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An innovative talent training mechanism for maker education in colleges and universities based on the IPSO-BP-enabled technique

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A R T I C L E I N F O

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A B S T R A C T

In this study, a path to improving students' core literacy is explored, and a new mechanism is developed for maker education and teaching based on research on students' core literacy and the essence of maker education. An evaluation model of college students' maker ability is established, and an improved particle swarm optimisation (IPSO) algorithm is introduced into the backpropagation (BP) neural network to improve the accuracy and speed of the evaluation of students' innovation ability. Finally, experimental verification is conducted. The results indicate that most students significantly improved their memory and understanding of knowledge, principle exploration and attitude formation after practising the core literacy training method. For an innovation ability evaluation dataset, the accuracy rate of the BP neural network model reached 76.42%. The prediction accuracy rate of the PSO-BP network designed above was 86.76%. The IPSO-BP neural network model had the highest accuracy rate, reaching 4.43%. Evidently, the combination of a talent training mechanism for maker education and information technology can improve the evaluation efficiency of students' abilities.

Introduction

The rapid development of maker education in colleges and universities has won a lot of praise. The emergence of this phenomenon is largely a result of high-quality maker teachers and a proper talent training mechanism (Cunningham & Menter, 2021; Zhang, 2021; Shahzad et al., 2021). Maker education requires an excellent team of teachers. Currently, most teachers engaged in maker education are information technology teachers. They have strong sensitivity and application ability to advanced technology. Moreover, they can provide students with professional guidance in software and hardware technology, advanced programming, electronic equipment, etc.; however, this support is far from sufficient (Du et al., 2021; Garces & O'Dowd, 2021; Zhang et al., 2021). Makerspaces are entering schools and communities and transforming teachers and students into makers. Makerspaces in colleges and universities encourage hands-on learning, experimentation and collaboration amongst parents and children (Wang et al., 2021; Allen, 2021; Al-Mamary & Alshallaqi, 2022). It requires teachers and students to have high physical strength, intelligence and perseverance. In the process of students' maker learning, teachers should give guidance in knowledge, technology, psychology and other aspects. In addition to the necessary teaching ability of teachers, maker education also requires teachers to have the ability to master multidisciplinary knowledge and have outstanding inspiration and guidance abilities (Xue & Liu, 2021). The multicourse integration of maker education has brought considerable challenges to the vast majority of teachers in traditional disciplines. Thus, new talent training mechanisms must be explored to address this challenge. Innovation is the core driving force of national development. Thus, cultivating innovative talent is a critical task of education worldwide. Amidst this situation, maker education has emerged as a new educational model for cultivating various innovative talents. Therefore, this work explores a new talent training model from the maker education perspective.

Maker education activities meet the training requirements of innovative talent. They can create a good environment for students to think independently, explore freely, innovate, stimulate curiosity and foster innovative thinking. Thus, they are an important channel to acquire tacit knowledge. Maker education is a form of education that integrates innovative manufacturing and learning. From the standpoint of its theoretical foundation, technical support and activity methods, it is a hybrid educational approach. Consequently, the following issues have arisen in the practice of maker education. The development of maker education activities is intended to foster the innovative and creative abilities of students (Li, 2021; Rafique et al., 2022; Dabbous & Tarhini, 2021). Acquiring invisible knowledge has

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been limited due to differences in funds, teachers, science and technology and the development level of maker education in different schools. Maker education is a viral way to transform declarative knowledge into procedural knowledge. It integrates the five modules of science, technology, engineering, art and mathematics, thus allowing students to learn, grow in a comprehensive knowledge base, have fun and discover their own strengths (Shu & Huang, 2021; Li & Gao, 2021; Lytras et al., 2022). Hence, we should cultivate divergent thinking and improve the art of logic and thinking through extensive liberal arts knowledge. Maker education is a comprehensive enlightenment education (Kim & Han, 2021; Son & Lee, 2021; Aljohani et al., 2022). In maker education, students can explore innovative thinking and hands-on creativity to a great extent through extensive search, skills training and creative challenges in the practice of various projects in various disciplines; at the same time, students develop social skills and qualities (Ozen et al., 2023). Therefore, maker education is equivalent to a catalyst to stimulate children's creativity and innovative spirit. It is a supplement to traditional education and teaching. It can change the old learning mode, reduce the lack of students' personalised development caused by standardised teaching and examination and subsequently stimulate children's creativity and innovative spirit. Therefore, exploring a reliable and efficient talent training mechanism from the perspective of maker education will help promote talent training in China to new heights. The status survey shows ample research on maker education and the corresponding research results. Such studies include the relationship between maker education, students' hands-on exploration and innovative thinking and the advantages of maker education implementation. However, few efforts have been made in the talent training mechanism. Integrating maker education into the talent training mechanism of colleges and universities is imperative. Therefore, this study explores the essential emergency measures to the talent training mechanism in the process of rapid development of maker education.

This work conducts literature research and model construction to investigate the current situation of talent training in colleges and universities. The main contributions and innovations of this study lie in the following aspects. (1) A maker education teaching mechanism is established with students' core qualities as the core. (2) The improved particle swarm optimisation (IPSO) algorithm is used to optimise the artificial intelligence (AI)-based back propagation (BP) neural network. (3) The particle velocity and position vector are combined with the weight threshold to calculate the optimal weight and threshold when the error meets the requirements. (4) The innovation ability of college students in maker education is evaluated. This study can provide new research ideas for the talent training mechanism of maker education.

The following content of this paper is divided into four parts. Section 2 summarises and analyses the research results of the research field in recent years. Then, section 3 presents the research method, including the advanced analysis of the role of education on high-quality economic development, research on the impact of the level of the digital economy on high-quality economic development based on intelligent decision-making and intelligent decision-making to achieve high-quality development of the digital economy. Section 4 presents the specific results and discussions for the research methods of section 3. Finally, section 5 summarises the current study and the limitations of the study and future research work.

Literature review

Review of maker education in colleges and universities

The current educational hotspots and the key to future progress and reform in tertiary institutions are maker education and student participation. Therefore, this development trend must be monitored, and comprehensive research must be conducted closely (Moore et al., 2020; Lee et al., 2021; Lemieux & Rowsell, 2020). With the maturation of AI and big data research, an increasing number of skilled professionals are entering the intelligence market. Consequently, many colleges and universities have shifted their focus to educating students on smart technologies (Balakrisnan et al., 2021; Li et al., 2021; Mehrotra et al., 2021). However, conventional education in colleges and universities is frequently a one-way classroom teaching model, and the flaws of this teaching model are evident. The defects of this teaching mode are apparent. Although students are cognitive subjects, they can only passively accept knowledge during the whole learning process, and teachers ignore or even suppress their learning initiative. This model is inconsistent with the talent training requirements of modern society. Moreover, it cannot bear the burden of cultivating high-quality creative talent. As the name suggests, maker education is an educational method to develop a creator and teach students to foster ideas.

