International Journal for Housing Science and Its Applications
Publish August 10, 2025. Volume 46, Issue 4 Pages 6383-6392

https://doi.org/10.70517/ijhsa464542

Practice and Challenge of Integrated Teaching of English and Computer Science in Primary Schools under CLIL Framework

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Abstract With the advancement of educational informatization, the integration of English subject and computer science has become an effective way to improve primary school students' comprehensive English application ability and interdisciplinary literacy. The purpose of this article is to explore the practice and challenges of integrated teaching of English and computer science in primary schools under the framework of CLIL (Content and Language Integrated Learning). In this article, BPNN (Back Propagation Neural Network) model is used to quantitatively analyze the application effect of CLIL instructional mode in ELT (English Language Teaching) in primary schools. By collecting the teaching data under the traditional instructional mode and CLIL instructional mode, this article compares the differences of students' English scores, classroom participation, language ability, intercultural communication ability and learning interest. The results show that CLIL instructional mode shows advantages in improving students' abilities in all aspects, especially in improving students' English scores and intercultural communication ability. This model also stimulates students' interest in learning and promotes their comprehensive development. The integrated teaching of English and computer science in primary schools under the CLIL framework is an effective instructional mode, but it also faces some challenges. In the future, we should fully consider these challenges and take measures to deal with them.

Index Terms CLIL framework, Primary school English, Computer science, BP neural network, Instructional mode

I. Introduction

Under the background of globalization, English, as an international language, is becoming more and more important. With the rapid development of science and technology, computer science has also become a key force to promote social progress. How to effectively integrate English with computer science is a subject worthy of discussion [1]. In primary school, children are in the golden age of language learning, and they are also curious about new things [2]. Combining English with computer science can improve their language ability, stimulate their interest in science and technology, and lay a solid foundation for their future study and life [3]. CLIL framework emphasizes teaching in the target language while learning subject knowledge, so as to realize the dual acquisition of language and content [4]. This instructional mode is helpful to improve students' language application ability and promote their in-depth understanding of subject knowledge. Primary school English is an important part of basic education. Its goal is to cultivate students' basic English skills such as listening, speaking, reading and writing, and lay the foundation for their lifelong learning and development [5]. Traditional ELT often focuses on the instillation of language knowledge and mechanical exercises, ignoring the application of language in actual situations [6]. This teaching method is difficult to stimulate students' interest in learning and meet their diversified learning needs. Driven by various factors, it has become an inevitable trend of education reform to explore a new ELT model for primary schools and combine English learning with subject knowledge.

As a new discipline, computer science is developing rapidly and has far-reaching influence. The introduction of computer science education in primary school can cultivate students' logical thinking ability and problem-solving ability, and also let them get in touch with and understand the frontier dynamics of science and technology from an early age [7], [8]. The teaching of computer science often involves a large number of technical terms and abstract concepts, which is difficult for primary school students to learn [9]. If we combine the teaching of computer science with English learning and explain the knowledge and skills of computer science in English, we can not only lower the learning threshold of students, but also improve their English application ability [10]. It is in this context that the integrated teaching of English and computer science in primary schools under the CLIL framework came into being. This instructional mode takes English as the teaching language and computer science as the teaching content,

creating real or simulated situations, so that students can master the skills of computer science while learning English [11].

The integrated teaching of English and computer science in primary schools under the CLIL framework is not easy. It requires teachers not only to have a solid knowledge of English and computer science, but also to be able to use various teaching methods flexibly to create attractive instructional situations [12]. It also requires schools and education departments to provide necessary instructional resources and support, such as instructional materials, instructional equipment and network platforms [13]. In order to scientifically assess the effect of integrated teaching of English and computer science in primary schools under the CLIL framework, it is needed to construct an effective instructional assessment model. This study applies BPNN to the construction of instructional assessment model, assesses the effect of integrated teaching by analyzing and processing a large number of teaching data, and provides scientific basis for teaching improvement.

