriptive analysis. A descriptive analysis method was used to gain a comprehensive understanding of the current status of DTC for international Chinese teachers. First, descriptive statistics on six dimensions of digital competence (table 4.1) were conducted, followed by descriptive analysis on 22 specific items. The specific findings of the analysis are shown in Tables 4.1 and 4.2.

The highest and lowest scores, mean scores, standard deviation (SD), and median of the five dimensions of digital competence, as well as 22 specific competence scores, are shown in tables 4.1 & 4.2. The scores for all six dimensions ranged from 4.4 to 4.9, indicating that teachers scored in the middle of the scale and that international Chinese teachers had a high level of overall DTC. The standard deviation for each dimension, however, is quite high, around 0.9, indicating that there are significant differences in scores among teachers.

With a mean of 4.817 and a standard deviation of 0.854, the Professional Engagement dimension received the highest score. Teaching and Learning and Digital Resources also scored highly, with means of 4.632 and 4.668, respectively, indicating that international Chinese teachers are adept at acquiring teaching resources to

Table 4.1: International Chinese Teachers' Digital Competence in Each Dimension

Variables	Max	Min	Mean	SD	Md
Facilitating Learners' Digital Competence	6	1	4.502	0.895	4.6
Empowering Learners	6	1.333	4.407	0.946	4.333
Assessment	6	1	4.478	0.935	4.667
Teaching and Learning	6	2.25	4.632	0.851	4.75
Digital Resources	6	2	4.668	0.904	4.667
Professional Engagement	6	2.25	4.817	0.854	5

Table 4.2: Questionnaire Information

Professional Engagement	
Organisational communication	5.03
Professional collaboration	4.8
Reflective practice	4.63
Digital CPD	4.8
Digital Resources	
Selecting	4.71
Creating and modifying	4.61
Managing and protecting and sharing	4.69
Teaching and Learning	
Teaching	4.73
Guidance	4.7
Collaborative learning	4.59
Self-regulated learning	4.51
Assessment	
Assessment strategies	4.4
Analysing evidence	4.46
Feedback and planning	4.58
Empowering Learners	
Accessibility and inclusion	4.32
Differentiation and personalisation	4.48
Actively engaging learners	4.42
Facilitating Learners' Digital Competence	
Information and media literacy	4.53
Communication	4.63
Content creation	4.22
Responsible use	4.6
Problem solving	4.52

support teaching students' digital competence in accordance with corresponding teaching needs. Empowering Learners, Assessment, and Facilitating Learners' Digital Competence all scored lower, at 4.407, 4.478, and 4.502, respectively, indicating that international Chinese teachers generally focus on self-development in their teaching practice while ignoring differentiated and personalized teaching, as well as awareness of digital competence assessment.

Among the 22 items, organizational communication received the highest score (5.03), while content creation received the lowest (4.22), followed by accessibility and inclusion (4.32), indicating that teachers' instruction is teacher-centered rather than taking into account learners' individual factors. Overall, teachers are well-equipped in terms of Professional Engagement and Digital Resources, but Assessment, Teaching and Learning may need to be improved.

Table 4.3: Correlation analysis of international Chinese teachers' digital competence in each dimension

	Professional Engagement	Teaching and Learning	Digital Resources	Assessment	Empowering Learners	Facilitating Learners' Digital Competence
Professional Engagement	1	.656**	.701**	.713**	.658**	.640**
Teaching & Learning	.656**	1	.770**	.809**	.740**	.753**
Digital Resources	.701**	.770**	1	.717**	.656**	.673**
Assessment	.713**	.809**	.717**	1	.835**	.804**
Empowering Learners	.658**	.740**	.656**	.835**	1	.871**
Facilitating Learners' Digital Competence	.640**	.753**	.673**	.804**	.871**	1