In China's deepening foreign exchanges, the direction of talent training in universities and colleges has gradually changed from traditional technical talents to all-around talents with both skills and innovation. Chen et al. (2021) believed that education leads to engineering, and engineering depends on practice. The Engineering Training Practice centre is an engineering practice teaching institution in China that improves students' practical and engineering abilities. It also empowers students to be innovative and well rounded in engineering literacy. With the increase in new challenges and situations, the innovation and reform of engineering practice education to meet development needs have become vital topics in the current higher engineering education. College students actively think, oppose stereotypes and have a sufficient knowledge reserve. They are the main force for the future development of the maker movement. For instance, Liang (2020) took Jilin Economic Management Cadre College as the representative in the research. The study expounded on the primary status of innovation and entrepreneurship education in higher vocational colleges from two aspects: the development of innovation and entrepreneurship education in schools and students' learning status. Emerging maker education has inspired creative technical talent training under the Internet of Things (IoT). In the IoT maker course, teaching problems include inadequate teaching models. It emphasises products rather than theory and only allows students to imitate practice. In response to these issues, Chen et al. (2020) proposed a new mathematics, science, engineering and technology teaching model called 'Advice, Instruct, Design, Review, Implement, Display and Evaluate' for IoT maker courses.

Under the influence of a new round of technological revolution, the Creator Movement is advancing and developing globally. As important avenues for talent training, colleges and universities generally lack motivation and innovation in classroom teaching. Hence, how to stimulate students' learning motivation and innovative development awareness is an immense test for every university (Wang et al., 2020). Maker education is significant for innovative talent training. However, most of the current maker courses in institutions of higher education have several problems, such as having a single teaching function, unsmooth course teaching and inconsistent course management systems. Therefore, concepts, strategies and models must be innovated to meet the new needs of higher education development for maker courses. Lu (2021) established learner-orientated maker education guided by the teaching concept of science, technology, engineering and art mathematics to realise the practical experience of 'creation, pleasure, cooperation and sharing'. At the same time, the teaching design of Scratch programming education led by game-based learning has been used as a supplemental teaching measure. Lv et al. (2020) proposed an automatic online assessment method to analyse the reliability of network information systems quantitatively. In addition, Lv and Qiao (2020) constructed a cognitive computing system based on deep belief networks and applied it to talent training prediction.

This work aims to study the contingency measures that should be taken by the talent training mechanism in the rapid development of maker education. Literature research and model building are conducted to examine the current situation of talent training in colleges and universities. The innovation lies in the establishment of a teaching mechanism of maker education based on students' core literacy and the concept of creator education. In addition, the AI-based BP neural network is optimised using a particle swarm optimisation (PSO) algorithm. Meanwhile, particle velocity, position vectors and weight thresholds are combined to obtain the optimal weights and thresholds when the error meets the requirements. Then, the innovation ability of college students participating in maker education is evaluated, which can provide new research ideas for the talent training mechanism of maker education.

Discussion on Ai techniques such as metaheuristic algorithms/heuristic algorithms

AI-related algorithms have been extensively used in various fields. Many researchers have also given their research conclusions. When optimising multiple target issues, the same strategy may behave differently when facing problems with different characteristics. As a result, the characteristics of obtaining problems help obtain premium-quality solutions. However, the problem is unknown in the practical optimisation process. In this case, learning adjustment strategies are characterised by challenging work. Zhao and Zhang (2020) studied a learning-based algorithm to enhance generalisation capabilities. The automatic learning machine was added to the algorithm based on the decomposition multitarget optimisation framework. In addition, the evolution strategy of the algorithm was adjusted to adapt to the characteristics of the problem according to the feedback information of the problem.

Ma and Ding (2022) studied the training of higher vocational education computer professionals. First, deep learning neural networks and data mining algorithms were used to introduce recurrent neural networks (RNNs) and fusion attention models to develop college talent training information systems. A diversified talent training plan was formulated in response to the need for employment forms and employment data. An efficient index system for talent training quality was established by analysing data on higher vocational education talent. Finally, the effectiveness of the system was verified through performance analysis. The results showed that the average prediction accuracy of the RNN WORD2 algorithm was 80.61%, which was significantly higher than that of the latest research algorithm model. The accuracy of the classification of talent training was 82%. This model was viable for classifying computer professionals' training and could accurately reflect the problems in talent training. The effect was evident through visualisation.

Quality education is the foundation, driving force and incentive of skill education. These two educational models can be supplemented and interact with each other. However, few scholars have discussed the status and future trends of the integration of two models, as well as the effects of quantitative integration. Bai and Huang (2021) applied the artificial neural network (ANN) to evaluate the integration effect of quality education and skill education due to the advantages of ANN in the adaptive processing of nonlinear information. First, the subject and motivation mechanism of the two model integrations were analysed. Then, the evaluation index system of the integration effect was established. Afterwards, an ANN model was created to evaluate the compatibility of the index and was used to predict the integral effect. The experimental results verified the rationality and effectiveness of the model system. Finally, the current status of the integration was analysed on the basis of the prediction results.

In reforming the talent training model, universities and colleges must promote and apply modern apprentices to meet the needs of intelligent manufacturing. However, most enterprises and schools have many differences in their enthusiasm for the modern apprenticeship system and their motivation for implementation. Hence, the critical influencing factors of the model must be analysed to enhance participation motivation and correctly evaluate the motivation status of enterprises and schools participating in modern apprenticeships. Therefore, Ji and Li (2021) adopted an ANN to evaluate this motivation state. First, the Modern Apprenticeship Motivation Status (MAMS) evaluation model established its evaluation index system. Then, they compared the difference in motivation status from seven aspects. Subsequently, an improved BP neural network was constructed to construct and optimise the MAMS prediction model. Finally, the validity of the model built was verified through experiments.

In summary, AI-based algorithms have many fields, and most of them have achieved good research results. In particular, the research results of neural networks in talent training provide a reference for the talent training mechanism of modern schools. On this basis, this study uses PSO algorithms to improve the BP neural network. This improvement will help to find the optimal solution in researching the innovative talent training mechanism to obtain accurate and satisfactory results.

Method

Concept of maker education in colleges

Maker education is a comprehensive practical course and a critical part of the university technology curriculum (Chiu, 2022). Maker education aims to learn new knowledge continuously, digest and absorb ancient expertise in the process of solving problems and internalise, consolidate and improve understanding through practical application (Camilleri, 2021). This kind of personalised, hands-on enquiry and problem-solving ability is what current school education neglects and needs to be enhanced significantly. Maker-style learning also provides a new solution to practical problems, such as high scores but low abilities and a lack of innovative talent in current talent training (Eckhardt et al., 2021). At present, youth maker activities mainly focus on students' interests and hobbies, allowing students to be spontaneous, independent, and accessible (Ifenthaler et al., 2021). Creator activities should turn students' short-term interests into ongoing interests and then interests into hobbies. Exam-orientated education requires examination as the final reference standard. In contrast, maker education focuses on process and mobilises students' enthusiasm for participation. The maker education method should be implemented according to the characteristics of students of different ages and education stages due to their various cognition and learning methods. Consequently, it requires a team of maker teachers with a strong sense of innovation, high comprehensive quality and outstanding technical ability.

