Research Article

Practical Research on Primary Mathematics Teaching Based on Deep Learning

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1. Introduction

The concept of deep learning was proposed by American psychologists Ference Marton and Roger Saljo in the mid-1950s, and in 2005, Professor Li Jiahou’s research team introduced the concept of deep learning in a more systematic way for the first time [1, 2]. The concept of deep learning advocates that when building resources, we should pay attention to both explicit subject knowledge and implicit thought and culture, which highlights the cultural characteristics in deep learning and shows that deep learning is indeed intrinsically related to teaching subject culture. At present, the more concentrated research areas are mainly deep learning teaching (learning) model and strategy research, environment design research, and resource construction research. Among them, there are fewer research results on microscopic deep learning strategies and deep learning research focusing on classroom context recreation, which have certain limitations in guiding the teaching of front-line teachers and the learning of students in primary and secondary schools. Deep learning is a new integration and growth point for mathematical culture classroom teaching [3, 4]. This paper intends to explore the structure of elementary school mathematics classroom teaching from a new perspective based on microscopic deep learning strategies, resource development, and classroom context recreation, in an attempt to contribute their own new thinking on the cultivation of moral and core literacy in mathematics subjects.

2. Introduction to Deep Neural Networks

2.1. Deep Learning Model. The deep learning model, also known as the deep neural network model, is a classical nonlinear machine learning model whose design is inspired by the neural networks in the biological brain [5, 6]. During the continuous exploration of the biological brain, it was found that the basic unit of the biological mechanism of the brain is the neuronal cell. The basic structure of neuronal cells is shown in Figure 1, and each neuronal cell differentiates upstream and downstream into dendritic and axonal structures, respectively. When a nerve signal is transmitted, a chemical is released from the upstream neuron cell, which is captured by the dendritic structure as an input signal, processed by itself, and then transmitted to the downstream neuron cell through the axon by releasing
the chemical. The neuronal cells release output signals that require the sum of the received input signals to reach a certain strength in order to be activated.

In Figure 2, the input of the \( j \)-th output neuron is \( \beta_j = \sum_{i=1}^{p} w_{ij} b_i \); the input to the \( h \)-th hidden layer neurons is \( a_h = \sum_{i=1}^{q} \nu_{ih} x_i \). In Figure 2, the neuron model is divided into three levels: “input layer,” “hidden layer,” and “output layer.” Each “circle” represents a neuron, and the neuron in the “input layer” has only axon endings, the neuron in the “output layer” has only dendrites, while the neuron in the “hidden layer” has both dendrites and axon endings. The neurons in the “hidden layer” have both dendritic and axonal endings, and the lines between neurons represent the transmission of information [7, 8]. It is easy to see that the neuronal model perfectly simulates the process of biological understanding of the world: first, \( x_i (i = 1, \ldots, d) \) in Figure 2 represents a number of input data, which is also the data to be transmitted from the “input layer” to the “hidden layer.” Second, \( \nu_{ih} (i = 1, \ldots, d; h = 1, \ldots, q) \) represents the “weight” of the information transmitted from the \( i \)-th neuron in the “input layer” to the \( h \)-th neuron in the “hidden layer.” “Third, \( b_k (k = 1, \ldots, d) \) denotes the data obtained by the \( k \)-th neuron in the “hidden layer.” If this data reaches a preset “threshold,” the neuron will be activated and the \( b_k \) data can continue to be transmitted to the “output layer”; if the “threshold” is not reached, the \( b_k \) will not be transmitted to the “output layer.” If the “threshold” is not reached, \( b_k \) will not be transmitted to the “output layer”; fourth, similarly, \( w_{ij} \) and \( y_i (j = 1, \ldots, l) \) can be understood. In an ordinary neural network model, the input data \( x_i (j = 1, \ldots, l) \) and the output data \( y_i (j = 1, \ldots, l) \) are known, and a large amount of training data is used to determine the “weights” between the layers. Once all the “weights” are obtained, the artificial neural network model is built, through which the machine can simulate the human way of understanding the world to perform clustering, recognition, and optimization. When the “hidden layer” has multiple layers of neurons, a “deep learning” model in computer science is obtained (Figure 3).

