Research on Case Teaching Reform Enabled by CNN Model

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ABSTRACT

With the continuous breakthrough of the key technologies of artificial intelligence and big data analysis of education, and their innovative applications in various industries, a diversified trend of digitalization, networking and intelligent development is created from the traditional education model. In order to meet the demand of intelligent curriculum reform in universities and solve the problem of multi-disciplinary teaching design, empowered by CNN model, a practical model of case teaching reform is proposed, centring on the suitability of C-STEAM education concept and case teaching method. Under the circumstance of insufficient sample size, the case classification ability of CNN model is improved by use of data enhancement and K-fold validation method. Through model decomposition, the key "four-step method" of teaching implementation is sorted out, and through model construction, the feasibility of deep learning workstation is verified. From the perspective of theory and technology, the construction of curriculum information is carried out by practice and exploration, which is expected to give some enlightenment for the teaching reform in the era of intelligence.

Keywords: *Big Date, CNN, STEAM Education, Case Teaching.*

1. INTRODUCTION

Benefited from the continuous release of various artificial intelligence (AI) policies, AI has been constantly evolving, breaking through and developing in various fields, which reshapes people's mental disposition, behaviour characteristics and way of thinking from a new perspective. AI can be regarded as a mirror image of human cognition, whether early weak AI based on classic algorithms, or strong AI with an emphasis on machine learning, reflecting some special laws of human cognitive behaviour, which is indirectly transformed into "objective" and "external" objects that can be studied from abstract behaviours, feelings and emotions [2]. As the core of the new technology revolution, AI is also profoundly changing the current education ecology. AI is bound to have explicit or implicit, positive or negative impacts on teaching methods and classroom activities, which requires teachers to produce the resonance in such aspects as methods, ways, contents in the process of the implementation of teaching [3].

With the strong intervention of artificial intelligence in the field of education, the role of "machine" has become increasingly prominent in education and teaching, which continuously opens up a path for educational reform and innovation, as well as, challenging the traditional teaching model [1]. In order to cope with the structural restructuring in the deep water of curriculum teaching reform and meet the urgent needs of technology-enabled teaching in the intelligent era, teachers should actively explore the fusion mode of classical teaching mode and artificial intelligence algorithm, and contribute to the smooth transition from traditional education framework towards intelligence, data and information. Combined with the years of teaching practice, the research team proposed an intelligent case teaching practice method oriented by C-STEAM idea, proceeding from the key link of improving the quality of talent cultivation, and realized a beneficial attempt of reform of AI enabling case teaching.

2. CORRELATIONAL RESEARCH

2.1. Intelligent Case Teaching Reform

The multiple-branch research fields are derived from the "AI + teaching reform", such as big data, AI, deep

A. El-Hashash et al. (Eds.): IEIT 2022, ACSR 100, pp. 729–737, 2023.
https://doi.org/10.2991/978-94-6463-058-9_114

learning, intelligent education, talent cultivation, engineering ability, new engineering and so on, whose network topology is uniform and atlas structure is remarkable. Liu designed a comprehensive computer experiment course based on Python, which effectively stimulated students' independent inquiry ability by use of task-driven and case teaching, which achieved good practice effect [4]. By building a case teaching library based on AI teaching content, Xu tightly coupled abstract algorithms with practical applications, which achieved remarkable results in improving teaching quality [8].

During the COVID-19, Murdock, of the Perelman School of Medicine at the University of Pennsylvania, provided students with a virtual morning paper (VMR) teaching session based on case teaching. Through problem hypothesis, students could initiate intense discussions including differential diagnosis, problem presentation and diagnostic reasoning, so as to develop their clinical reasoning skills [5]. Through comparative experiments, Nayakanti found that case teaching has strong advantages in cultivating students' problem-solving, critical thinking and reasoning skills, which will help improve students' understanding and memory ability [6].

2.2. STEAM Education

The STEAM education concept is that the integrate education will be launched in the fields of science, technology, engineering, arts, and mathematics. STEAM emphasizes the interaction and innovativeness, improving students' overall quality of multiple dimensions, such as sharing and collaboration, creative innovation, exploration and learning, scientific practice and thinking.

