



Creative Teaching Model of Civil Engineering Classroom Based on Brain Cognitive Science

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ABSTRACT

In the past ten years, the researches on brain science and neuropedagogy has developed rapidly, which has a revolutionary influence on education and teaching. The cross development of brain science, neuroscience and classroom teaching is the inevitable trend of education development. Based on the macro-micro principle of brain cognition and in combination with various factors that influence the teaching of civil engineering course, this study establishes a model of full time-space infiltration teaching system, and puts forward the teaching strategy on the basis of the teaching model, so as to improve and realize the scientific and high-efficient classroom teaching and promote the efficiency and effect of teaching.

Key Words: Brain cognitive science, Civil engineering, Classroom innovation, Teaching model

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Introduction

Since the 1990s, the United States, Japan and Europe have invested a great deal of energy and funds to the research on the advanced cognitive function of human brain, which has greatly promoted the development of brain cognitive science. With the rapid development of modern molecular biology, imaging technology, cytology and information technology, more simple, direct, precise and scientific tools have been provided for the scientific research of brain cognition. The research of brain cognition is in a period of vigorous development (Chinese Academy of Sciences, 2012). After more than 20 years' development, the research on brain cognitive science can be divided into two directions: the research on brain function and mechanism of brain diseases on the level of micro-molecular cells and the research on multi-level integration of brain function on the level of macro-system (Hu *et al.*, 2016). Along with the rapid development of brain cognitive science and the

establishment of the status of brain cognitive science, the cross-integration of many disciplines and brain cognitive science is being promoted.

The teaching discipline is studied from the perspective of brain cognitive science. This new teaching idea not only involves in the fields of brain science, psychology and pedagogy, but also impacts on the traditional teaching thinking and raises questions on the existing teaching methods. It's necessary to understand the principle, process and structure of brain cognition, study the adaptability of different teaching contents, and apply the research on process mechanism of brain cognition to teaching. This new trend poses new challenges to the existing teaching system and methods.

Interactive Coupling of Brain Cognition and Knowledge Learning

According to Battro (2008), the synchronous development of cognition and brain is the driving force to the combination of psychology, brain and

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may adapt to different environments according to different stimuli, such characteristic is called plasticity by researchers. Foreign researchers have found that when one is born, all the neurons of the brain are already in place, but the connections among some neurons have not yet been established (Dehaene *et al.*, 2010). The plasticity and adaptability of the brain determines that the brain is constantly learning from the outside world all its life.

From the micro-cognitive point of view, the external objective stimuli act on the sensory organs through physical and chemical forms. The sensory organs transform the stimuli into bioelectric signals that can be propagated, which pass through the brain neurons and finally reach the designated cerebral cortex to form feelings, which is accompanied by the establishment of neuronal circuits. The connections established between synapses are not immutable, and the connections among neurons can be strengthened or weakened to disappear. Researchers refer to short-lived connections as working memory, and intensive and non-degenerating ones as long-term memory. When external stimuli are transmitted to the brain through neurons, the stimuli are first linked into certain patterns awaiting recognition, a process known as sensory registration. Then the stimuli are input in two ways in the thalamus: one to the reticular structure of brain stem to have experience in long - term memory, and another to the working memory for identification. Through analysis, comparison and decision-making, the stimuli received by the brain is stored in the memory bank through synaptic connection to form memory.

To study the memory cognitive process of brain, to understand the interactive principle of brain cognition and teaching from micro and macro levels, to give full play to the adaptive characteristics of brain, to combine teaching, cognition and brain mechanism organically, and to integrate micro and macro levels through multi-angle, multi-layer and multi-level interaction, to achieve creative teaching based on brain cognition (Huang, 2017). To strengthen the interactive coupling between brain cognition and civil engineering teaching, consider the macro-micro factors in brain cognition, rely on the innovation of civil engineering classroom teaching, and construct the full space-time infiltration teaching system model based on brain cognition.

Full Time-Space Infiltration Teaching System Model

Starting from teaching practice and drawing lessons from the way of brain cognition, a "triangle of cognitive process" is constructed, which reveals the root of cognition from macroscopic level and reflects the relationship among feeling, thinking and action in cognitive process (Yu, 2010).