The purpose of this study is to explore the practical methods of integrated teaching of English and computer science in primary schools under the CLIL framework, and build a instructional assessment model by using BPNN to scientifically verify the effect of integrated teaching. This study will focus on the following aspects: First, analyze the basic principle of CLIL framework and its application value in the integrated teaching of English and computer science in primary schools; The second is to explore the practical methods of integrated teaching; The third is to build a instructional assessment model based on BPNN to assess the effect of integrated teaching; Fourthly, the assessment model is used to analyze the application effect of CLIL in primary school ELT, and suggestions for improvement are put forward. With the help of this study, I hope to provide help for the integrated teaching of English and computer science in primary schools under the CLIL framework and contribute to the further promotion of educational reform.

(1) In this study, CLIL framework is applied to the integrated teaching of English and computer science in primary schools, which breaks the barrier of clearly defined disciplines in traditional ELT.

(2) Combining the characteristics of English and computer science in primary schools, this study designed a targeted and personalized teaching program, aiming at improving students' interest in learning and promoting their multi-faceted development.

(3) In this study, BPNN is applied to the effect assessment of the integrated teaching of English and computer science in primary schools, and a scientific and objective instructional assessment model is constructed.

(4) Using teaching practice cases, this study analyzes the implementation process, effects and challenges of the integrated teaching of English and computer science in primary schools under the CLIL framework.

II. Overview of CLIL framework

CLIL is an innovative educational concept and practice mode. It skillfully combines language learning with subject content learning, aiming at teaching non-linguistic knowledge in the target language, thus promoting students' double improvement in language ability and subject knowledge. The CLIL framework is not only a challenge to the traditional language instructional mode, but also a positive response to the trend of educational globalization and interdisciplinary integration. The origin of CLIL framework can be traced back to Europe in 1980s. At that time, with the acceleration of European integration, transnational exchanges and cooperation became increasingly frequent, and the demand for multilingual talents became increasingly urgent. Traditional language teaching often focuses on the individual training of language skills and ignores the application of language in practical situations [14]. Some European countries have begun to try to combine language learning with subject content learning, and to teach other subjects with the help of target language, so as to improve students' language use ability and interdisciplinary understanding ability. This instructional mode gradually developed into the later CLIL framework.

In CLIL class, language is no longer an isolated learning object, but a tool to acquire and understand subject knowledge. Students learning subject knowledge in the target language can not only improve their language application ability, but also deepen their understanding and mastery of subject knowledge. Teachers need to balance the relationship between language and content in teaching, not only to ensure that students can express effectively in the target language, but also to ensure that they can master and understand the core concepts of the subject [15]. The implementation of CLIL framework is flexible and diverse. It can be adjusted according to students' age, language level, subject requirements and other factors [16]. In primary school, CLIL teaching usually adopts thematic or project-based teaching methods to create attractive instructional situations and stimulate students' interest in learning.

The advantage of CLIL framework is that it can promote the comprehensive development of students. With the help of CLIL teaching, students can use language in real context and improve their fluency in language use. CLIL teaching can cultivate students' interdisciplinary thinking ability. In CLIL class, students need to use the knowledge and skills of different disciplines to solve problems. This interdisciplinary integration can stimulate their creativity

and imagination. CLIL teaching can enhance students' international vision and intercultural communication ability. By learning the knowledge of other subjects in the target language, students can better understand and respect the differences between different cultures.

The implementation of CLIL framework also faces some challenges. Teachers need to have solid language skills and professional knowledge in order to carry out CLIL teaching effectively. This requires teachers to constantly learn and improve their professional quality. CLIL teaching needs rich instructional resources and support. Schools and education departments need to provide necessary guarantee for the smooth development of CLIL teaching. The assessment of CLIL teaching is also a difficult problem. Because CLIL teaching involves both language learning and subject content learning, how to scientifically assess and assess students' learning achievements has become a problem that needs in-depth study.

III. Construction of BPNN instructional assessment model

III. A. Instructional assessment model

BPNN is a multilayer feedforward neural network, which consists of IL (input layer), HL (hidden layer) and OL (output layer). Its core idea is to use the back propagation algorithm to adjust the network weight and bias to minimize the prediction error. The learning process of BPNN includes two stages: forward information propagation and backward error propagation. In the forward information propagation stage, the input information is processed layer by layer from IL through HL, and finally reaches OL to produce the output value [17]. If there is an error between the output value and the expected value, it will enter the error back propagation stage. The error signal propagates backward along the original connection path, and the weights and biases of neurons in each layer are adjusted to minimize the output error of the network [18]. The first step of constructing BPNN instructional assessment model is to determine the assessment index system. This system should comprehensively and objectively reflect all aspects of teaching quality, including teaching content, teaching methods, teaching attitude and teaching effect.