### 2.2. Deep Learning in Education

If deep learning in computer science is to achieve intelligence by activating neurons and calculating weights among neurons, deep learning in education is to achieve teaching goals by activating students’ knowledge and clarifying the relationship between old and new knowledge in teaching practice [9, 10]. It is clear that the “model” of deep learning in computer science corresponds to the teaching process based on deep learning in pedagogy, and there is a clear correspondence in terms of objectives, methods, and focus (see Table 1).

From the abovementioned correspondence between the two fields of deep learning, differences can be obtained [11, 12]. These are mainly reflected in the following aspects.

Firstly, machines do not have the ability to build models on their own, while one of the goals of deep learning in pedagogy is to enable students to explore the connections between knowledge on their own, which is the most essential difference between “human” and “machine.”

Secondly, for machines, the modeling is roughly the same for the same input and output. However, for teaching, each student often has different knowledge constructs in the face of new knowledge, and the activated knowledge may be different.

Finally, although the implementation process of deep learning in these two fields is roughly the same, in computer science, deep learning requires the use of “sea of problems” and a large amount of data to get the model; while in pedagogy, teachers should pay more attention to the activation of students’ knowledge and should not give students too much practice.
3. Teaching Practices of Elementary School Mathematics Based on Deep Learning

The teaching practice of deep learning revolves around the core content of the subject, which requires teachers to create contexts suitable for deep learning so as to promote the overall development of students [13, 14]. Based on the understanding of the meaning of deep learning, the teaching process of deep learning should include setting learning tasks, actively exploring and activating knowledge elements, acquiring the essence of mathematics, consolidating the connections between knowledge elements, and summarizing the learning process.

3.1. Assigning Learning Tasks. The purpose of assigning learning tasks is to enable learners to carry out independent learning with the tasks. The learning tasks should be chosen to meet the requirements of the teaching objectives but also to be appropriately challenging for the students. These tasks can be mathematical knowledge itself or can be derived from real life, rich and complex teaching contexts created by the teacher.

3.2. Active Inquiry and Activation of Knowledge Elements. This component refers to students’ deep inquiry into the learning tasks set by teachers and their active construction of their own problem-solving approaches and methods [15, 16]. The core content of a subject is the carrier for carrying out deep learning, a class of core content is composed of several learning units, a learning unit is composed of several knowledge points, and these basic constituent elements can be called knowledge elements. The process of active inquiry is student-oriented, and students are expected to make connections between new knowledge and old knowledge and activate as many existing knowledge elements in their cognitive structure as possible. The more knowledge elements students activate, the more likely they are to approach the essence of mathematics.

Take the process of proving the “butterfly theorem” for an arbitrary quadrilateral as an example. As shown in Figure 4, the main content of the “butterfly theorem” is for any quadrilateral, there is $S_1: S_2 = S_3: S_4$ or $S_1, S_2, S_3, S_4$ (where $S_1, S_2, S_3,$ and $S_4$ are the areas of four triangles).

The proof of this theorem is as follows: first, the magnitudes of the areas of the four triangles are $S_1 = 1/2 \cdot OD \cdot h_1$, $S_2 = 1/2 \cdot OB \cdot h_1$, $S_3 = 1/2 \cdot OB \cdot h_2$, and $S_4 = 1/2 \cdot OD \cdot h_2$. Second, it can be observed that $\triangle AOD$ and $\triangle AOB$ are two triangles of the same height, and their area ratios are $S_1: S_2 = OD: OB$. $\triangle COD$ and $\triangle BOC$ are also two triangles of the same height, and their area ratios are $S_3: S_4 = OD: OB$. Finally, the two equations are equivalently substituted, i.e., $S_1: S_2 = S_3: S_4$ or $S_1 \times S_3 = S_2 \times S_4$.

In fact, the proof of “butterfly theorem” is not very difficult, but there are many knowledge elements that need to be activated in the process of proof, such as ratio and proportion, calculation of triangle area, letters for numbers, simple equations, and equivalent substitution, which are all knowledge elements that students may activate in the process of learning the lesson. Only by activating the knowledge elements behind the “butterfly theorem” can students successfully acquire the essence of mathematics [17, 18].