** At level 0.01 (2-tailed), the correlation was significant.

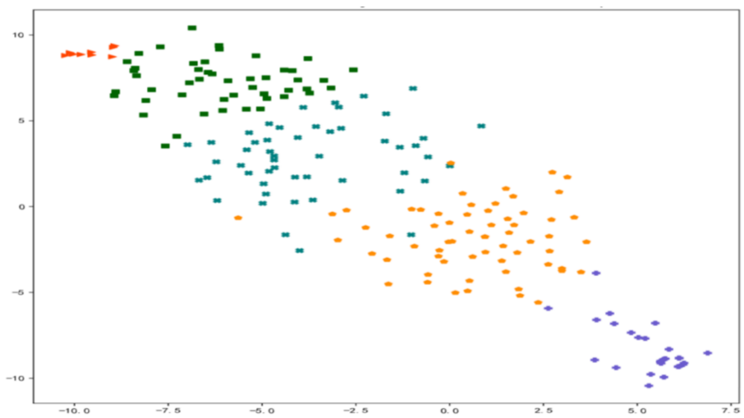

Fig. 4.1: Data dimensionality reduction feature map

4.1.2. Correlation analysis. This study used Pearson correlation analysis to validate the relationship between the six dimensions of international Chinese teachers' DTC, with higher numbers indicating stronger correlations. According to the data analysis, all six dimensions were positively correlated. The six dimensions had a significant impact on international Chinese teachers' DTC. Based on this, the author investigated the relationship between the assessment dimensions and the other dimensions further. As shown in Table 4.3, the correlation coefficients were: Empowering Learners (0.835) > Teaching and Learning (0.809) > Facilitating Learners' Digital Competence (0.804) > Digital Resources (0.717) > Professional Engagement (0.713), and the results indicated that the assessment of DTC was most correlated with empowering learners followed by teaching and learning. This showed that digital competence assessment and students' perspective had a certain impact on teaching effectiveness.

4.2. Experiment on the DTC Assessment Model.

4.2.1. Data quality analysis. Figure 4.1 illustrates the outcomes of feature distribution for several data categories following feature reduction scaling and t-SNE operation. Internally, it can be seen that different colors stood in for the five pre-established categories, distances between points denoted variations in features, and different regions showed the distribution of several categories. They had little overlap and were each rather small in their own divisions. It demonstrated the accuracy and value of the data collection process used in the study.

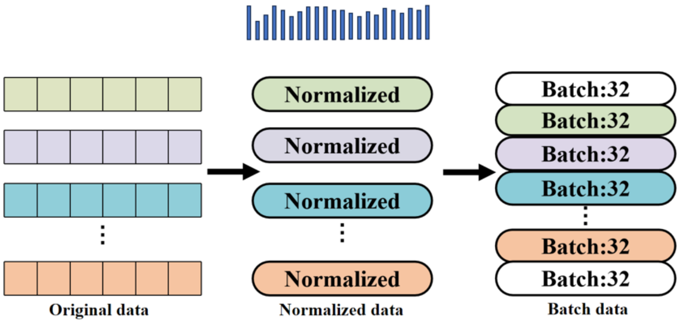

Fig. 4.2: DTC data conversion

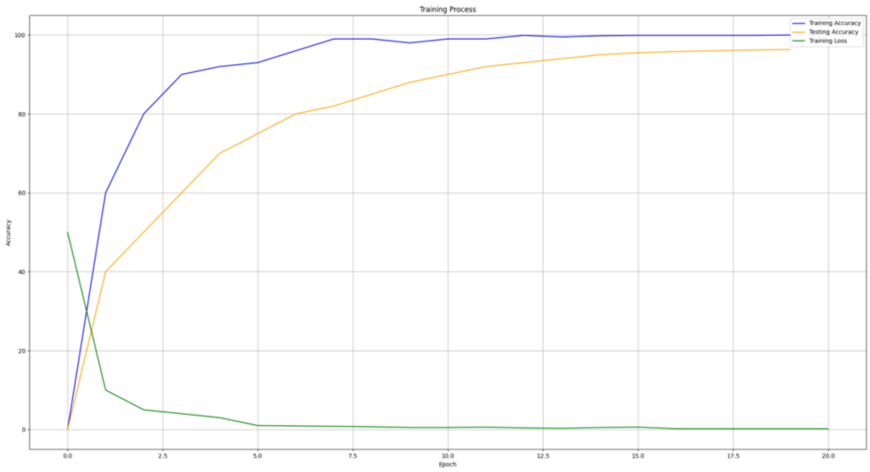

Fig. 4.3: New TDSet model predictive value

4.2.2. Data processing analysis. The experimental findings demonstrated that data conversion sped up the deep learning model's gradient descent procedure, allowing it to reach the best solution more quickly and increasing the classifier's prediction accuracy. As seen in Figure 4.2, the outcomes of the data transformation procedure could change the DTC data into neural network training data that could be applied to batch iterative neural network optimization.

