

# A Study on the Causes of a Particularly Serious Plane Crash

Ping Gao

Institute of Aviation Safety  
China Academy of Civil Aviation  
Science and Technology, Engineering  
and technical research center of civil  
aviation safety analysis and prevention  
of Beijing  
Beijing, China  
gaop888@163.com

Shanghong Shi

Information Resources Department  
Information Institute of the Ministry  
of Emergency Management of the  
PRC  
Beijing, China  
shishanghong88@126.com

Huiying Liu

Institute of Aviation Safety  
China Academy of Civil Aviation  
Science and Technology,  
Engineering and technical research  
center of civil aviation safety analysis  
and prevention of Beijing  
Beijing, China  
liuhy@mail.castc.org.cn

**Abstract**—Safety is the lifeblood of the aviation industry. Aviation accidents occurred occasionally in recent years. Studies have shown that human unsafe behavior is the main cause of accidents. For the purpose of preventing accidents, the most basic method of behavioral safety is to correct people's unsafe acts and habits. Based on the behavior-based accident causation '2-4 model', this paper analyzed the causes of a particularly serious plane crash from different aspects of human acts and habits, organizational system and cultural atmosphere. A conclusion was drawn that the organization's wrong behavior was the leading cause of the accident. The chain of causes of the accident was obtained as well. According to the analysis results, we put forward the specific measures for preventing accidents as followings, cultivating employees' habits, improving the safety management system and publicizing safety culture. Finally, the chain of precaution for accidents was formed.

**Keywords**—aviation, plane crash, the behavior-based accident causation '2-4 model', cause analysis, precaution, chain of causes of accidents, chain of precaution for accidents

## I. INTRODUCTION

Safety is the eternal theme of the civil aviation industry. In recent years, the safety situation of civil aviation in China has been generally stable and the safety record is superior to the average level of civil aviation in the world [1]. The data from the Civil Aviation Administration of China shows that, the number of plane crashes that can be counted in the world reaches 28 (excluding navigation accidents) in 2018. Plane crashes usually lead to large number of casualties and deaths and enormous economic losses. So, it is particularly important to study and prevent plane crashes. In the aviation safety system, the analysis of incidents or accidents sequence may lead to their' happening, which should be valued [2]. In the past, the analysis of aviation accidents was accustomed to targeting the person directly responsible and didn't pay attention to the hidden factors. Such analysis cannot get all the causes as the root of the errors and the defects of the system are not obtained. Then, the measures taken cannot play the fundamental role of prevention[3].Based on the behavior-based accident causation '2-4 model', this paper analyzed of the causes of a particularly serious plane crash in depth and obtained the roles of people's actions and

habits, organization and cultural atmosphere in causing this accident. Measures to prevent accidents were also put forward.

## II. BEHAVIOR-BASED ACCIDENT CAUSATION '2-4' MODEL

According to the investigation reports of accidents, the accidents those caused by people's unsafe behavior directly or indirectly account for 70% to 80% of the total annual accidents [4]. So, in order to prevent accidents effectively, it is important to study, find, eliminate or reduce the unsafe behavior of people (employees) [5].

The behavior-based accident causation '2-4 model' is one of accident cause theories in modern time [6]. The behavior-based accident causation '2-4 model' starts from the basic principle of behavioral science that organizational culture orients organizational behavior and organizational behavior determines individual behavior. It illustrates the mechanism of accidents. The number '2' indicates that the causes of accidents include two dimensions of organization and individual. The number '4' indicates that according to the characteristics of behavior in the development of an accident, the accident sequence can be divided into four stages, namely organizational guidance, operation of organization, individual habitual behaviors and individual one-time behaviors. The model proposes that the individual unsafe acts are the main direct cause of the accidents, and the deeper reason is that the errors of the organization lead to individual wrong behaviors. It is clarified by the model that the lack of organizational culture is the root cause of accidents. See Table I.

## III. ANALYSIS OF THE ACCIDENT

Through in-depth analysis of the causes of one typical accident, it will provide reference for the study of the same type of accidents in the future. Considering the typicality of the accident and the integrity of the references, this paper selected a particularly serious plane crash in 2010 for a detailed study.