BPNN can learn and store a large number of pattern mapping relationships between input and output without specifying the mathematical expression of this mapping relationship in advance. BPNN's learning rules adopt the steepest descent method, and the weights and thresholds of the network are constantly adjusted by using the back propagation mechanism to minimize the sum of squares of network errors. Figure 1 shows the structure of a three-tier BPNN model.

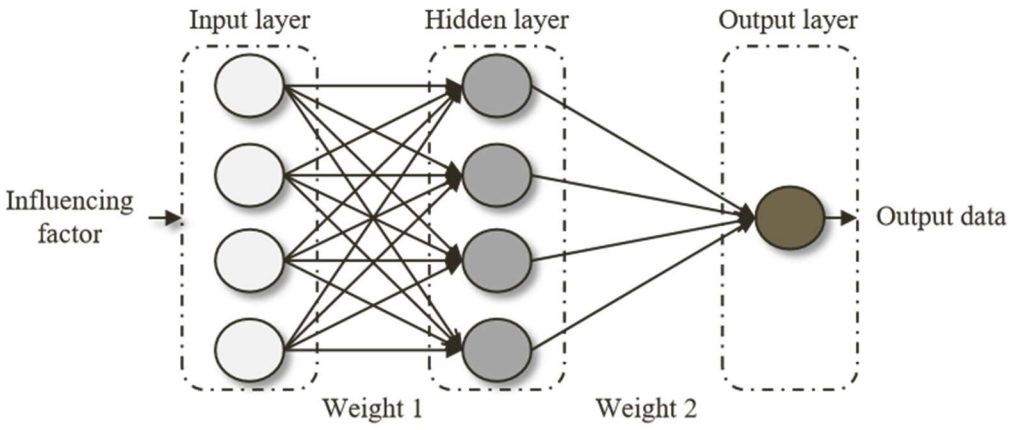

Figure 1: Three-layer BPNN model

There are often noises and missing values in teaching data, which need to be preprocessed, including data cleaning and normalization. Data cleaning and denoising, normalization unifies data of different dimensions, and improves the accuracy of model training and prediction [19]. The network structure design should determine the number of input, hidden, OL neurons and connection mode [20]. The number of IL neurons is generally equal to the number of assessment indexes. OL is determined according to the assessment requirements. If the teaching quality is graded, the number of OL neurons can be set as the grade number. The determination of HL is complicated and can be solved by experience, trial and error or optimization algorithm. The increase of its number and neurons can improve the nonlinear mapping ability, but it is easy to over-fit. The activation function determines the output mode of neurons, and it is selected as needed in the instructional assessment model. Network weights should be initialized before training.

Output of i neuron in HL:

$$a_{1i} = f_1\left(\sum_{j=1}^{r} w_{l_{ij}} p_j + b_{1i}\right), i = 1, 2, \cdots, s_1 \tag{1}$$

Output of the k neuron of OL:

$$a_{2i} = f_2\left(\sum_{i=1}^{s_1} w_{2_{ki}} a_{l_i} + b_{2k}\right), k = 1, 2, \cdots, s_2 \tag{2}$$

The $f(x)$ transfer functions are entirely composed of unipolar sigmoidal (or hyperbolic tangent) functions:

$$f(x) = \frac{1}{1 + e^{-x}} \tag{3}$$

The BP learning algorithm defines the error function based on the discrepancy between the network's output for a single sample and the desired response:

$$E_s = \frac{1}{2}\sum_{S=1}^{N_3}\left(T_s^k - O_s^k\right) \tag{4}$$

BPNN is especially good at dealing with nonlinear relations. Neural network can approximate nonlinear continuous function with arbitrary precision, and the number of variables is variable, and the number of input/output is determined according to the actual situation, and there is no fixed setting [21]. Combined with this factor, the BPNN theory is applied to the primary school English assessment system, which solves the problem of the integration of qualitative indicators and quantitative indicators in the comprehensive assessment index system to some extent. The application of BPNN also avoids artificial subjectivity and makes the assessment results more effective.