On the basis of the integration of information technology, maker education inherits the ideas of experiential education, project learning methods, innovative education and 'do it yourself' concepts. It emphasises the learner's involvement in the creative situation and process. In the process of maker education in colleges and universities, students are seen as creators or contributors of knowledge rather than just consumers. The maker movement creates an educational culture that encourages students to engage and explore creative solutions to real-world problems.

The constituent elements of maker thinking include four aspects: focusing on the integrated application of knowledge, advocating problem awareness and critical thinking, encouraging risk-taking/enquiry and emphasising creativity and innovation. The concept of maker education includes many aspects (Niiranen, 2021). Firstly, it turns ideas into real objects. Makers turn personal ideas into artefacts and advocate putting ideas into practice, not just imagining them.

Maker teaching allows students complete visible creative work in individual and group units in modern learning technology courses instead of learning from paper and text. Secondly, makers generally learn by doing and solving any problems they encounter. Knowledge learning and problem solving are carried out simultaneously rather than being separate from each other. Furthermore, makers must continue sharing and introducing the new constructivist shared-learning concept into classroom teaching. Specifically, maker teaching usually adopts a step-by-step approach for group and class-sharing activities, including speaking, writing and practical exercises. Thirdly, maker education advocates collaborative and interdisciplinary learning. Maker learning entails interdisciplinary learning out of a traditional subject classification according to the needs of the problem. It also requires students to complete work that includes multidisciplinary knowledge rather than be limited to a particular subject field. Finally, maker activities are generally closely related to information technology and its products, such as open-source software and hardware and 3D printing technology for creation. Students are required to use information technology tools in their creative work.

Maker education teaching mechanism based on students' core literacy

Driven by technological innovation, maker education provides a solution to the predicament of uncoordinated social development and talent training. An inseparable relationship exists between maker education and developing students' core literacy. As one of the ways to cultivate core literacy, maker education can integrate high-quality resources and furnish a carrier (Cunningham & Menter, 2021). Constructivism believes that learning is created on the basis of the meaning of context and individual experience, emphasising the establishment of knowledge systems through interaction with others (Heiskanen et al., 2021). According to this theory, instructional design should follow to embed learning in real problems, offer a suitable learning environment and integrate continuous assessment into the teaching environment (Ramírez-Montoya et al., 2021). Core literacy is the literacy required for individuals to attain self-realisation and development, become active citizens, integrate into society and have successful employment. Maker education is the concept of 'maker movement + education' formed on the foundation of Dewey progressivism and Papert constructivism. It takes the cultivation of innovative, practical, cooperative and shared maker culture and spirit as the essential content in educational practice.

Maker education enables students to understand the process of scientific enquiry and form their own maker culture by learning through innovative experiences (Debarliev et al., 2022). Therefore, maker education must be implemented on the basis of China's core literacy framework. Furthermore, it must reconstruct the cultivation of core literacy from three directions: curriculum foundation, innovative practice and individual development literacy. These measures can help students understand and establish a creative culture. Fig. 1 presents the ways to improve students' core literacy from the maker education perspective.

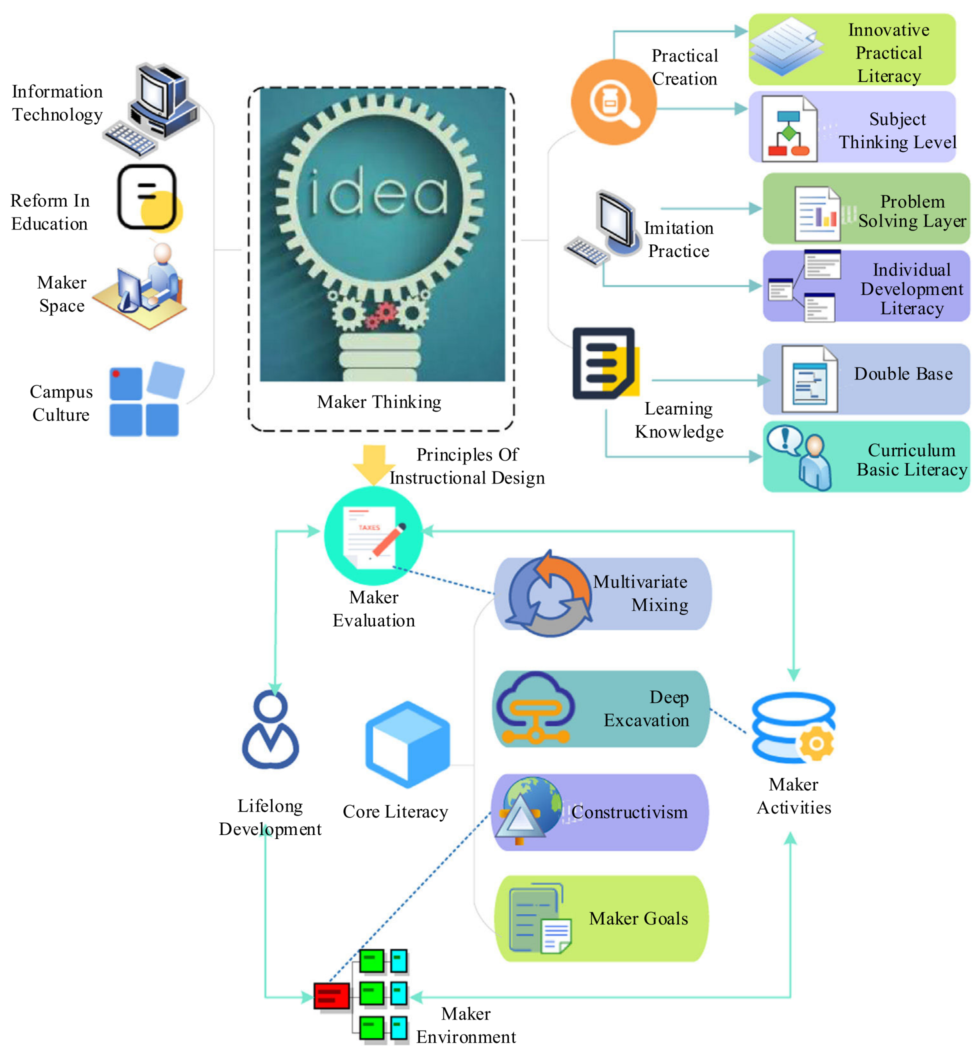

Fig. 1. Teaching model of maker education to promote the core literacy development.

According to Fig. 1, maker education mainly strives to improve students' core literacy from three aspects: practical creation, imitation practice and knowledge learning. The path to improve students' core literacy is based on the technical environment of the maker space. Combining the principles of the construction of an open and virtual innovative learning space with path practice can fundamentally change the traditional educational model of education mechanisation and create a flexible learning atmosphere for students. Maker education based on the system view can improve the core literacy of students and take the cultivation of high-level literacy and key abilities as the training goal. It will become a teaching system that dynamically develops in the exchange of information and energy with the goal of core literacy.