4.2.3. Analysis of model prediction results. In this work, a 32-person batch size was used to train the model over 10,000 iterations. Also, in order to aid in the network's process optimization, we employed an approach to lower the learning rate. It was established that deep learning could be used as an algorithm for teachers' digital competence evaluation model because the predictive value of our research results reached 96.33% (Figure 4.3), which was significantly higher than that of the Bias Classifier, Decision Tree, Fuzzy Clustering, and Random Forest algorithms (Table 4.4). The high score also demonstrated the objectivity and accuracy of the deep learning algorithm for evaluating the DTC of Chinese teachers, and that deep learning could successfully gauge teachers' overall proficiency through a large number of experiments.

Expert evaluation was also used in the study to guarantee the model's accuracy. To evaluate the DTC of Chinese language teachers, five foreign experts in the field of Chinese language teaching were invited. The outcomes revealed agreement between the model's predictions and the expert assessment, proving the model's

Table 4.4: Model experiment results

Methods	Accuracy (%)
Bayes Classifier	93.67
Decision Tree	91.74
Fuzzy Clustering	90.86
Random Forest	91.22
New TDSet	96.33

Table 4.5: Chinese teachers' digital competence assessed by experts

	Professional Engagement	Teaching and Learning	Digital Resources	Assessment	Empowering Learners	Facilitating Learners
Expert1	4.80	4.70	5.30	4.00	4.00	4.20
Expert2	4.70	5.00	5.50	4.50	4.50	4.90
Expert3	4.90	4.80	5.30	4.30	4.60	4.80
Expert4	4.50	5.00	4.00	3.00	3.00	4.00
Expert5	5.00	4.80	5.00	4.50	4.60	4.80

viability from a different angle.

5. Discussion. The research findings indicate that international Chinese teachers demonstrate a relatively high level of DTC, with an average score surpassing 4.4. Notably, the dimensions of Assessment (4.478) and Empowering Learners (4.407) received lower scores, underscoring their significance and necessity of future development in these areas. Furthermore, the teachers' DTC exhibits variations and continuous development that aligns with their years of experience (standard deviation greater than 0.8). These results support the notion that foreign language teachers generally possess lower digital competence [30]. These observations could be attributed to evolving standards of proficiency and insufficient training and self-assessment [54, 52]. As technology advances, teaching methods have become more diverse and complex, transitioning from traditional face-to-face instruction to blended learning. This rapid transformation presents a significant challenge for teachers, as they are required to enhance their DTC within a limited time frame [19]. Previous studies mainly focused on specific factors such as age and teaching experience when assessing teacher's DTC, neglecting the complexity of teaching practices and the dynamic nature of teacher abilities.

The findings also indicate that insufficient attention has been paid to DTC, reflecting issues with international Chinese teachers' training methods, thinking, and development, as well as a demand for training sessions to address DTC deficits and improve the overall quality of teacher training [54]. The teachers' DTC assessment can also assist them in enhancing their teaching skills and identifying gaps in their practice and training, ultimately promoting their professional development. Teachers are expected to engage in practical reflection, focusing on the needs of their students, differentiating their instruction appropriately, and using digital technology responsibly to improve learner-centered teaching effectiveness. Furthermore, through focus group discussions and interviews with ten participants from the initial questionnaire survey, the effectiveness of the proposed model in assessing digital teaching competence and providing strategies for improvement was acknowledged. It facilitated self-enhancement and professional development. The study thoroughly examined the current status of teachers' DTC and proposed pathways for improvement.