With its innovative perspective, pioneering thinking and forward-looking concept, STEAM education philosophy has quickly attracted the attention of various education research teams. Scholars have carried out a lot of exploration and practice focusing on STEAM education concept. With the COVID-19 spread around the world, data analysis by the Institute of Educational Sciences at the University of Madrid, which specializes in training STEAM educators, found that online teaching during the COVID-19 had an overall impact on course objectives, content and teaching effectiveness, forcing institutes to change the direction of educational practice and carry out diversified ability learning activities, from face-to-face blended learning to dual mode synchronous teaching training assistance [7].

2.3. C-STEAM Education

In the past few years, the new generation of information technology, represented by deep learning and big data in education, has been continuously applied to education and teaching, promoting the rapid development of the traditional classroom into the direction of digitalization, visualization and openness. At the same time, the knowledge content of communication courses is increasing exponentially. Communication, digital signal processing, advanced mathematics, software radio and other courses are deeply intertwined. The last "kilometre" of "learning" and "application" is broken through, and the comprehensive quality of students is improved in the round. In the process of teaching, more and more teaching methods are introduced into the classroom, such as participation and inquiry. However, it is difficult to find a comprehensive concept to lead in full implementation of class.

STEAM focuses on cultivating students' systematic logical thinking, which is good at inspiring students to explore the inner connection of things, and has unique advantages in cultivating students' systematic thinking, so it has been gradually applied in the teaching process by the research group. Traditionally, STEAM education concept is relatively macroscopic. In the process of practical application, it is localized according to the teaching needs of communication courses. In the teaching process, the students of communication major should be guided to solve practical problems in communication skilfully (or artistically), with the help of mathematical tools from a scientific perspective, using technical means and engineering thinking, namely C-STEAM.

As is shown in Figure 1, the "positive pyramid" of C-STEAM education framework, the top layer is the ultimate teaching goal that is to improve students' comprehensive quality, which reflects the persistence and lifelong nature of education. The second layer is STΣ@M, representing the interdisciplinary synthesis of C-STEAM, which emphasizes that students should broaden their horizons and integrate path analysis to solve problems after learning in the professional field. Meanwhile, it puts forward higher requirements for students' basic information literacy. The third layer is "A+C+STEM", highlighting the potential connection of the ideological and political contents of curriculum and the artistic knowledge among disciplines. The fourth layer is the basic skills. In the courses stipulated by the talent training plan, students should master the basic knowledge and sublimate it into basic skills. The fifth layer is composed of various courses, as well as a distributed presentation of students' comprehensive quality.

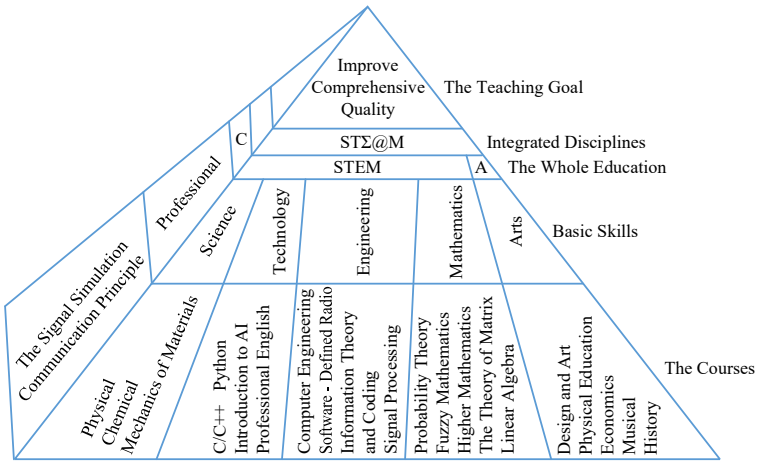

Figure 1: C-STEAM Education Framework - "Positive Pyramid".

3. THE SUITABILITY OF C-STEAM EDUCATION CONCEPT AND CASE TEACHING METHOD

Under the background of classic cases, case teaching is that teachers guide students to carry out intense discussion and thinking collision for the given problems in the case through scenario simulation or reduction, which could make students use their own knowledge or sort out materials, seeking the solutions and approaches to problems, unconsciously to promote the development of students' comprehensive quality. In the 1870s, Randall, the dean of Law School of Harvard in the United States, put forward case teaching for the first time that is another presentation of the Ancient Greek Socratic questioning teaching method, so as to inspire students to think deeply. After that, case teaching is gradually developed to other countries and applied in many teaching practices.