The teaching principles targeting core literacy include four aspects: maker goals, maker evaluations, maker activities and maker environment. The maker environment is composed of physical space, virtual space and cultural space. The maker environment should create an open cultural atmosphere for students and integrate the core literacy and ability requirements with the learning objectives of maker education practice and the use of technology. Maker activities based on the cultivation of core literacy should also adopt a learning method that involves the deep excavation of the project theme so that students can form the ability to understand and analyse the problem as a whole on the premise of mastering the relevant knowledge principles and application methods. In addition, maker goals are the foundation for formulating maker evaluations, and maker evaluations are the yardstick for measuring the achievement of maker goals. Educators must grasp the connotation of maker education and core literacy and have these concepts complement each other to design learning goals and evaluation systems with internal consistency.

This study constructs a teaching activity model for maker education to promote the development of core literacy from a micro perspective based on the idea of constructivism and 'learning by doing'. This model follows maker education's implementation path to cultivate core literacy and the design principle to improve students' core literacy under the guidance of the systematic view. The developed teaching activity model enables students to establish an individual knowledge system in the process of project creation in an experimental learning method to achieve the training goals of high-level literacy and key abilities. Fig. 2 shows the design procedures of teaching activities.

Fig. 2 presents the course teaching situation in which maker education improves core literacy and takes the maker project derived from the real situation as the axis. It also takes the interesting and life-orientated teaching concept as the orientation that follows the teaching centre of students and the openness of space, comprehensive content and cultural integration as the principle. Furthermore, it creates a cultural and open teaching situation through a variety of creative methods.

This study examines the teaching activity mode in practice using the maker education elective course at a university in Zhejiang Province as the teaching environment for basic literacy training. A comprehensive maker education and science course are conducted according to the core literacy teaching plan. Twenty-one students are randomly taken as the research object to analyse the teaching effect.

Evaluation model of college students' innovation ability in maker environment

Given the unequal distribution of educational resources in China's colleges and universities, a great number of institutions remain unable to foster a productive maker culture. Most schools use information technology education to implement maker education or introduce digital tools and information resources to conduct teaching. However, they only emphasise the application of information technology in the maker teaching mode. ANNs can predict data because the weights and thresholds can be adjusted as needed to achieve the best accuracy (Hoang et al., 2021). x_i represents the input signal, ω_{ik} denotes the connection weight between neuron k and neuron i, and m signifies the number of input signals. Then, the output u_k

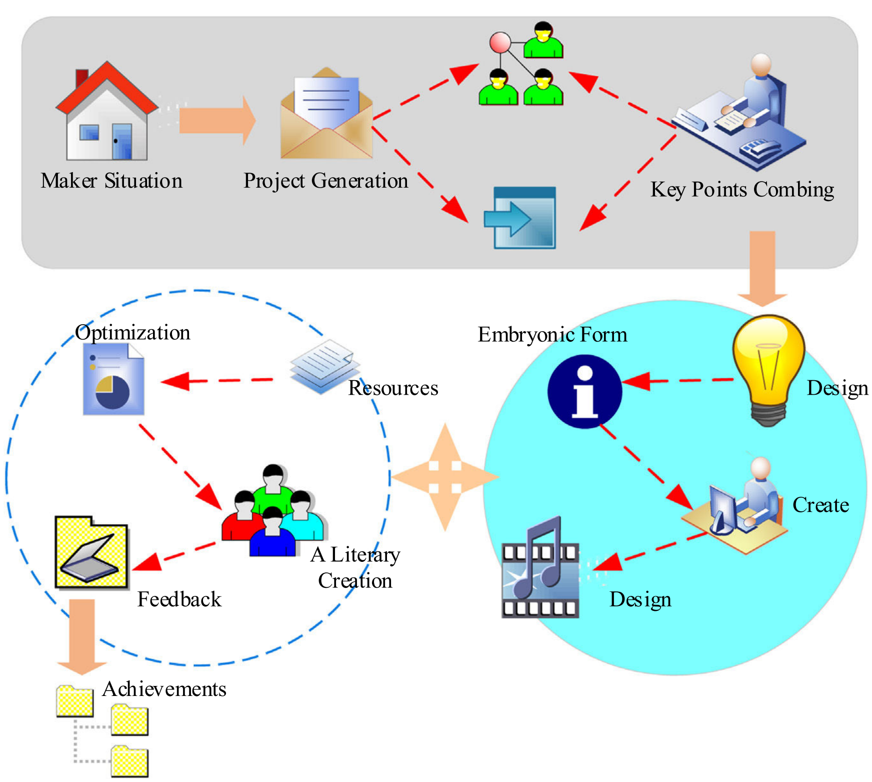

Fig. 2. Teaching Model of maker education to Promote the Core Literacy Development.

after the linear combination of the input signal can be expressed as Eq. (1).

$$u_k = \sum_{i=1}^{m} \omega_{ik} x_i. \tag{1}$$

The output of the neuron y_k is calculated according to Eq. (2).

$$y_k = f(u_k - b_k). \tag{2}$$

In Eq. (2), u_k refers to the output after a linear combination of input signals, b_k represents the threshold of the neuron, and $f()$ denotes the activation function of the neuron. A BP neural network is a guided learning algorithm using the weight coefficient of each layer to approximate a nonlinear function.

Gradient descent descends in the direction of the derivative every time until the gradient does not change sharply. The iteration continues until the network converges. For example, the parameter change is less than a specific value, the number of training times reaches a certain value, and the objective function is less than a particular value.

The development of the PSO was inspired by gregarious animals' migration and foraging behaviour (Zhu et al., 2021). Each particle, which is individually distributed randomly and dynamically, has a specific solution in the solution space. The search direction and distance of the group are determined according to the speed. Then, the group searches in the space according to the position of the optimal particle individual. In the iterative process, both the optimal local solution and the optimal global solution will affect the fitness changes of the particles to update themselves constantly. The optimal solution searched by the individual particle is also the optimal local solution P_{best}, and the optimal solution searched by the group is the optimal global solution g_{best}.

Individual particles search in a D -dimensional space. N particles represent the group, and the i-th particle indicates a D -dimensional vector, as shown in Eq. (3).

$$\begin{cases} X_i = (x_{i1}, x_{i2}, \cdots, x_{iD}) \\ i = 1, 2, \cdots, N \end{cases}. \tag{3}$$

The i-th particle is also a D -dimensional vector, as presented in Eq. (4).

$$\begin{cases} V_i = (v_{i1}, v_{i2}, \cdots, v_{iD}) \\ i = 1, 2, \cdots, N \end{cases}. \tag{4}$$

The optimal location searched by the i-th particle in the entire space is called the individual optimal solution, which can be written as Eq. (5).

$$\begin{cases} P_{best} = (p_{i1}, p_{i2}, \cdots, p_{iD}) \\ i = 1, 2, \cdots, N \end{cases}. \tag{5}$$

The optimal location searched by the whole group is called the optimal global solution, as shown in Eq. (6).

$$g_{best} = g(p_{g1}, p_{g2}, \cdots, p_{gD}). \tag{6}$$

As long as the particle finds the optimal local solution and the optimal global solution, it can update its position and velocity through Eqs. (7) and (8).