In the design process of neural network, the network needs to go through several training stages with different learning rates [22]. By observing the decline rate of the sum of squares of errors after each training, we can judge whether the selected learning rate is appropriate. In order to reduce the training times and time to find a suitable learning rate, a variable adaptive learning rate method is adopted, so that the network can automatically adjust the learning rate at different training stages [23]. Figure 2 shows the assessment model structure based on BPNN. Figure 3 shows the application process of BPNN model.

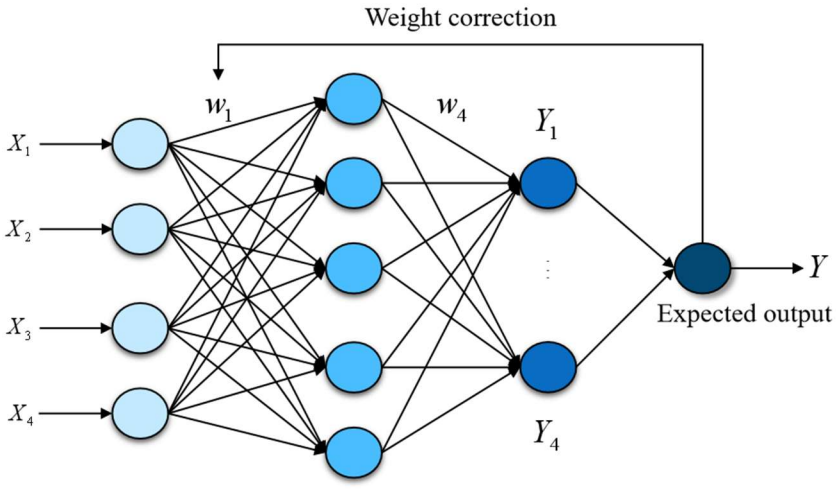

Figure 2: Assessment model based on BPNN

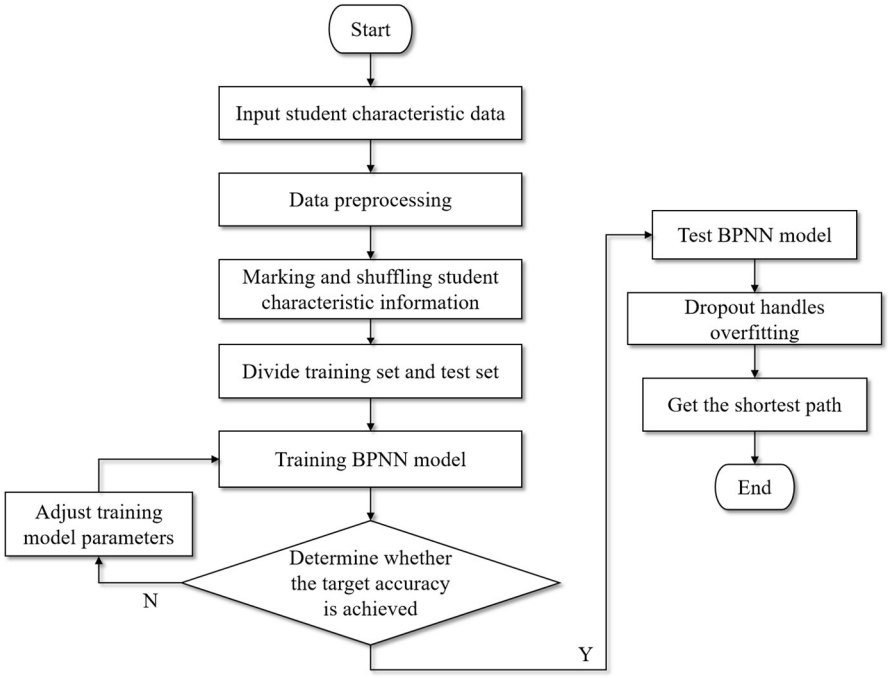

Figure 3: BPNN process

Let $x_i(t)$ be the input at time t, and $o_j(t)$ the output of j at time t. The neuron j's state is represented as:

$$o_j(t) = f\left\{\left[\sum_{i=1}^{n} \omega_{ij} x_i\left(t-\tau_{ij}\right)\right] - T_j\right\} \tag{5}$$