In order to achieve the teaching objectives better in communication courses, under the guidance of C-STEAM education concept, through repeated practice and the creation of teaching scenarios of appropriate case, the teaching objectives could be achieved with high quality, and the students' class participation and sense of gain would be significantly improved.

The three kinds of suitability as below are concluded from C-STEAM education and case teaching, both of which can boost the advanced classroom activities.

3.1. Perspective of Educational Intention

C-STEAM advocates the education concept of multi-disciplinary integration and focuses on the cultivation of students' comprehensive quality and information acquisition quality. It requires students to skilfully analyse various problems in the interdisciplinary field with solid theoretical foundation, broad thinking mode and unique integrated perspective, so as to promote the comprehensive quality of students in an all-round way. Case teaching method takes specific scenarios, hypothetical models and application scenarios as the central framework, which reasonably matches the teaching content frame by frame along the time axis, combines the "post production" methods, such as ingenious problem setting, classic instant replay, wonderful scene reproduction and so on, and guides students to solve the symptom of each problem by using comprehensive thinking of the subject, to improve students' comprehensive ability to analyze and solve problems by combining theory with practice. The starting point of both C-STEAM and case teaching method is to improve the comprehensive quality of students, so that they can gradually acquire the ability of interdisciplinary traversal and pay attention to the overall improvement of ability.

3.2. Perspective of Practical Purpose

The carriers of C-STEAM and case teaching method are both high-level classroom teaching activities. The unique advantages of C-STEAM and case teaching mode are deeply reflected through enlightenment and guidance, achievement display, and cooperation and exchange between teachers and students, and among students. On the one hand, C-STEAM is the theoretical basis in the practice process, which guides the construction of interdisciplinary, multi-professional and multi-field collaborative education framework, firmly grasps the threshold of talent training quality, and leads all practical activities to improve the comprehensive quality of students. On the other hand, case teaching method is an action guide in the practice process, which is in charge of the design and presentation of specific classroom practice links under the coverage of multiple scenes and all elements. It is a strong link rooted in the "framework" between teachers and students, and among students, maintaining the orderly and efficient implementation of classroom teaching practice activities, and boosting the focus of classroom teaching objectives to build students' excellent skills.

3.3. Perspective of Process Analysis

The whole-process monitoring mechanisms with multimode, flexibility and open style, which are adopted for stage indicators measurement in both C-STEAM and case teaching methods, monitor the transient deviation of the growth trajectory of students' ability and quality in different stages of class, semester and grade, by use of the non-standard assessment methods, such as achievement display, investigation report, design scheme and innovative works, etc. comparing with "theoretical basis" and "action guide", giving real-time feedback on the educational effect of each link of teaching practice, and dynamical guide of the educational mechanism, so as to constantly enrich and improve the curriculum construction.

4. CONSTRUCTION OF CASE TEACHING MICRO REFORM MODEL

It is the key that how to improve students' core quality and cultivate interdisciplinary innovative spirit and practical ability in an increasingly broad space, so as to improve the quality and efficiency of talent training.

In order to actively explore the intelligent case teaching mode of communication courses under the interdisciplinary and multi-professional background, the research team introduced CNN (Convolutional Neural Network, CNN for short) model under the C-STEAM vision, and tried to construct a new case teaching mode of typical disciplines under the effective intervention of deep learning. In the complex case materials, the data mining ability of deep learning is used to explore the non-linear structural relations among data, which provides lateral support for the information construction of communication and related courses. In the collection of massive teaching data, the assistant prediction function of deep learning is used to establish the micro-relationship between teaching effect and learning situation analysis, which provides decision support for intelligent education evaluation.