$$v_{id}(t+1) = w * v_{id}(t) + c_1 r_1 (p_{id} - x_{id}(t)) + c_2 r_2 (p_{gd} - x_{id}(t)), \tag{7}$$

$$x_{id}(t+1) = x_{id}(t) + v_{id}(t+1). \tag{8}$$

In Eqs. (7) and (8), w stands for the inertia weight; c_1 and c_2 represent the learning factors ranging between 0 and 4; v_{id} refers to the particle's speed; t denotes the t-th generation; r_1 and r_2 range between 0 and 1, respectively. The particle velocity is constrained to be within $[-v_{max}, v_{max}]$, and the position should be within the $[-x_{max}, x_{max}]$range, as shown in Eq. (9).

$$v = v_{max} - \frac{v_{max} - v_{min}}{T_{max}} \times t. \tag{9}$$

The maker education mode in Chinese colleges and universities is mainly based on enquiry-based and project-based learning. It is a process of (1) generating creativity, (2) analysing and designing and (3) materialising. This study integrates the specific implementation steps and procedures for educational activities on the basis of an analysis of the existing maker education environment and the teaching objectives of maker education in colleges and universities. Fig. 3 depicts the flow of maker education activities in colleges and universities.

According to Fig. 3, the process of the teaching activities of maker education in colleges and universities is divided into three parts. Firstly, students need to understand and explore the situation. Secondly, they need to create ideas based on imagination, that is, innovative design. Finally, they need to find problems through innovative practice, propose solutions and share between groups to achieve a win–win situation.

The selection of indicators must initially take into account the characteristics of maker education in colleges and universities as well as the student's physical and mental development levels. Finally, five first-level indicators are established on the basis of literature research

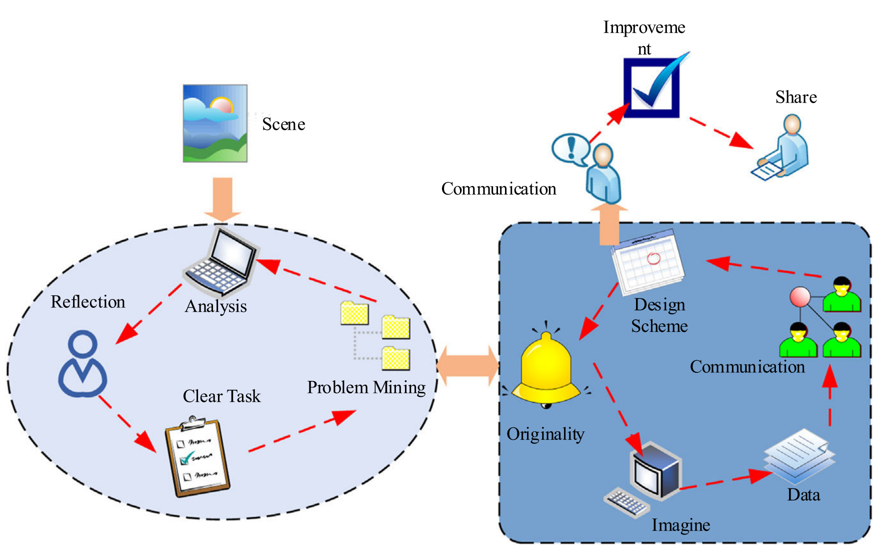

Fig. 3. Process of maker education Activities in colleges and universities.

Table 1
Flow of the IPSO-BP neural network algorithm.

1	Start
2	Determine the topology of the network according to the actual evaluation problem, and set the initial threshold and weight value
3	Set network parameters.
4	The initial population was obtained by coding.
5	Randomly initialize particle velocity and position.
6	Calculate particle fitness values.
7	Update individual and global extremum.
8	Update individual extremum and global extremum according to particle fitness value
9	$v_{id}(t+1) = w * v_{id}(\mathrm{t}) + c_1 r_1 \left(p_{id} - x_{id}(t)\right) + c_2 r_2 \left(p_{gd} - x_{id}(t)\right) \ldots (10)$
10	$x_{id}(t+1) = x_{id}(\mathrm{t}) + v_{id}(t+1)$ (11)
11	If Meet the conditions
12	The weights and thresholds are obtained by decoding.
13	Network training.
14	Weight threshold update.
15	If The error satisfies the condition.
16	Else Adjust network weights and thresholds and continue network training
17	End

and case analysis: innovative knowledge reserve, innovative learning ability, innovative awareness, innovative thinking and innovative skills evaluation. The weight can measure the importance of an indicator. The coefficient of variation is a relatively objective index weighting method.

Using AI as basis, this study introduces the IPSO in the BP neural network for accuracy and operation speed improvements. The optimal weight and threshold are obtained when the calculation error meets the requirements. A minor, moderate value function can be obtained through continuous optimisation. The particle with the smallest fitness function in each iteration is regarded as the optimal global particle. Table 1 provides the specific algorithm flow for optimising the BP neural network using IPSO.

The update of thresholds and weights reduces the network training error. Hence, the mean square error (MSE) of network training is regarded as the fitness function of the particle swarm, which is expressed as Eq. (12).

$$MSE = \frac{1}{2N} \sum_{i=1}^{N} \sum_{j=1}^{C} \left(O_{j,t} - d_{j,t}\right)^2. \tag{12}$$

In Eq. (12), N represents the number of training samples; C denotes the number of neurons output by the network; $O_{j,t}$ stands for the actual output value of the j-th output point in the i-th training sample; $d_{j,t}$ refers to the ideal output value of the j-th output point in the i-th training sample.

A mutation probability factor for the position of the particle swarm is introduced by analysing the mutation idea in the genetic algorithm to improve the diversity of the population and prevent the particles from converging prematurely. Furthermore, analysing the degree of difference of the samples and expanding the search range of the solution space facilitates a comprehensive and effective search, thereby increasing the probability of converging to the local optimal solution. If the particle swarm converges prematurely, the particle position vector mutates randomly according to the environment. Otherwise, it will continue to iterate normally.

In this study, the inertia weight is set to a random number in a certain area. In the early stage of evolution, if the particle is near the optimal position, a smaller weight value is generated according to the optimal position to speed up the convergence speed. If it is far from the optimal position, the particle velocity is corrected in the iterative process. In addition, it is constantly attempting to jump out of the local optimum. Before using the IPSO algorithm to train the neural network, the topology of the neural network must be established. Then, the weights and thresholds are encoded, which can be divided into matrix encoding and vector encoding.

If X connection weights and thresholds are optimised in vector encoding, then the particle individuals in the population will be encoded into an X-dimensional vector composed of X weights and threshold parameters. Weights and thresholds represent individual particles. These individual particles in the particle population are encoded into matrixes through matrix encoding, and all weights and thresholds are represented by individual particles.

After the encoding process, the individual particle is the weight and threshold of the network and iterates according to the corresponding update position and velocity formulas in the algorithm. The mean square error (MSE) in the iterative process is the fitness function. The decoding of vector encoding is relatively easy. Thus, this study selects the vector encoding strategy.

Experimental design and procedure

This research conducts simulation experiments and case analyses on the performance of the abovementioned IPSO-BP neural network model to verify the evaluation of innovation ability.