### A. Review of the Accident

The aircraft was delivered in November 2008 and obtained the flight certificate in December. There was no fault on the day of flight. The systems worked normally, and

the fuel quality was qualified. All passengers and luggage were examined for safety and there were no dangerous goods. The crew had legal and valid licenses and their physical condition was in line with the flight requirements. They all took the mission for the first time. The physical condition of the airport controllers met the duty requirements. The facilities such as airport navigation, road surface and runway were in normal condition. No birds were found to threaten the flight. On the night of the accident, the airport experienced a heavy fog and visibility decreased rapidly. The airport was permitted to use in August 2009. The airline company obtained airline operation permit in October 2009 and business certificate in July 2010.

Before the aircraft descended, the airport controllers informed the crew that the visibility was 2800 meters. The crew completed partial approach, descent and approach checklist, and confirmed that the plane descended to 440 meters. The airport controller reminded the crew of poor visibility again. The crew completed the programmed turn and reported that the runway was visible. Then the airport controller issued a landing permit and reminded the crew the minimum descending height was 440 meters before the airport entered into the radiation fog. The crew then disengaged the autopilot and landed the plane with manual driving without seeing the runway at the height under the standard. The plane crashed into the ground.

TABLE I. BEHAVIOR-BASED ACCIDENT CAUSATION '2-4 MODEL'

Name of the Chain	Dimensions of the causes and accident sequence				Results	
	First dimension (Behaviors of organization)		Second dimension (Individual behaviors)			
	First stage	Second stage	Third stage	Fourth stage		
Behavior sequence	Behaviors of guidance	Behaviors of operation	Habitual behaviors	One-time behaviors	Accidents	Loss
Type of causes	Root causes	Essential causes	Indirect causes	Direct causes		
Chain of causes of accidents	Lack of safety culture	Deficiency of safety management system (including programme files and operational process)	Lack of safety knowledge Poor awareness of safety Bad safety habits Bad mental state Bad physical state	Unsafe acts(main causes) Unsafe conditions and circumstances		

TABLE II. ANALYSIS OF UNSAFE ACTS

Person	No.	Unsafe Acts	Against the Regulations (Y/N)	Regulations
Captain	1	Carried out the approach below the minimum operating standards	Y	a
	2	Landed below the lowest descent height without seeing the runway and establishing the visual reference necessary for landing		
	3	Landed wrongly without taking a go-around in the case of a high radio voice prompt and no runways in sight		
	4	Failed to evacuate the passengers and rescue the injured after the accident happened		
Copilot	5	Offered the wrong information of height/location	Y	b
	6	Failed to remind the captain to take a go-around while maintaining the lowest descending height		
Head of flight technology management department	7	Failed to rectify the long-term problems of the captain, such as careless maneuvering and instability of approaching landing, etc.	Y	a
Head of the operation control center	8	Deployed the crew improperly as the crew took the mission for the first time	N	---
Head of flight department	9	Failed to conduct the emergency training strictly in accordance with the aviation training program	Y	c, d
	10	Failed to equip the corresponding door trainer		
Person chiefly in charge of the airline	11	Failed to invest enough safety funds and technical support for the company	Y	e
Head of local civil aviation authority	12	Approved the operation permit before the airline obtained the business certificate	Y	a
Administrator of meteorological database system belonging to the local air traffic management bureau	13	Input the special weather report address code wrongly	N	---
<b>Regulations</b> a. Civil Aviation Law of the People's Republic of China b. Regulations for the Certification of Public Air Transport Carriers with Large Aircraft c. Standards of Cabin Training Equipment and Facilities d. The Issues on Training the Flight Attendant Who Are not From the Affiliated Training Agency of the Certificate Holder e. Safety Work Law of the People's Republic of China				

### B. Analysis of Unsafe Act

With the evolution of aircraft design and production, aviation accidents caused by mechanical failure are becoming less and less, human factors come to play the most important role in aviation accidents [7]. Unsafe acts of people lead to unsafe conditions and circumstances. Every unsafe condition and circumstance imply an unsafe act. So, the prevention of unsafe act is the key to prevent accidents. We found out the unsafe acts of this accident and sorted them according to different organization and the length of time between the person made the unsafe act and the accident happened. See Table II.