Here, τ_{ij} represents the synaptic delay, T_j the neuronal threshold, ω_{ij} the weight from i to j, and $f(\cdot)$ the transfer function. Given τ_{ij} as the unit time, we have:

$$o_j(t+1) = f\left\{\left[\sum_{i=1}^{n} \omega_{ij} x_i(t)\right] - T_j\right\} \tag{6}$$

The subscripts for input and output reflect the variety of modes in the neuron model, allowing us to leverage this model's flexibility to address diverse problems as needed. The input to neurons at time t is given by the following formula:

$$net_j'(t) = \sum_{i=1}^{n} \omega_{ij} x_i(t) \tag{7}$$

The neuron model is only effective when $net_j'(t) > T_j$. Upon simplification, it transforms into:

$$o_j = f\left(net_j\right) = f\left(W_j^T X\right) \tag{8}$$

Using neural network training error as the metric for individual fitness:

$$F = a \times f + b \tag{9}$$

$$F = \alpha \times \frac{1}{E} + \beta \times \frac{T}{t} \tag{10}$$

In the formula, T denotes the upper limit of HL neurons, t the count of activated neurons in the network, a, b, α, β a real number within [0,1], and E the mean squared error of BPNN.

In neural networks, sample training data is crucial. To enhance data processing and network efficiency, normalize input samples to fall within the [0,1] range using the following formula:

$$X = \frac{T - T_{\min}}{T_{\max} - T_{\min}} \tag{11}$$

X represents the normalized input to the neural network, T the raw input value, $T_{\max}$ the maximum input value, and $T_{\min}$ the minimum input value.

When constructing BPNN instructional assessment model, we should pay attention to ensuring the scientific assessment index system; Fully preprocess the original data to improve the efficiency of model training; Reasonable design of network structure to prevent over-fitting and under-fitting; Select appropriate activation function and weight initialization method to improve convergence performance; The training parameters are set reasonably to ensure the stable convergence of the model.

III. B. Modelling verification

Figure 4 shows the convergence of the BPNN model. In the process of model training, the error value after each iteration is recorded, and the curve of error changing with the number of iterations is drawn. With the increase of iteration times, the model error gradually decreases and eventually tends to be stable. This shows that the model can gradually learn the rules in the data during the training process and achieve better fitting effect.

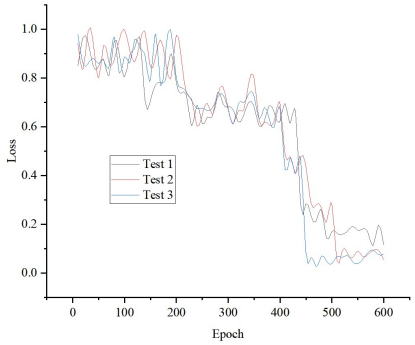

Figure 4: Model convergence

In order to avoid the network falling into local minimum during training, the momentum factor is introduced. Momentum factor adds the direction information of the previous update when the weight is updated, so that the model can find the global optimal solution faster in the search process. According to experience, the momentum factor is set to about 0.86.

In order to assess the prediction error of BPNN instructional assessment model, it is compared with several traditional assessment methods. Figure 5 shows the assessment errors of different algorithms. The fuzzy assessment model of teaching quality based on BPNN has smaller prediction error and is obviously superior to other traditional assessment methods. This shows that the BPNN model can capture the nonlinear relationship in the data more accurately when dealing with complex instructional assessment problems.

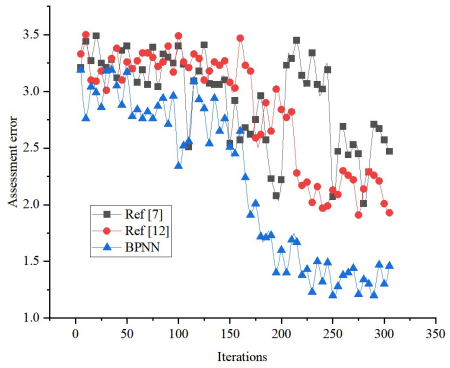

Figure 5: Error situation of algorithm

With the combination of multi-layer neurons and nonlinear transformation of activation function, BPNN model can learn complex patterns in data and accurately predict unknown data. BPNN model can also automatically adjust the network weight and bias with back propagation algorithm to achieve better fitting effect.