As is shown in Figure 2, the reform model of intelligent case teaching aims at the integration and application of knowledge, taking AI-assisted teaching as the framework and case scenario immersion participation as the method, which realizes the advanced interaction between teachers and students and the in-class intelligent assessment. Horizontally, the key elements of teaching implementation consist of resources, environment and technology, making the case teaching reform develop into open source, shared space and drive data and so on. Vertically, the activities involved in teaching implementation are closely connected and deeply proceeded, enhancing the participation, sense of identity and sense of achievement in the whole teaching process. On the whole, the case teaching reform is supported by the C-Steam concept, constructing a "reverse pyramid" that covers the covered curriculum, subject integration and goal achievement. The core of its overall part is AI technology, and the purpose is quality cultivation, which illustrates the logical relationship among each key steps in teaching implementation. According to the general process of teaching implementation, the implementation process of AI enabling case teaching micro-reform is divided into four parts: preparation stage, concrete implementation, assessment and evaluation, and behaviours feedback, namely the "four-step method".

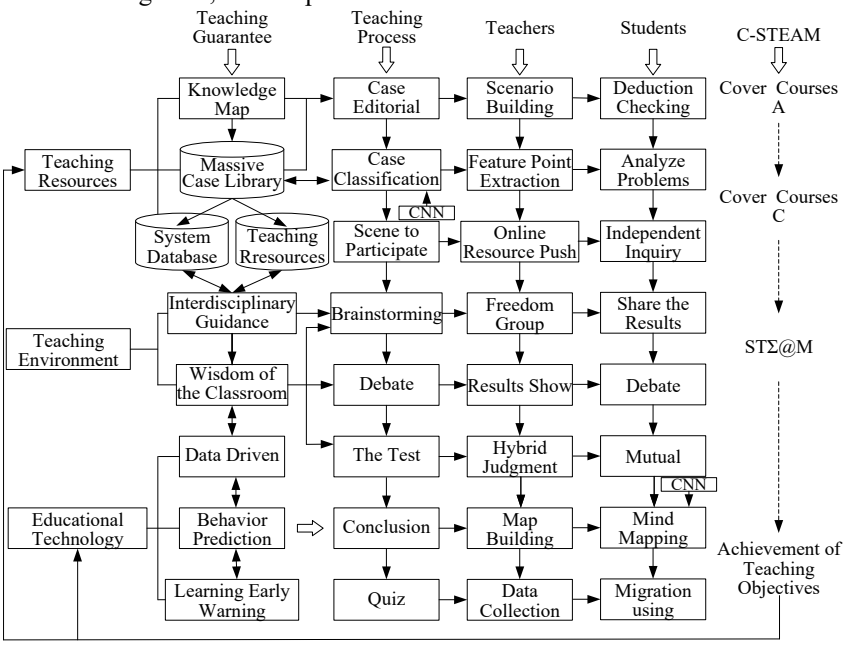

Figure 2: Micro Reform Model of Intelligent Case Teaching.

4.1. Preparation Stage

The preparatory stage of case teaching includes case gathering, case classification and situational participation, which is one of the focuses of the micro-reform of intelligent case teaching, corresponding to "A (Arts)" and "C (Communication)" in C-STEAM. At this stage, relying on massive teaching resources, the basic database of case teaching is established. Centring on the distribution of knowledge points, teachers carefully construct scenarios of case teaching and skilfully set interdisciplinary related quest ions. Students are guided to explore questions independently in groups by using offline and online to push resources to research problems autonomously, so as to form an intra-group achievement sharing.

4.1.1. Case Editor

Before teaching, according to the distribution of knowledge points in this lesson, teachers index the interdisciplinary knowledge map, search for similar knowledge clustering nodes, systematically comb the clustering contribution of each node, and provide direction reference for case selection. Combined with massive case database, expert system database and online teaching resource database, cases and examples are preferentially reported through filtering case keyword and screening intelligent algorithm, which will be brought into the list of case editor for teachers. According to the characteristics of distribution of knowledge points, on the premise of not violating the authenticity of cases, sometimes cases even need to be edited or matched for students to create a learning environment of realistic scene, vivid steps and sufficient materials.

4.1.2. Case Classification

The collected cases are input into the intelligent classification mode of CNN, forming case label coding and being archived into massive case library. Taking the problems existing in the implementation of case teaching method under the C-STEAM education concept as the starting point, the relevant technologies in the field of deep learning are applied into the strategic research of case classification, striving to improve the scientific character, unity and normalization of case classification.