It can be seen from Table II that the crew's illegal implementation of the approach and the absence of the go-around measures are the main direct causes of the crash. The person in charge of the flight technology management department did not rectify the long-term problems of the captain timely, such as careless maneuvering techniques and instability of approaching landing, etc. Head of the operation control center deployed the crew improperly for all of them took the mission for the first time. The two factors above are directly related to the occurrence of the entire accident. The crew did not command the evacuation of passengers and the crew members' lack of training lead to the expansion of the loss. The local civil aviation authority approved the operation permit illegally and the air traffic management bureau input the wrong special weather report address code buried the hazards for the accident.

### C. Analysis of Habits

The habitual behavior of people played indirect roles in

causing this accident, including five aspects, namely lack of safety knowledge, poor awareness of safety, bad safety habits, bad mental state and bad physical state. These five factors are in a progressive relationship. Employees' lack of safety knowledge lead to their poor awareness of safety, forming the unsafe behavior habits and then. When bad safety habits appear, employees will behave badly psychologically and physically. However, this is not the only case. Their relationships can also be elaborated as follows.

(1) Employees do receive safety training and grasp the safety knowledge of their job. However, due to their poor safety awareness, they break the law on purpose. Unsafe habits are developed finally.

(2) Employees do not lack safety knowledge and have good safety awareness. However, they tend to follow the trend of the general. There are no accidents caused by group illegal operations in ordinary days, resulting in the development of unsafe habits;

(3) Employees behave well, but because of other reasons, their psychological defects lead to unsafe acts;

(4) Employees behave well and are mentally healthy. However, due to physical defects emerge before completing the task or during the task, they are not suitable for the task, unsafe acts emerge as a result.

Through the above analysis, there are many situations which cultivate habits. Those may be one or several of the five reasons as follows, knowledge, consciousness, habit, psychology and physiology. Through analysis, we found out the main habits causing unsafe acts. See Table III.

TABLE III. ANALYSIS OF HABITUAL AND SAFETY MANAGEMENT SYSTEM REASONS

Unsafe Acts	Type of Habits	Deficiency of Safety System
No.1	Lack of safety knowledge, Poor awareness of safety, Bad safety habits	Failed to execute the program files
No.2	Poor awareness of safety, Bad safety habits	
No.3	Lack of safety knowledge, Poor awareness of safety, Bad safety habits	
No.4	Lack of safety knowledge	
No.5	Lack of safety knowledge, Poor awareness of safety	
No.6	Poor awareness of safety	
No.7	Poor awareness of safety	
No.8	Poor awareness of safety	Lack of program files
No.9	Poor awareness of safety, Bad safety habits	Failed to execute the program files
No.10	Poor awareness of safety, Bad safety habits	
No.11	Poor awareness of safety	
No.12	Poor awareness of safety, Bad safety habits	
No.13	Poor awareness of safety, Bad safety habits	Lack of program files

#### D. Analysis of Organizational System

Imperfect operation in the organization generates the unsafe habits. The main reason for the wrong behaviors of organization during operation is lack of program files (i.e., the safety rules and regulations) or program files are imperfect. The crash occurred had a relationship with the imperfect management system and poor implementation of the rules and regulations in the organization. Every unsafe act is related to a specific system deficiency correspondingly. See Table III.

#### E. Analysis of Cultural Atmosphere

Safety culture, namely safety vision, is composed of a number of safety culture elements or concept items. Every safety culture element has its working principle and is a key factor affecting the safety performance of enterprises. They all play a guiding role for the safety management system [8]. Safety culture manifests as the purpose, vision, values and beliefs of organizational safety activities in modern organizations [6]. In the practice, it can be expressed as ‘the relative importance of safety’, ‘safety creates economic benefits’ and ‘understanding of safety investment’. The

missing safety culture elements in this accident covered the following points.