In order to further verify the accuracy of BPNN instructional assessment model, the assessment results of model simulation output are compared with those of experts. Figure 6 shows the comparison between the expert assessment results and the model output results. The model output results are close to the expert assessment results. The error between them is within the acceptable range.

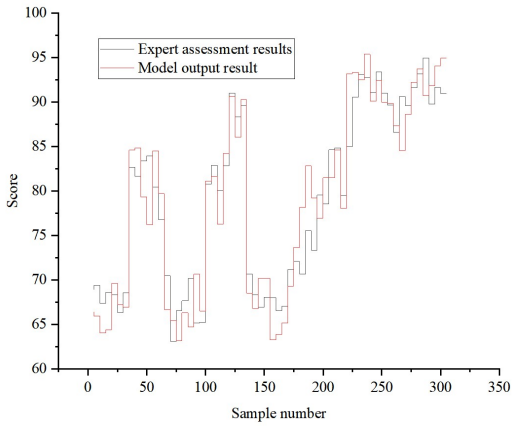

Figure 6: Comparison between expert assessment results and model output results

This result shows that the BPNN instructional assessment model can accurately determine the ELT effect of primary schools according to each assessment index. Compared with traditional assessment methods, BPNN model not only considers the linear relationship of assessment indexes, but also captures the nonlinear interaction between indexes, thus giving a more comprehensive and accurate assessment result.

BPNN model also has good generalization ability. In training, the model learns the rules in a large number of sample data and can form the generalization ability of unknown data. This means that even in the face of new instructional assessment tasks, BPNN model can give more accurate prediction results.

With the help of model convergence, error analysis and the comparative analysis of output results and expert assessment results, we can draw the following conclusions: the primary school ELT assessment model based on BPNN has the advantages of fast convergence, small prediction error and high accuracy, which can weaken the artificial influence factors of index weight determination in traditional assessment methods to some extent. The model has excellent ability in practical application, which can help to improve the quality of ELT in primary schools.

IV. The application effect of CLIL in primary school ELT

CLIL instructional mode emphasizes the integration of language teaching into the teaching of subject content, so that students can improve their English listening, speaking, reading and writing abilities while learning subject knowledge [24]. In order to objectively and accurately assess the application effect of CLIL in primary school ELT, the BPNN instructional assessment model constructed above is adopted. Based on a large number of teaching data, the model can capture the complex relationship between instructional assessment indexes by using the nonlinear mapping ability of multi-layer neurons, thus giving accurate assessment results.

In the assessment process, several teaching classes were selected as experimental objects. Some classes adopt the traditional ELT mode, while others adopt CLIL instructional mode. By collecting the teaching data of these classes, the effect of CLIL instructional mode is quantitatively assessed by using BPNN model.

The following is the result of quantitative analysis of CLIL teaching effect with BPNN model. From Table 1, it is not difficult to find that the class with CLIL instructional mode is obviously superior to the class with traditional instructional mode in English achievement. Average score increased by nearly 7 points, and pass rate increased by 7%. Good rate and excellent rate increased by 15% and 15% respectively. Highest score and lowest score have also been improved, which shows that CLIL instructional mode has a significant effect on improving the overall level of students.

Table 1: Comparison of English Scores

Instructional Mode	Average Score	Pass Rate	Good Rate	Excellent Rate	Highest Score	Lowest Score
Traditional	78.5	85%	30%	20%	95	50
CLIL	85.3	92%	45%	35%	100	60

Table 2 shows the participation of students in the classroom. It is not difficult to find that CLIL instructional mode has significantly improved students' participation in class. The proportion of high participation has increased by 20%, while the proportion of medium participation has decreased, but the proportion of low participation and almost no participation has also decreased accordingly, and the proportion of very active participation has also increased. To some extent, this shows that CLIL instructional mode can stimulate students' interest in learning and make them more actively participate in classroom activities.

Table 2: Comparison of Student Classroom Participation

Instructional Mode	High Participation	Medium Participation	Low Participation	Very Active Participation	Hardly Participate
Traditional	40%	45%	10%	5%	0%
CLIL	60%	30%	5%	4%	1%

Table 3 is the teacher's assessment of students' language ability (out of 5). CLIL instructional mode is excellent in improving students' language ability. The scores of listening, speaking, reading and writing abilities are higher than those of the traditional instructional mode, and the comprehensive assessment is also improved accordingly. This shows that CLIL instructional mode can improve students' language ability in an all-round way.