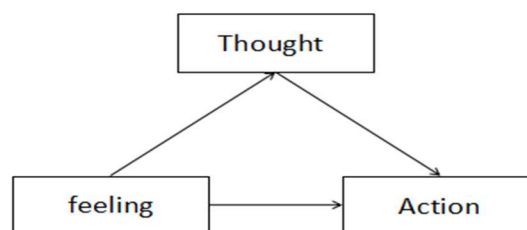


Figure 1. Triangle of cognitive process

Among them, the feeling is that the brain feels the external objective stimulation on the body through the main senses, and then transform the stimulus into chemical physical information that can be identified by the body. The thinking is the brain's ability to visualize and experience the outside world by collecting this chemical information. Through understanding the attributes of sensory objects and its relationship with other things, it can achieve the goal of understanding the world. Action is the transformation or operation of the subject to the cognitive objects. The three factors interact and promote each other, and the correlation and non-skipping among the three factors constitute the macro-basic structure of cognition.

Learning cognition is the process of active participation of the brain, and the process of interaction between the senses and the functional areas of the brain (Hu *et al.*, 2016). To realize the organic combination of brain cognition and teaching, it is necessary to fully understand the principle of brain cognition and the role of teaching strategies in the process of brain cognition. Combining the macro-micro process of brain cognition, APT teaching model (Fan *et al.*, 2015), mobile network feedback platform and the elements related to learning, a full time-space infiltration teaching system model is constructed according to a certain level, as shown in Figure 2.

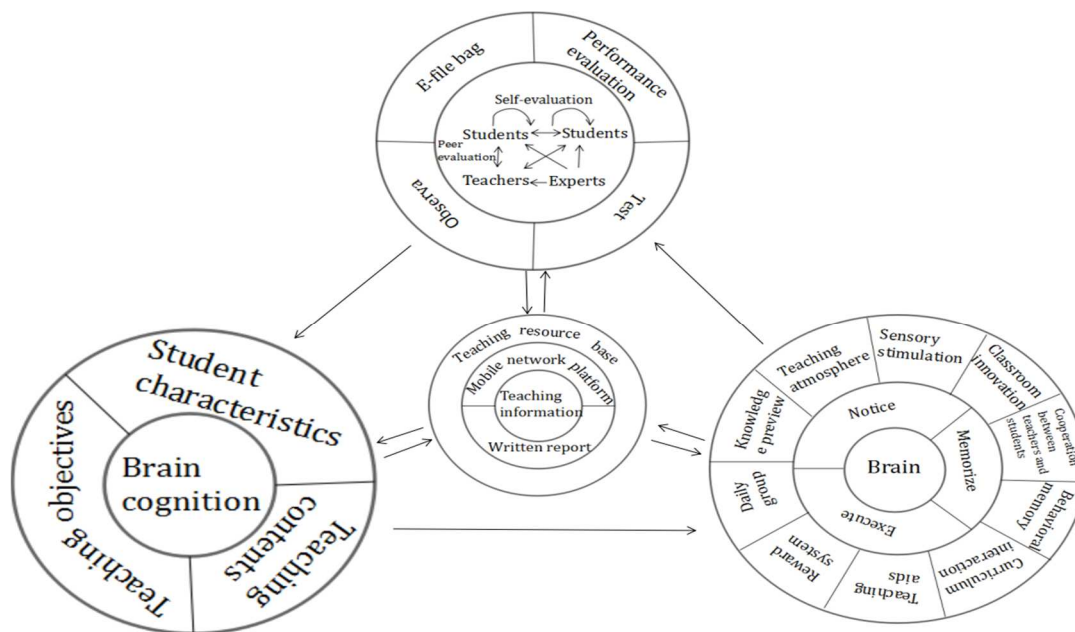


Figure 2. A full time-space infiltration teaching system model

In the model, based on the laws of brain cognition and students' psychological characteristics, teaching contents and objectives are formulated. Teaching students according to their aptitude is the premise of teaching system model circulation.