3.3. Acquiring the Essence of Mathematics. This is the part where students are guided by the teacher to use the activated knowledge elements to acquire the essence of mathematics. If students cannot complete the deep learning through independent inquiry, the teacher can guide appropriately by prompting students which knowledge elements the task is related to and then allowing students to activate them,
unifying student independent inquiry and teacher guidance. This process is teacher-led and is intended to help students acquire the true essence of mathematics. Take the proof of the butterfly theorem as an example [19, 20]. For elementary school students, the mathematical essence of the theorem can be summarized as follows: one is the use of letters to represent unknown quantities and the use of letters to perform operations; the other is the use of the formula for the area of a triangle to convert the ratio of the area to the ratio of the “base.” Therefore, teachers can guide students from these two aspects in the actual teaching process, prompting them to activate the relevant knowledge elements and then letting them use the activated knowledge elements to obtain the essence of mathematics.

3.4. Consolidating the Connections between Knowledge Elements. This component can also be called “continuous assessment,” i.e., multiple assessments to determine whether students have “learned” something [21, 22]. Scientific continuous evaluation can improve teachers’ teaching and professional development; it can optimize students’ in-depth learning and promote their overall development. The assessment can be done by practicing postlesson exercises, taking unit tests, etc. For the proof of the butterfly theorem for any quadrilateral, the teacher can ask students to complete the following task after the proof is completed.

For example, the diagonal AC of quadrangle ABCD compares to BD compared to point O.

If the area of the triangle ABD is equal to 1/3 of the area of the triangle BCD, and it is AO = 2 and DO = 3, then how many times the length of the CO is the length of the DO (Figure 5).

The problem is the ratio of CO and DO. Since AO and DO are known quantities, the ratio of CO and DO can be converted to the ratio of AO and CO. From the diagram, we can see that AO and CO are in two triangles with the same base, which is in line with the essence of the butterfly theorem. Through the above example, teachers can guide students to further understand the process of proving the butterfly theorem, and let them apply the theorem to solve problems, consolidate the connection between knowledge elements, and finally achieve the purpose of in-depth learning.

3.5. Summarizing the Learning Process. Summarizing the learning process means that students can review the meaningful learning process they have participated in [23, 24]. Teachers can determine whether students have integrated new knowledge with old knowledge based on their summaries, which simply means that they “know how to learn.” The deeper goal is to prepare students for learning new knowledge, encourage them to develop the habit of summarizing the learning process, and take the initiative to learn in depth, hoping that they will achieve the goal of “knowing how to learn.” The above teaching practices correspond to the process of deep learning in computer science as shown in Table 2.

4. Teaching Strategies for Elementary School Mathematics Based on Deep Learning

4.1. Stimulating Positive Emotional Experiences and Cultivating Interest in Mathematics Learning. Teachers cause empathy between teachers and students through effective and positive communication with them in the teaching process. Give full play to the positive role of emotional

| Deep learning in computers | Deep learning in teaching science |
|----------------------------|----------------------------------|
| **Model**                  |                                  |
| Input layer (initial data) | Challenging learning tasks       |
| Hidden layer (transmitting between neurons in the brain, processing information, contains multiple layers of neurons) | The existing knowledge in the cognitive structure |
| Output layer (output-processed information) | The essence of mathematics |
| Inspection model           | Persistent evaluation            |
| **Goal**                   |                                  |
| Get the machine to be able to learn | Promote students to have the ability of deep learning, independently explore the connection between knowledge, from "learn" to "learn" can "learn" |
| Under the guidance of teachers, students complete tasks, activate more knowledge elements, and independently explore the relationship between knowledge elements |
| **Method**                 |                                  |
| Use a large amount of training data to determine the model | Students’ thinking process, the activation of knowledge element and the relationship between knowledge element |
| **Keynote**                |                                  |
| Training process, neuronal activation, and determination of the weights |                       |

Figure 4: Butterfly theorem for arbitrary parallelograms.
factors in teaching activities, so as to promote teaching with emotion, teaching with emotion [25, 26]. With the help of multimedia to make mathematics teaching more intuitive and visual, to break the students’ fear of mathematics and gradually cultivate students’ interest in learning mathematics. Teachers try to connect the knowledge points learned in class with students’ life, so that students can feel the existence and charm of mathematics in real life. Connecting mathematics with real life creates a lively, relaxed and interesting learning atmosphere so that students really love mathematics and take the initiative to learn mathematics.