Table 3: Teacher's Assessment of Students' Language Skills

Instructional Mode	Listening	Speaking	Reading	Writing	Overall Assessment
Traditional	3.7	3.5	3.8	3.6	3.65
CLIL	4.2	4.0	4.3	4.1	4.15

Table 4 shows the comparison of students' intercultural communicative competence. CLIL instructional mode can be integrated into other subjects and enhance students' cross-cultural awareness. Cross-cultural communication ability score, cross-cultural understanding ability, cross-cultural adaptability and cross-cultural communication ability are all higher than traditional instructional mode.

Table 4: Comparison of Students' Intercultural Communication Competence

Instructional Mode	ICC Score	Understanding	Adaptability	Communication
Traditional	3.9	3.8	3.7	4.0
CLIL	4.5	4.4	4.3	4.6

Table 5 reflects students' interest in English learning. CLIL instructional mode creates real language situations and stimulates students' interest in learning. The proportion of high interest in English learning has increased by 20%, while the proportion of high interest in English learning has decreased, but the proportion of general interest in English learning has also decreased accordingly. The proportion of students who are not interested in English learning is also greatly reduced, which shows that CLIL instructional mode can significantly improve students' interest in English learning.

Table 5: Comparison of Students' Interest in Learning English

Instructional Mode	High Interest	Moderate Interest	Neutral Interest	Low Interest	No Interest
Traditional	50%	25%	20%	4%	1%
CLIL	70%	20%	8%	1%	1%

Table 6 shows the improvement of students' comprehensive quality. CLIL instructional mode also has a significant effect in improving students' comprehensive quality. The proportion of obvious improvement in comprehensive

quality has increased by 20%, and the proportion of improvement in comprehensive quality has also increased, while the proportion of basically unchanged and decreased comprehensive quality has decreased accordingly.

Table 6: Comparison of Students' Overall Quality Improvement

Instructional Mode	Significant Improvement	Some Improvement	No Change	Slight Decline
Traditional	30%	40%	25%	5%
CLIL	50%	35%	10%	5%

With the quantitative analysis of BPNN model, we can see the advantages of CLIL instructional mode in primary school ELT. It not only improves students' English scores, but also enhances their classroom participation, language ability, intercultural communication ability and interest in learning. However, CLIL instructional mode also has some shortcomings, such as higher requirements for teachers and more instructional resources. Combined with this factor, when implementing CLIL instructional mode, schools should fully consider their own conditions, rationally plan instructional resources and ensure the effective implementation of the instructional mode.

To sum up, the application effect of CLIL in primary school ELT is deeply analyzed by using BPNN model, and the results show that CLIL instructional mode has performed well in many aspects. In the future, with the continuous development of educational technology, CLIL instructional mode is expected to play a greater role in ELT in primary schools.

V. Conclusion

CLIL framework emphasizes teaching in the target language while learning subject knowledge, so as to realize the dual acquisition of language and content. In this study, BPNN model is used to analyze the application effect of CLIL instructional mode in primary school ELT. The results show that CLIL instructional mode has different advantages in improving students' English performance, enhancing classroom participation, improving language ability, promoting cross-cultural communication ability and stimulating learning interest.

The integrated teaching under the CLIL framework not only enriches the teaching content, but also creates a real language situation, which enables students to communicate and practice naturally in English while learning the subject knowledge. The implementation of CLIL instructional mode also faces some challenges. It requires teachers to have interdisciplinary instructional ability and good English literacy. Integrated teaching needs more instructional resources and technical support, and schools need to plan instructional resources reasonably.

To sum up, the integrated teaching of English and computer science in primary schools under the CLIL framework is an innovative instructional mode. However, in the process of implementation, it is also needed to fully consider the challenges it faces and take corresponding measures to deal with them.

Acknowledgements

This research was supported by Philosophy and Social Sciences Research Project of Shaanxi Province 'Research on Integration of University, Secondary and Primary CLIL Teacher Education Cultivation From the New Quality Productive Forces Perspective', grant no. 2025YB0134 and Basic English Education Research Centre, School of English Language and Culture, Xi'an Fanyi University.

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