4.1.3. Participation in Scene

Teachers distribute case scenarios to students before class through offline and online resource push. By previewing relevant materials and combining deduction and replay of cases, students can summarize ideas and methods to solve communication problems skilfully for subsequent sharing and communication among groups. Situational participation is an important part of case teaching. Students analyse case materials from different aspects by using their reserved knowledge and understanding ability, which not only stimulates their interest of independent inquiry, but also strengthens the teaching content of the course, obviously improving the efficiency of classroom teaching.

4.2. Implementation Process

It consists of brainstorming, debate among groups and quantitative scoring in the concrete implementation stage of case teaching, which is supported by STΣ@M (integrated disciplines) in the C-STEAM concept, as the construction part of advanced behaviour. According to their own knowledge literacy, students make a comprehensive analysis around the case, form a theoretical point of view and a scheduled list of problems by intra-group collision of ideas. In order to support their own opinions or intra-group ideas, teachers should be active to guide students to "wander" in interdisciplinary map, so as to strengthen the winning chips.

4.2.1. Brainstorming

By means of divergent thinking, students independently explore cases from the aspects of structure, scene, contradiction, problem and application to form a "free view" within the group. In order to support its correctness, students are guided to provide necessary formulas, theories, typical application cases, etc., to achieve the aim to improve comprehensive thinking of the subject through continuous training. In the process of teaching, teachers organize inter-group demonstration of achievements and summarize students' different perspectives on problem analysis, forming a list of class problems.

4.2.2. Debate Among Groups

According to the scheduled questions of case collection and compilation, teachers organize "3-minute limited debate". The debate is held as an open format, in which anyone can state his or her own position or refute the others. Through the fierce debate between both parties, restraint of thought and complement of knowledge would be realized to promote the good effect of win-win learning. Teachers should pay attention to timely guide students to absorb correct views and be good at analysing the root cause of wrong positions, so as to check pointedly and make up for the shortage and timely update the knowledge map of students.

4.2.3. Quantitative Scoring

This step belongs to the second part of inter-group questioning, which is mainly carried out by students. According to the process of "3-minute limited debate", each group scored the members for the other party,

mainly based on three aspects, which are case analysis, opinion statement and argument support. In order to avoid emotional and invalid scores, the evaluation form is submitted anonymously, and the scores of team members are calculated by weighted average method. Quantitative score is also considered as one of the input indicators for subsequent behaviour prediction and learning situation warning, which is involved in intelligent calculation in the deep learning workstation.

4.3. Evaluation

Evaluation is the second focus of the micro-reform of intelligent case teaching, covering condensed classroom knowledge and in-class tests, corresponding to the achievement of classroom teaching objectives of C-STEAM.

According to the students' achievement show, mutual evaluation effect, class participation, teachers judge the students' ability deviation against the teaching objectives, and review the key step of the case again combining with focal and difficult points, so as to build the map of classroom knowledge. According to their own knowledge, students construct the difference map, summarize the personalized mind map, and then obtain the individual differentiation distribution of classroom teaching effects by using the CNN classification function. Teachers combine the analysis of in-class test data collection with the distribution rule of individual differentiation, and guide students to update their knowledge map to realize knowledge transfer and application in the new field. In-class tests are taken online. CNN generates individual behaviour prediction curves by relying on the historical accumulated database and classroom behaviour collection database to assist teachers in matching students' differentiated learning effects as required, which has completed the data-driven push of accurate after-class resources. The evaluation part is mainly relied on the deep learning workstation to build a data-driven learning behaviour prediction model. It can realize the integration of intelligent warning of learning situation and intelligence of knowledge, and the transformation from historical experience review to drive of intelligent data in teaching effect evaluation.

4.4. Behaviour Feedback

Behaviour feedback means that teachers check the degree of achievement of teaching objectives and complete teaching reflection according to students' knowledge mastery and training plan.

In the micro reform of AI enabling case teaching, with the preliminary application of AI technology, teachers can be boosted to drive of data from previous experience review, and gradually improved to the exploration of teaching nature and laws, showing the characteristics of data, systematization and collaboration. Behaviour feedback plays a corrective role in the improvement of deep learning workstations and the optimization of teaching resources, which is an important data support for model structure adjustment and teaching effect evaluation.