(1) Firstly, data collection and preprocessing are conducted, and the process is as follows.

This study's data collection is based on evaluation index data from the literature. These data are used as a training sample when combined with the background data of the Zhejiang Provincial Teachers' Ability Improvement Project. As a test sample, the evaluation data of 20 experts in maker education research at the Zhejiang Provincial Audio−Visual Education centre and the evaluation data of existing experts are compiled following data screening. Table 2 displays the evaluation data of the top ten experts.

The min-max method is adopted for the standardisation of the evaluation index to retain the data between 0 and 1.

(2) The experimental environment settings are as follows.

According to the characteristics and requirements of the experiment, the MATLAB software platform is selected to use its own functions and simulation tools to reduce the workload of programming,

Table 2
Review data from 10 experts.

Serial number	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	Output
1	6	4	4	3	5	8	5	5	6	8	8	6	7	5	8	94
2	3	2	2	2	3	5	5	5	3	4	4	3	4	2	8	58
3	6	2	1	1	3	5	8	8	6	4	4	3	4	5	8	74
4	1	1	4	2	1	2	2	2	3	2	2	1	2	1	4	31
5	6	4	4	3	3	5	8	8	6	4	4	3	4	5	8	85
6	3	2	1	2	1	2	2	2	1	2	2	1	2	1	2	27
7	6	4	4	2	5	5	8	5	3	4	4	3	4	2	4	74
8	3	2	2	1	3	2	2	2	3	2	2	3	4	1	2	37
9	6	4	4	3	5	5	5	5	6	4	4	3	2	5	8	80
10	3	2	1	3	5	2	2	5	6	4	2	3	2	5	4	55

realise the automation of evaluation and conduct accurate and efficient modelling. The hardware environment is one PC. In the software environment configuration, the CPU is Intel (R) Core (TM) i7 −10750H CPU @ 3.60 GHz 2.59 GHz. The memory is 16 GB, the operating system is Windows 10, and the hard disk capacity is 1 TB.

(3) The performance test process is as follows.

This study uses three test functions to assess the iteration speed and convergence performance of the algorithm and compare the performance of the PSO algorithm before and after the improvement. The test functions are Schaffer, Rosenbrock and Rastrigrin:

$$f_1(x) = 0.5 + \frac{0.5 - sin\sqrt{x^2+y^2}}{(0.001(x^2+y^2)+0.1)^2}, \tag{13}$$

$$f_2(x) = -\sum_{i=1}^{m}\left[(x-1)^2 + 100\left(x_{i+1} - x_i^2\right)\right], \tag{14}$$

$$f_3(x) = -\sum_{i=1}^{k}\left[x_i^2 + 10 - 10\cos(2\pi x_i)\right]. \tag{15}$$

The dimensions of the Schaffer, Rosenbrock and Rastrigrin functions are 20, 30 and 20, respectively. The particle size of the particle swarm is 10.

This experiment compares the performance of using the PSO algorithm and the IPSO algorithm to solve the maximum and minimum values to which the three test functions converge within a certain value range. The test function is used to assess the algorithm before and after the improvement. With the increase in the number of iterations, the change in the moderate value is observed to reflect the convergence performance. During the operation, the iteration value and the moderate value are recorded. The moderate value is used as the ordinate, the number of iterations is the abscissa, and the moderate value curve is drawn. The curve is expressed as monotonically decreasing. The moderate function is the MSE. With the iteration of the algorithm, the global optimal solution is constantly updated, and the performance before and after improvement is compared by observing the moderate value.

Results and discussion

Simulation result analysis of the maker education training model for students' core literacy

The students are scored from three perspectives: basic curriculum literacy, innovative practice literacy and individual development literacy. The results are shown in Fig. 4.

Fig. 4 suggests that after most students practice the core literacy training method, their memory and understanding of knowledge, exploration of principles and attitude formation have been dramatically improved. The maker education model of 'learning by doing' is in line with the students' nature to like hands-on operations. The use

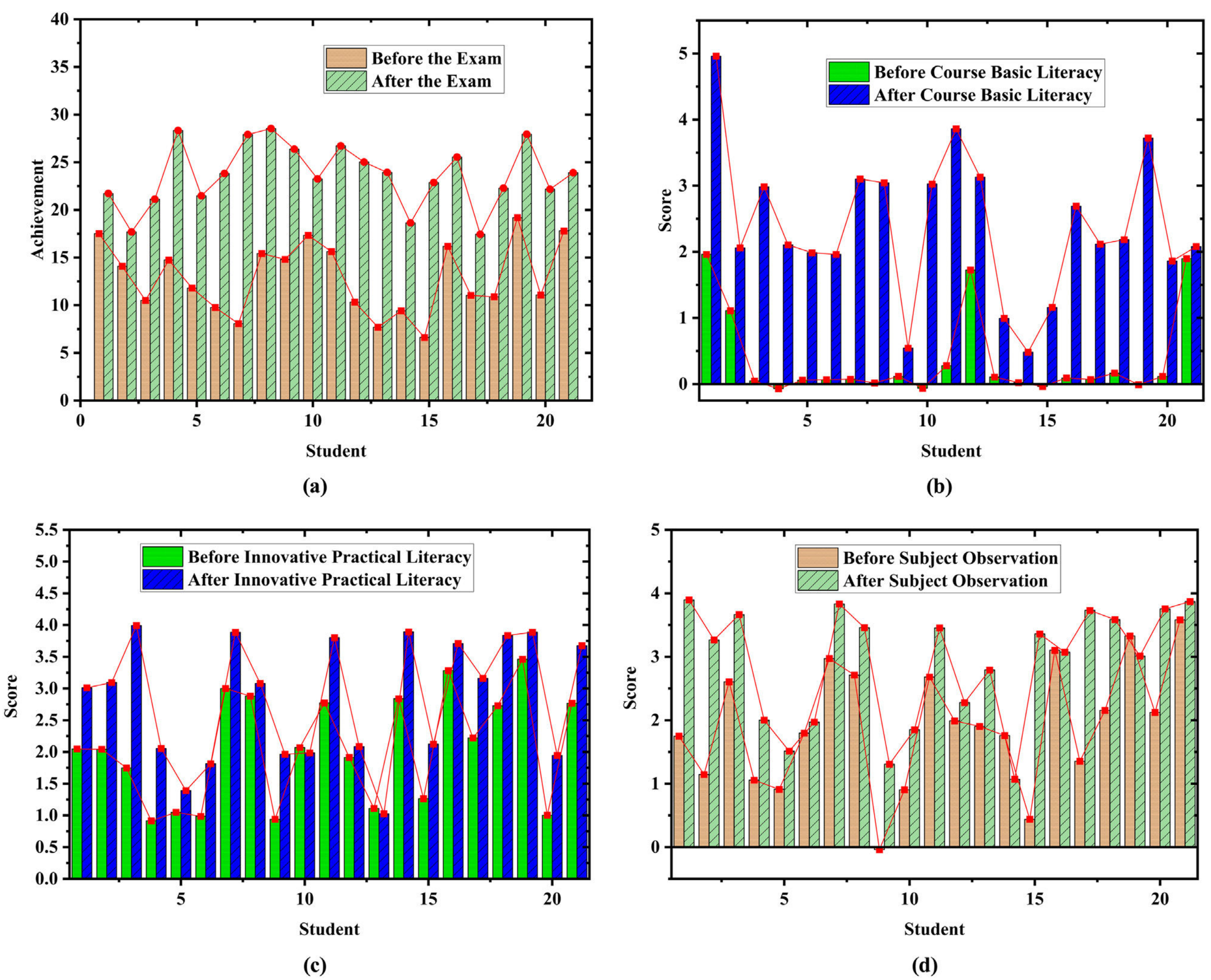

Fig. 4. Individual learning data analysis (a. course examination results; b. basic curriculum literacy; c. innovative practice literacy; d. individual development literacy).