4.2. Students Fully Participate in Teaching and Learning to Achieve Depth of Thinking. Master the laws of mathematics in a hands-on way. Piaget’s cognitive development stage theory that children between the ages of 7 and 12 years old are in the concrete operation stage, the children of this stage of concrete operation thinking cannot leave the support of concrete things, has not yet formed the ability to abstract thinking. Psychological research shows that the more senses involved in collecting information, the more information is obtained, and the more solid knowledge is learned [27, 28]. Therefore, for students who are still in the concrete arithmetic stage, the use of multiple senses is conducive to the mastery of mathematical laws and the deepening of mathematical knowledge.

The development of mathematical thinking is promoted in cooperative learning. The exchange of ideas with each other produces two or even more ideas. This is also true in elementary school mathematics. In the process of learning knowledge, each student has a different way of thinking when faced with the same problem because of their individual differences and motivational characteristics, as well as their life environment and emotional and attitudinal differences. Through group discussion, each member of the group has the opportunity to express his or her own views and to exchange experiences and emotions with other members. Through group discussions, students incorporate the experiences and knowledge structures of others into their own knowledge structures and continuously promote self-reflection so that their own knowledge spirals upward and in the process students’ mathematical thinking develops and deepens.

4.3. Breaking the Boundaries of Disciplines to Integrate Learning and Building a Mathematical Way of Thinking. In today’s world, it is difficult to rely on the knowledge of a single discipline when students need to mobilize a wide range of knowledge, abilities, and methods to solve the complex problems of tomorrow’s society [29]. Therefore, it is important to integrate the knowledge of other disciplines in the teaching and learning process of mathematics and to develop interdisciplinary thematic learning, not only to deepen students’ understanding of mathematics and promote deeper learning of mathematics but also and more importantly, to develop students’ comprehensive thinking skills and the ability to transfer knowledge, which is an important ability to solve complex problems across disciplines. Teachers break the limitations of their own subject knowledge in the mathematics teaching process and collaborate with teachers of other disciplines to create an integrated, multidisciplinary curriculum that fosters students’ ability to think in multiple, holistic, and innovative ways and promotes the transfer of knowledge and skills.

4.4. Timely and Positive Assessment to Develop Students’ Self-Confidence in Mathematics. Learning assessment is an essential part of teaching and learning activities [30–38]. For
students at the elementary school level, affirmative and positive assessment from teachers can stimulate students’ intrinsic motivation to learn. The logical and abstract nature of mathematics makes it a subject that is not easy for students to master. In the process of learning, students will inevitably make mistakes, even some simple mistakes that teachers often emphasize, and when students make mistakes, they should not speak harshly, but should be “kind” to them. We should find out the weaknesses of students’ knowledge and provide them with targeted individual counseling.

5. Conclusion

Deep learning is a hot topic of research and practice in the field of learning science, and it is important for understanding how people learn and how learning is best achieved. The ultimate goal of deep learning is to enable students to learn basic mathematical knowledge, explore the connection between related knowledge and understand the essence of mathematics, and finally move from “learning” to “knowing.” As front-line teachers, they need to design challenging learning topics under the guidance of deep learning theory, so as to create good conditions for students to realize deep learning. According to the above discussion, teachers should pay attention to the following aspects.

First, the need for students to engage in deep learning is determined by mathematical knowledge itself. When mathematical knowledge is limited, the teaching process is much like the implementation of an artificial neural network, with few meta-connections in the “hidden layer” of knowledge. However, as students learn more mathematics, the teaching process should be based on the implementation of deep learning in computer science, and the connections of knowledge elements in the “hidden layer” become more and more complex. For example, in the lesson “position and direction,” rays, angles, measures, number pairs, etc., are all knowledge elements in the “hidden layer,” and their connections should be understood by students during the lesson.

Second, students’ ability to learn in depth is not a task of one lesson, but a long-term process. In the middle and lower grades, teacher guidance may play a key role, as teachers can take the initiative in guiding connections to what students have already learned, but they should also give students as much time as possible to think on their own. In the upper grades, the key role should gradually shift to students, emphasizing interknowledge connections, multiple solutions to problems, and adequate communication.

Third, teachers should try to let students construct their own knowledge system and form the habit of independent learning during the teaching process. When summarizing the results of a lesson, students should not only be asked “what they have learned,” but also “what they have used,” so that they can recall the learning process. Only in this way can students gradually “learn” mathematics.

Data Availability

The dataset can be accessed upon request to the corresponding author.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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