In combination with the triangle of the brain cognition and principles of cognitive neuroscience, the multiple factor affecting teaching and learning effects are comprehensively considered to transform the "feeling-thinking-action" mode into "attention system-memory system-execution system" mode and divide the cognitive process of teaching into the attention stage, the memory stage and the execution stage. In each stage, the influence of factors such as psychology, school environment, and social environment is considered to make the targeted teaching strategies, and realize the combination of brain cognition-teaching-psychology.

The evaluation system in the teaching process can effectively evaluate the results of the stage teaching, and the summarization and rating should be carried out through self-evaluation and peer evaluation of teachers, students and experts and with comprehensive application of such evaluation methods as testing, observation, performance evaluation and electronic archives.

Based on the establishment of the teaching database of the electronic information monitoring feedback system, the uncontrollable

factors in the teaching system can be found in real time through the instant feedback of teachers and students, the scientific optimal solutions to the uncontrollable factors can be found by using APP mobile platform and interactive processing of different teaching systems, and the experience of the optimal solutions to problems by the monitoring feedback system is sent to the teaching database in time to enrich database and further develop the self-learning system. In the database, teachers can share their own teaching gains anytime and anywhere; students can propose their own questions and get answers at any time in the database; students can self-study the knowledge in the database, and the teaching process can be simplified to provide a good learning platform for students. In each link of teaching system, teachers and students can express their opinions, suggestions, questions and answers through written report and real-time mobile network platform. With the teaching resource database as the core, it can realize the multiple combination of teaching and time and space.

Innovation of Civil Engineering Classroom Based on Brain Cognition

In terms of the teaching of civil engineering, due to the complexity of the theoretical knowledge of civil engineering and the diversity of the practical contents, teachers must consider the disciplinary system of civil engineering comprehensively, the



average cognitive level and thinking mode of students, as well as the plasticity of brain cognitive development on the basis of the naturalness and authenticity of the civil engineering discipline itself to make scientific and effective teaching plans and strategies.

The course of civil engineering construction mainly studies the construction technology and organization of civil engineering, and is basic and comprehensive. As a basic course of civil engineering specialty, civil engineering construction has been regarded as one of the compulsory courses of civil engineering in many colleges and universities of China. In combination with the teaching strategies of the concrete classroom, this study makes the model concrete, truthful and meticulous, and provides the reference for the establishment of the teaching system model of other courses.

Formulation of teaching contents and objectives

According to the differences between the learning objects and the learning environment, the learning contents can be flexibly arranged in the detailed and brief mode with the constant optimization, and the key points and difficulties of teaching can be analyzed to improve teaching methods, so that the presentation of classroom knowledge is consistent with the rules of students' brain cognition, which is the core of teaching innovation based on brain cognition (Volkova, 2015). In the process of brain cognition, when the external information is transmitted to the brain in the form of stimulation, it is first registered and organized into patterns waiting for recognition. The brain analyzes and extracts features (or attributes) to activate the related experiences, knowledge and their features in long-term memory, tune them out and compare with the physical features (or attributes) of stimulation. If it is consistent with the existing memory in long-term memory, the pattern name is assigned to the identified stimulus or the known phenomenon is stored in the long-term memory. If it is not consistent, it the identification stimulus pattern shall classify and store it into the cognitive structure in the new knowledge mode. Therefore, in the course of teaching, teachers can make the teaching contents and goals in a way from simple to complex and from easy to difficult.

As a basic subject of civil engineering, the content of civil engineering construction course covers a wide range of multifarious

knowledge. The content of the course is mainly divided into construction technology and construction organization. The construction technology content includes earthwork, deep foundation engineering, masonry engineering, concrete structure engineering, pre-stressed concrete engineering, building structure installation engineering, bridge engineering, road engineering, waterproof engineering, building decoration and decoration engineering (He *et al.*, 2012; Straka and Hašová, 2016; Wang and Wang, 2016; Zhang, 2015).