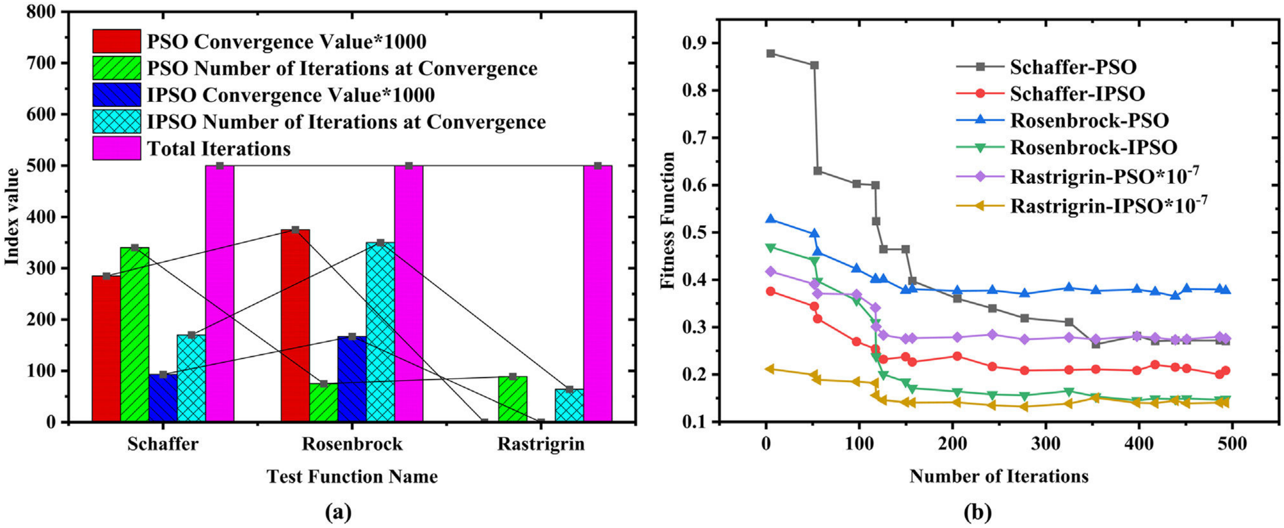

Fig. 5. Function test results and changing curves (a. test results; b. changing curves).

of tools and materials to explore knowledge principles collaboratively further stimulates students' enthusiasm for learning. Moreover, it is an important means of exploring spirit. In the process of knowledge mining, through conversational negotiation, reflection and exchange and interpretation of conclusions, students can master knowledge skills, apply principles and comprehend scientific culture and concepts to cultivate their basic literacy of courses.

Evaluation of university and college students' innovation ability by the BP neural network optimised by PSO

The improved BP neural network algorithm is tested using the test function. This experiment observes the change in the appropriate value with the increase in iterations, reflects the convergence performance by the changing curve and records the iterative value and proper value during the operation. The results are shown in Fig. 5.

Fig. 5 indicates that the IPSO algorithm has a faster convergence speed, stronger ability to find the global optimal solution and smaller error value than PSO. The optimal solution of the IPSO algorithm may be continuously updated with the increase in overlapping times, and the accuracy will be higher as well. The target error of the BP neural network is set to 0.0001, the learning rate is 0.01, and the maximum training time is 1000. The activation function is the sigmoid function. Fig. 6 reveals the MSE values in this case.

As shown in Fig. 6, the preset requirements are met through 100 iterations of the algorithm. After the training is completed, the test samples are input, and the test results are shown in Fig. 6(b). The accuracy of the test results and the generalisation ability are both relatively high. The ability to identify samples is also relatively strong, and the consistency is very good. However, the BP algorithm has shortcomings, such as being very sensitive to the initial value and threshold settings, which will lead to large differences in results. Therefore, the IPSO algorithm is needed.

The training results of the BP neural network optimised by PSO and IPSO are shown in Fig. 7 and Tables 3 and 4.

According to Fig. 7(a), the PSO-BP neural network meets the error requirement after 35 iterations. Table 3 and Fig. 7(b) show that the IPSO-BP neural network meets the expected requirements in only 10 iterations, converges very fast and has better accuracy than the PSO-BP network. As shown in Table 4, the fitness value in IPSO represents the motion property of the globally optimal particle in each iteration and corresponds to the weights and thresholds in the BP neural network. The fitness value is the mean square error of the BP network model. Meanwhile, the comparison of the three sets of experimental

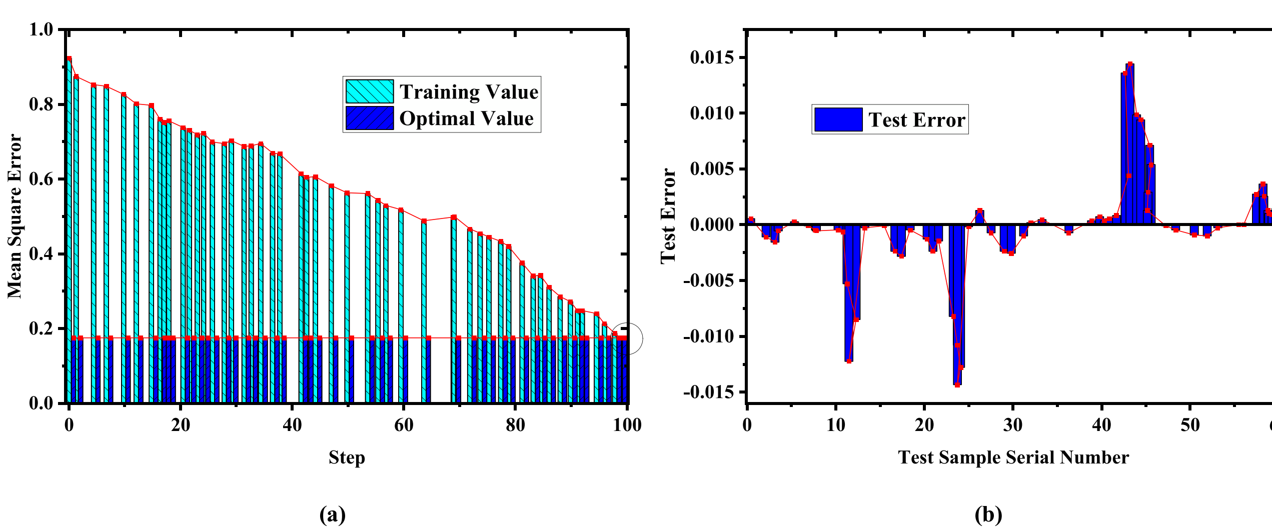

Fig. 6. Training error of the BP Neural Network (a. test results; b. changing curves).