- (1) the importance of safety;
- (2) safety creates economic benefits;
- (3) the degree of safety integrating in corporate management;
- (4) safety is mainly determined by safety awareness;
- (5) responsibility performance of the management;
- (6) employees’ participating in safety;
- (7) needs of safety training;
- (8) the role of the management system;
- (9) consistency in the implementation of the safety system.

#### F. Chain of Causes of the Plane Crash

Through the analysis of the causes of this crash from four aspects, the cause chain of the crash accident was formed, as shown in Figure 1.

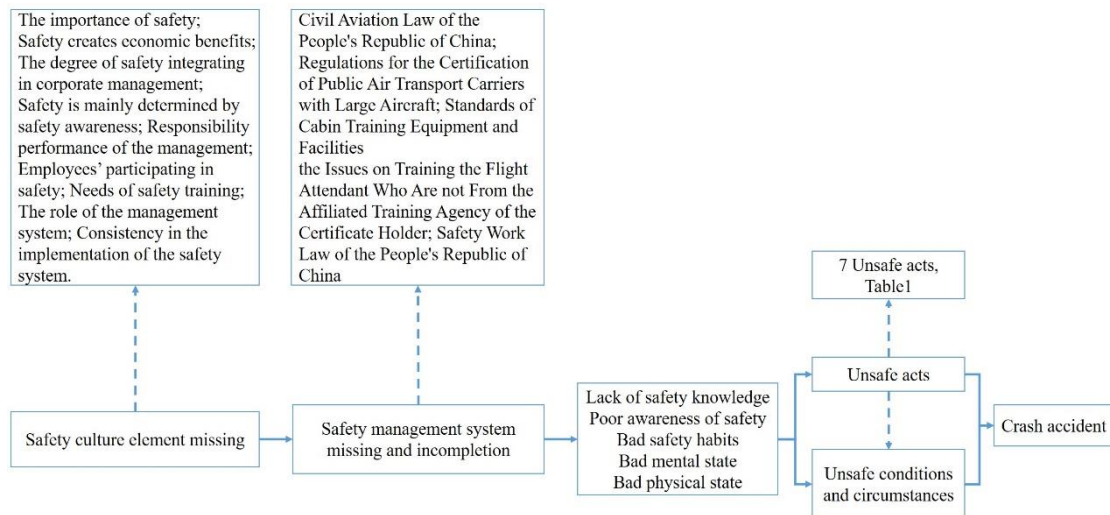


Fig. 1. Chain of causes of the plane crash

### IV. PREVENTIONS FOR ACCIDENTS

According to the behavior principle of ‘culture orientates organizational behavior, organizational behavior determines the individual behavior’ and combining with the above analysis results, precautions were put forward as following.

#### A. Cultivating Employees' Habits

Unsafe acts are caused by unsafe consciousness and unsafe habits. Therefore, in order to enable employees to complete the task with safe acts, their good habits must be cultivated. This paper came up with several training methods to solve unsafe acts of plane crash.

##### (1) Demonstration of unsafe acts with three-dimensional animation

According to the statistical plane crashes, three-dimension animated movies can be applied to display the unsafe acts of plane crashes [9]. The trainees can know what unsafe acts and their harmfulness are. The safe methods to work are taught and workers will keep them in mind. So that

the safe work habits can be formed.

##### (2) Safe acts training with virtual reality technology

Virtual reality technology can create a virtual environment through the computer and allow users to produce immersive feelings and realize the interaction between the users and the environment by means of three-dimensional vision, hearing and touching [10][11]. Usually, the virtual reality system has multiple output forms (such as graphics, sound and words, etc.) and the ability to handle multiple input devices. It also possesses the ability of collision detection, real-time interaction, viewpoint control and complex behavior modeling, etc. With repeated training, the trainees abandon the unsafe acts and can consciously make a safety act when encountering a similar situation in the practical work.