5. INTELLIGENT CLASSIFICATION IMPLEMENTATION OF CASE TEACHING

5.1. Construction of Data Set

40 images were randomly selected from the image case data base as the training set S, and each image was marked as S_i, and $i \in [0, 40]$. In addition, other 40 images were randomly selected as the verification set V, and each image was marked as V_i, and $i \in [0, 40]$. The rest images are served as the test set. Both the training set and the verification set of image materials are required to distribute in the communication teaching content of the course "Principles of Airborne Information Equipment".

5.2. Construction of CNN Model

In the early process of experiment, it is found that the model overfitting phenomenon is serious, whose reason is that there are too few learning samples to train models that can generalize to new data. In view of the above problems, the implementation process is mainly dealt with from two aspects: one the one hand, it is to increase the database capacity artificially. On the other hand, it is to adopt k-fold validation to make up for the deficiency of verification data.

(1) The database capacity is Increased artificially. Due to the small database capacity, it is easy to produce training of over-fitting resulted from too few samples, so in the training set S, the image read by the instance of "Image Data Generator" is performed random transformation for many times to achieve data enhancement.

Table 1: Data Enhancement Parameter Settings.

Item	Parameter
rotation_range	50
width_shift_range	0.5
height_shift_range	0.5
shear_range	0.5
zoom_range	0.5
horizontal_flip	True

(2) K-fold validation. The data is divided into K partitions with equal size. For each partition i, the model is trained on the rest K-1 partitions, and then evaluated on partition i. The final score is equal to the average of K scores.

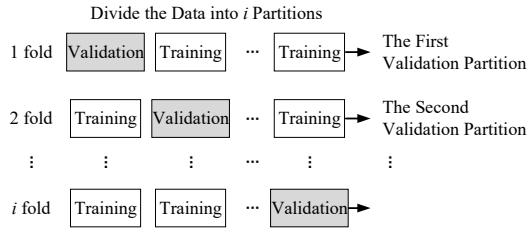

Figure 3: K-fold Validation Diagram.

The processing framework of CNN is shown in Table 2. It consists of four conv2D layers and four Max Pooling2D layers, and both the output of each conv2D and Max Pooling2D are a 3D tensor. By observing the "output shape" column, the sizes of the output width and the height dimensions are generally decreasing with the network deepening.

Table 2: CNN Architecture.

Layer	Shape	Value
conv2d (Conv2D)	(None, 148, 148, 32)	896
max_pooling2d (MaxPooling2D)	(None, 74, 74, 32)	0
conv2d_1 (Conv2D)	(None, 72, 72, 64)	18496
max_pooling2d_1 (MaxPooling2D)	(None, 36, 36, 64)	0
conv2d_2 (Conv2D)	(None, 34, 34, 128)	73856
max_pooling2d_2 (MaxPooling2D)	(None, 17, 17, 128)	0
conv2d_3 (Conv2D)	(None, 15, 15, 128)	147584
max_pooling2d_3 (MaxPooling2D)	(None, 7, 7, 128)	0
flatten (Flatten)	(None, 6272)	0
dropout (Dropout)	(None, 6272)	0
dense (Dense)	(None, 512)	3211776
dense_1 (Dense)	(None, 1)	513
Total params: 3,453,121, Trainable params: 3,453,121, Non-trainable params: 0		

5.3. *Analysis of Operation Results*

After the classification model is constructed, the model is first trained on the training set, and the times of iterations are set as 20. Then, the validity of training data is verified on the validation set. Various parameters of the model are evaluated by plotting training accuracy, test accuracy, training loss and test loss, so as to provide necessary data support for subsequent model optimization. Before the fitting method is added, the performance of the model is shown in figures as follows:

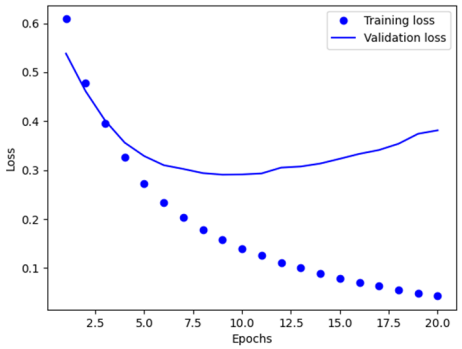

Figure 4: Training Loss and Validation Loss.