In terms of the choice of teaching contents, teachers should arrange the classroom contents scientifically and reasonably according to the specific professional direction of each student, mainly explain the units and chapters related to the students' specialties, teach students according to their aptitude, make them clear the specific tasks of learning, find suitable learning paths, and consciously devote themselves into effective learning activities, with high-efficient learning of the course.

Sensory stimulation and teaching tools

As a "central processing unit," the brain can realize the reception of external information only through the physical senses. The initial information transmitted by the physical senses is complex and bulky. In order to avoid unnecessary information, the brain may optimize some information through psychological resource allocation while receiving different modal information input. This mechanism is called selective attention of the brain (Li *et al.*, 2016). How to turn the content of classroom teaching into the information that is easier to be "selectively noticed" by the brain becomes the premise of brain-based cognitive teaching.

In the course of curriculum teaching, teaching tools and platforms of different forms have been applied, and good teaching results have been obtained. Applying moodle platform to assist teaching can provide personalized service for learners and make it more convenient for cooperative learning between teachers and students and between students (Huang *et al.*, 2014; Qi *et al.*, 2012). By constructing an exploratory classroom teaching model based on YouTube and applying it, it is found that YouTube can attract more attention of students in exploratory classroom teaching, and the teaching effect is good (Krauskopf *et al.*, 2012).

Similarly, in the teaching of civil engineering construction course, teachers can use multimedia projection equipment, electronic teaching demonstration tools, network social tools, APP interactive learning platform and others to assist classroom teaching, and enrich classroom teaching forms. On the basis of teaching classroom contents, let teaching information be noticed by the senses, captured and transformed into neural information as far as possible, forming memories in the brain. Teachers should pay attention to the emotional interaction effect between teachers and students in the classroom, and specific operation methods shall be designed differently often due to different teachers, students and learning contents. The rich emotion and humorous language often can attract the student's classroom attention.

Innovation and interaction in the Classroom

In the classroom teaching of civil engineering construction course, teachers can divide the classroom time into three stages. In the first phase, students have focusing concentration and active thinking so it's good to teach the abstract definitions of nouns and the principles of technology and mechanics. The brain's acceptance of external stimuli can be fully mobilized to allow receive more knowledge and information. With the progress of class time, the brain begins to enter the fatigue stage, during which teachers can play some teaching courseware and video, organize some classroom games and other means to stimulate the students' sight and hearing, and again let the brain produce selective attention, and improve the information reception rate. In the final stage, the brain is in the more sensitive stage of the first and second stages, during which stage summaries of the course can be conducted together with group discussions, raising questions and answering questions.

At the same time, the cooperation between teachers and students, and the teacher's interaction in the course of explanation and the application of teaching tools can promote the formation of brain neural memory.

In addition, organizing the teaching with the students' existing knowledge and experience as the starting point can arouse the students' curiosity about the next learning content, reduce the teaching difficulty, and help to deepen the students' acceptance and understanding of the

new knowledge. In this way, the alternating cognition of new and old knowledge can make students form a virtuous circle of memory system. In the course of civil engineering construction course teaching, the teaching plan is made in combination with the related civil engineering course, it's necessary to know the course progress information of the student before the course begins, use the course knowledge that the student grasps to guide the student to learn the new course content.

Classroom motivation and interaction

The study found that memory maintenance in the brain is not a static but dynamic process. There are more complex mechanisms involved in the process of memory fading, which doesn't affect previous excitatory connections, but forms another inhibitory connection. There is a common brain cognitive mechanism between memory regression and habituation (Chen *et al.*, 2012). How to suppress the fading of memory, let the transient memory students obtain in the memory stage change into permanent memory, and pay more attention to the realization of re-circular cognition in the execution phase, which is the ultimate goal of teaching based on brain cognition.

(1) Dopamine reward system

The study found that when the brain feels the extra reward, the dopamine neurons in the brain are activated and release dopamine, which has an important effect on the activity of neurons in the brain such as the prefrontal lobe (Li *et al.*, 2016). According to Koeppe, when people play sports or video games, endogenous dopamine is released from the striatum of the human brain, and dopamine is active in nerve transmission related to learning, attention and feeling (Koeppe *et al.*, 1998).