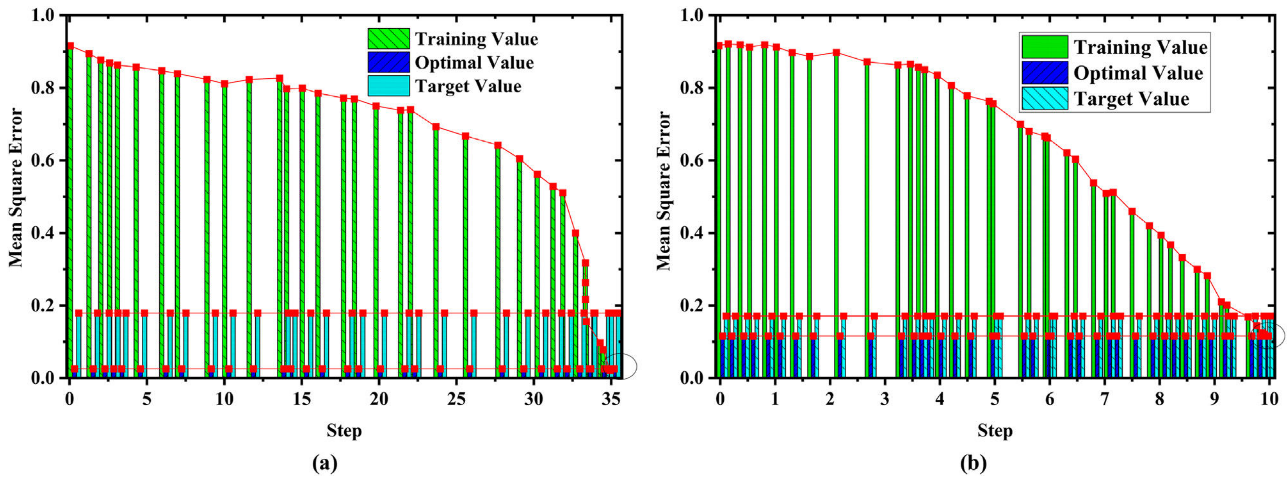

Fig. 7. Optimization effect of the BP Neural Network algorithm by PSO and IPSO (a. training error curves of the BP Neural Network algorithm optimized by PSO; b. training error curves of the BP Neural Network algorithm optimized by IPSO).

Table 3
Training errors of the BP neural network algorithm optimized by PSO.

Test Sample Serial Number	PSO*10−3	IPSO*10−6
2	0.01217	0.06792
4	0.01258	0.1053
5	0.01816	0.14272
6	0.02383	0.08511
7	0.0239	0.12306
8	0.01877	0.17973
10	0.00269	0.17965
13	0.01964	0.02657
15	0.01992	0.0454
16	0.02559	0.0642
17	−0.02322	−0.2024
20	0.03186	−0.35475
21	0.03202	0.12048
22	0.02125	0.04381
23	−4.39E-04	−1.0972
24	−0.13634	−1.43957
26	−0.01619	−0.77518
27	0.04401	0.09924
28	0.02239	−2.01113
31	0.01207	−4.29247
32	0.00674	−7.90496
34	0.00701	−4.40705
35	0.00732	−1.91664
36	0.00752	0.17458
39	0.01885	−1.51774
40	0.03005	−0.75804
43	0.00323	0.11619
45	0.02545	0.17252
47	0.02029	0.13411
49	0.0425	0.07622
51	0.03741	0.03757
53	0.016	0.03677
55	0.0055	0.07463
56	0.01653	0.07391
57	0.03855	0.03497
59	0.02796	0.09045

results indicates that the accuracy of the BP neural network model reaches 76.42%. Furthermore, the accuracy of the PSO-BP network model reaches 86.76%, and the highest accuracy of the IPSO-BP network model based on AI reaches 94.43% on the dataset for innovation capability evaluation. Therefore, the IPSO algorithm achieves a better optimisation effect for the BP neural network than the PSO algorithm and is suitable for evaluating the innovation ability of university and college students.

The IPSO algorithm achieves a good optimisation effect and can adjust the initial weights and thresholds effectively, which makes the network converge faster and the training results more accurate than the initial network. In addition, the advantages are more evident compared with the other two network models. The error results obtained by applying this model to the evaluation of students' innovation ability in creative education are also satisfactory. The development level of students' innovation ability can be truly and accurately reflected using the structure of the evaluation system constructed here combined with the scientific and effective algorithm. The experimental results are similar to the conclusions reached in similar studies by other scholars. For instance, Fayoumi and Hajjar (2020) reported that the integration of innovative data mining and decision-making techniques in the context of higher education can effectively improve performance. They proposed a new method via AI techniques to predict academic performance. They also developed an ANN model based on the decision support system that illustrates the added value of applying AI techniques to advanced decision-making in education. Their study recognised that applying a scientific approach to standard problems in academia is feasible. In addition, Mirzayi and Sepahpanah (2021) used the Misra and Dhingra model to assess e-learning maturity in Iranian agriculture using ANNs. A cross-sectional study verified that the level of academic achievement in the field of agriculture can be predicted using the Misra and Dhingra model. Hence, the relevant research demonstrates that the ability to evaluate educational orientation and talent development using neural networks is highly effective.

Table 4
Testing results of three models.

Test Sample Serial Number	Training Sample Simulation Error	Test Sample Simulation Error	Number of Iterations/100	Accuracy	Moderate Value
BP	0.17865	0.06943	1	0.7642	0.1798
PSO-BP	0.00231	5.5E-4	0.35	0.8676	0.1434
IPSO-BP	6.7E-5	9.35E-6	0.1	0.9443	0.1218

Conclusion

Maker education emerged in the United States. This educational model emphasises the training of hands-on ability and the integration of theory with practice. In other words, students can change from having passive acceptance of knowledge to engaging in active exploration, in-depth study, spontaneous learning and the encouragement of innovation through interdisciplinary hands-on creation to solve practical problems in life and improve students' learning ability. This study examines the connotation of maker education and its impact on students, discusses the research status of maker education, proposes a maker education mechanism based on students' core literacy and uses a neural network model to evaluate the innovation ability of college students in maker education. The study further proves that the IPSO-BP network algorithm model has fast convergence speed and high accuracy. The model does not need the error function to be derivable and has wide applicability based on the adaptive function to search for the optimal value. However, the research still has some shortcomings. The algorithm has some uncertainties, such as inadequate stability and accuracy and a limited number of samples. The model and method need further case analysis to find problems in practical application. Therefore, future work will improve the algorithm by addressing some uncertainties. In addition, sufficient experimental data must be collected, and repeated attempts must be made to reach the optimal conclusion.

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