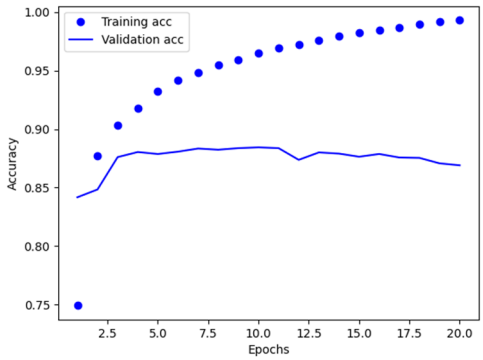

Figure 5: Training Accuracy and Validation Accuracy.

In Figure 4 and Figure 5, the characteristics of the model can be comprehensively analysed as follows: ① The training loss decreases in each round, and the training accuracy increases linearly in each round. If the times of iterations are enough, the training loss will approach 0 and the training accuracy will approach 1. ② The validation loss and the validation accuracy both reached the best value in the 11th round, which kept getting worse then. Such a large performance gap was the result of only fitting the training data. The model does not fit the general data that is not used in training (i.e. the validation data set) very well, which indicates that over-fitting phenomenon has occurred.

In order to overcome the over-fitting phenomenon and give better play to the classification processing ability of the model, data enhancement was added in the second round of testing, and k-fold validation was adopted to verify the generalization ability of the model. The number of iterations was set to 100 in order to continuously pay attention to the good performance of the model.

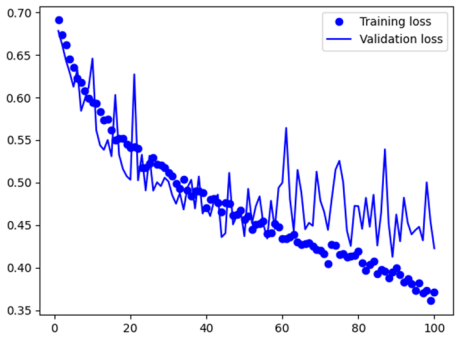

Figure 6: Training and Validation Loss.

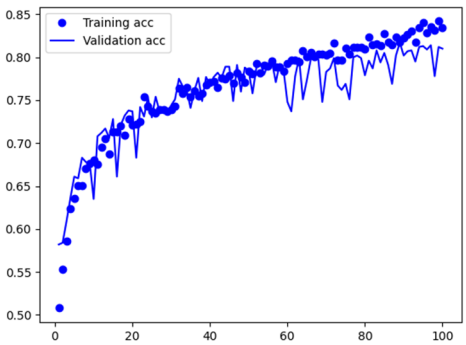

Figure 7: Training and Validation Accuracy.

With data enhancement, the model is no longer over-fitting. The training curve closely follows the verification curve. Although there is an oscillation in Fig.6 when the number of iterations exceeds 60, the overall trend is downward. With further research, higher accuracy can be obtained by using other regularization methods and adjusting network structure and parameters.

6. CONCLUSIONS

Through continuous practice and exploration, the research group has gradually concluded the general method of reform of AI enabling case teaching under the guidance of C-STEAM concept. This method integrates the classical STEAM education concept with case teaching method into CNN deep learning framework. Through the use of data enhancement and K-fold validation, it overcomes the adverse influence of model overfitting for case classification and learning situation warning under the influence of limited data, and has a good effect in practice.

Curriculum is the most microscopic problem of education, but it solves the most fundamental problem of education. Artificial intelligence and big data in education not only impact traditional teaching, but also provide a broad space for the development of course information construction. But how to assign new ideas to new missions still needs constant practice and exploration, concluding a localized method framework that is easy, able and effective to use, which can meet the urgent needs between “teaching” and “learning”. With the continuous development and application of intelligent technology, college education and teaching will launch the new development trend, extend the new connotation mechanism, and practice the new scientific practice.

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