In order to better promote the activity of brain neurons and the establishment of memory circuit, teachers can make learning games, competitions or learning practice for students in combination with the content of course teaching in the course of learning, and carry out short-term working memory through sensory organs, so that they can pay more attention to learning. The proper reward system can be set to promote the secretion of brain dopamine, stimulate brain nerve activity, and achieve the better memory goal.

In the teaching link of civil engineering construction course, teachers can combine the content of a certain lesson, let students understand construction and organization principles through classroom explanation, and guide students to make engineering model by themselves through competition among groups and design competition after class, so as to deepen the understanding of the content explained in the classroom. The incentives can also be set up to stimulate students' enthusiasm for learning. In the game and hands-on process, the brain neurons of the students constantly improve the memory circuit under the stimulation of dopamine, so as to achieve the teaching goal of deepening the memory.

(2) Interaction

Interactive teaching is a teaching method which aims at constructing teacher-student interaction and student-student interaction, implementing student-centred teaching atmosphere, achieving research-based learning and realizing the goal of ability.

In classroom teaching, teachers should properly handle the relationship with students, and give full play to their own strengths and creativity. Humorous and witty language, vivid and imagery body movements and guided question and answer teaching can eliminate the students' bad psychology in the classroom. Cooperative learning groups are divided before class with scientific collocation of excellent students, secondary students and underachievers to lay a foundation for common learning and growth. The teacher-student and student-student interaction communication should also pay attention to, and a student-centred teaching atmosphere is created through classroom interactive question-and-answer, group discussion, group interaction activities and other means so that students develop a proactive learning attitude, and students are encouraged to actively participate and explore with willingness, training and strengthening the learning ability of students.

Evaluation and comparison

The evaluation and comparison of course teaching with the help of the teaching database based on the monitoring system can reflect the state of each part of the course in real time. The evaluation system includes the self-evaluation of students, the peer evaluation of each member in

the study group, the mutual evaluation of teachers and students, the evaluation of experts on teachers and students and classroom teaching, etc. There are various means of evaluation such as observation, testing, implementation evaluation based on mobile platform, electronic filer (Fan *et al.*, 2015). With the evaluation tools, a true and objective evaluation on teaching is conducted, during which the method of class contrast analysis can be used to determine the unfavourable factors in teaching and perfect teaching system model in combination with teaching system model.

Conclusions

(1) Learning is based on the plasticity of the brain. With acquired learning, external stimuli are transformed into bioelectric signals through the selective attention of the sensory organs, which are transmitted among brain neurons and finally reach the designated cerebral cortex to form working memory. Through analysis, comparison and decision-making, working memory is further transformed into long-term memory.

(2) According to the principle of brain cognition, the full time-space infiltration teaching system model is constructed with the macro-micro process of brain cognition, APT teaching model, mobile network feedback platform and various elements related to learning.

(3) Based on the rules of brain cognition and the psychological characteristics of students, it is a prerequisite for the cycling of teaching system to make teaching contents and target teaching according to students' aptitude. In the teaching system model, the teaching resource database is the interactive core of the model, the brain cognition principle is the foundation of the model, and the written report and the mobile network platform are used to provide the conditions for the teaching evaluation system, so as to realize real-time learning, evaluation and supervision.

(4) Civil engineering construction is greatly basic and comprehensive. As a basic course of civil engineering specialty, it has been regarded as one of the compulsory courses of civil engineering in many colleges and universities. According to the differences between the learning objects and the learning environment, the learning contents can be flexibly arranged with the constant optimization, and the key points and difficulties of teaching can be analyzed to improve teaching methods, so that



the presentation of classroom knowledge is consistent with the rules of students' brain cognition, which is the core of teaching innovation based on brain cognition. From the four aspects of sensory stimulation and teaching tools, classroom innovation and interaction, classroom motivation and interaction, and evaluation and comparison, the innovation teaching strategy carefully summarizes the key points and difficulties in the classroom teaching of civil engineering construction, and further puts forward the concrete requirements for students and teachers. It provides reference for brain cognition in other aspects of teaching innovation.

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