This study presents compelling evidence regarding the efficacy of deep learning models and their potential to enhance teacher research, reinforcing the promising role of artificial intelligence in education [53, 35]. The proposed model has the capability to gather a broader range of classroom data, including fixed achievement tests, self-reports, and multimodal data from interactive classroom sessions, encompassing teacher behaviors and expressions. Currently, the assessment methods for assessing teachers' digital teaching competence often rely heavily on self-assessment or framework-based assessment, which are susceptible to subjective factors and yield limited and inconsistent outcomes. Furthermore, in the teaching and learning process, there is now greater emphasis on general pedagogical skills rather than digital technologies [13]. This study adopts a pedagogical standpoint to create an algorithmic DTC assessment model that takes self-reporting and other important measures into account, ensuring convenience and validity [12, 47, 9]. The future implementation of the model will have the potential to be applied and promoted to teachers from other backgrounds.

The construction of this deep learning-based model represents a novel and intelligent approach to personalized and digitized evaluation. It is characterized by automatic feature extraction, data-driven analysis, adaptive learning, and high accuracy. By automatically extracting meaningful features from data without the need for complex feature engineering, deep learning algorithms simplify the assessment process of teachers' digital competence, thereby reducing research complexity. This approach facilitates a comprehensive understanding and capture of teachers' behaviors and skills in real-world teaching scenarios. Moreover, deep learning algorithms possess the ability to adaptively adjust their parameters to accommodate dynamic data changes, ensuring the effectiveness and accuracy of the evaluation method when confronted with new teaching contexts and technologies. The approach promotes accurate self-reflection among teachers, enhances teaching effectiveness, and fosters their professional development capabilities. Aligned with the imperative future trend of empowering teachers with technology, this study contributes by providing a novel and effective assessment model. In summary, this model surpasses prior studies in terms of data extension and maintenance, noteworthy visualization features, and high prediction rates, thereby broadening the scope of previous research and aligning more closely with the definition of competencies.

6. Conclusion. With the advent of the digital era, the education community has increasingly focused on the assessment of Digital Teaching Competence (DTC). However, existing assessment methods primarily rely on self-reports and traditional frameworks, lacking relevance, accuracy, and in-depth research on international Chinese teachers. This study delves into the current state of DTC among international Chinese teachers and proposes a new assessment method based on an intelligent algorithmic model, thereby improving the relevance and accuracy of the assessment. The findings of this study will help place the assessment of working teachers' DTC in an interrelated and integrated perspective from the standpoint of professional development for Chinese international teachers [3]. The results indicate that the deep learning algorithm performs effectively on the given data set, leading to an improvement in classification accuracy by 2%-5%. The model evaluation, established through the deep learning algorithm, allows for the identification of teacher ability characteristics, aiding in proper self-evaluation and preparation for promotion. Furthermore, the classification criteria established provide clear visualization of the distribution characteristics of teacher DTC in different categories. The use of t-SNE technology during data processing significantly reduces calculation cost.

However, this is just the beginning of a long journey. Future studies should continue to innovate the algorithm and incorporate the latest technology into the evaluation model. The model will thus be improved along the following two aspects. On the one hand, the researchers will continue to use new types of data screening to realize data visualization and data analysis methods, in order to improve the quality and effectiveness of data collection. Second, in future algorithm research, the researchers will make the network multi-functional while adjusting for current computing speed. For example, while predicting teacher's DTC, it should also be possible to generate new and specific improvement strategies. In the future, the researchers will also attempt to deploy the network on mobile devices to enhance network reusability. Beyond this, empirical research can be carried out to promote the implementation and application of the model.

7. Limitations. It must be acknowledged that there are some limitations in the considerations of model construction. Deep learning algorithms rely on a large amount of data, and in this study, we only collected data from teachers in 26 countries, which may not be representative of all international Chinese teachers. Therefore, ensuring the quality and quantity of data remains an issue that needs to be addressed in future research. In addition, although deep learning can automatically recognize data characteristics, setting hyperparameters is still dependent on both technology and experience. Therefore, it is essential to set reasonable parameters to ensure the reliability and validity of the assessment model.

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