##### (3) Contest of unsafe acts knowledge

Knowledge contest mainly refers to a kind of funny games in which knowledge quiz and knowledge competition are held [12]. It allows employees to learn the unsafe acts of

plane crashes more actively and master the safe ways to work. Statistics crash accident cases serve as the item pool and participants are divided into several groups. They are told to point out unsafe acts in the case and present the safe acts. An upsurge to learn is set off by the contest during which employees master the knowledge of safe acts and improve their safety awareness.

#### (4) Formula teaching of safe acts

Teaching method of pithy formula is a very practical body dynamic language which is widely used in our country [13]. The preparation of simple and practical formulas to narrate occurrences can not only make the workers read fluently but also make them to remind themselves during the work process. Teaching method of pithy formula is often applied in the state of emergency and as a guidance to handle complex operations. So, it is more suitable for the most of safety technology training. To organize the safe acts into a catchy formula and make staff memorize it constantly and repeatedly, internalizing it into their ability and habits. Then they will consciously use safe acts to complete the task at work.

#### (5) Emotional training method

When controlling unsafe acts, in addition to the rigid regulations, aviation corporation should use the function of sincere feelings between people to strengthen the employee emotion control and communication and call on the workers to obey the rules and cherish life. Through the communication, we guide the workers to change from 'let me to be safe' into 'I want to be safe' and jointly build a defense line for protecting life. Cultivate the safety habits of all groups and make them aware that unsafe operations may cause accidents, thus harming themselves, their colleagues and the passengers, which will also bring pains to their family and friends and the others'. Considering the accidents, people care more about their family and friends than themselves. Thus, employees will keep high vigilance and consciously eliminate unsafe operation in their daily work.

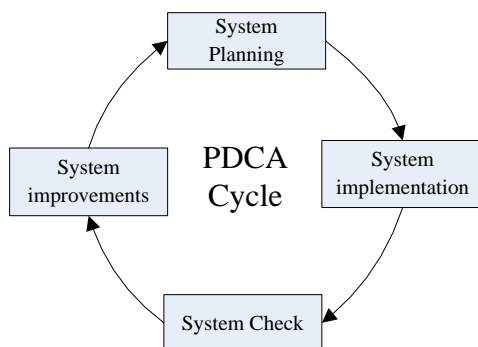


Fig. 2. PDCA safety management system

### B. Improve the Safety Management System

To improve the management system, the author draws on the PDCA cycle of scientific procedures that should be followed in the overall quality management and proposed the aviation safety management system shown in Figure 2. 'System planning' includes the establishment of safety policy and objectives, as well as the formulation of operating procedures. 'System implementation' should design specific methods, solutions and layout according to existing production conditions. Then to the work according to the

design and layout and achieve the safety objectives of the system planning. 'System Check' should summarize the results of the implementation plan, distinguish the right and the wrong, clear results and identify the problems. 'System improvements should deal with the results of check, affirm the successful experience and make them to be standardized. Summarize the lessons of failure as well and pay attention to them. The unresolved issues should be submitted to the next cycle to resolve.

### C. Publicity of Safety Culture

#### (1) Contents of safety culture

Construction of safety culture is actually to enhance the members' understanding of the safety culture elements. So, the content of construction safety culture includes two aspects, one is to improve the concept themselves, the other is the construction of carriers bearing the safety culture concepts.

##### 1) Improve of safety concepts

One research center combines the study related to safety culture home and abroad and set out 32 safety culture elements. These 32 elements are from the practice of safety management in many enterprises and they guide the safety practice, which can serve as good reference for enterprises. However, they are not the only safety culture elements and safety culture could be different in every enterprise. Aviation corporation can conduct in-depth research and make the concept mature and stable in further and promote sound safety culture elements.

##### 2) Construction of safety culture carriers

Carriers can express the meaning of safety culture elements and make people easy to remember and understand the safety culture elements by different external forms. The forms of carriers are various, such as safety culture manual, panels, animation, uniforms, stationery, sculpture, art programs, and safety activities and so on. The construction of safety culture carriers is to improve the members' understanding of safety culture elements. Therefore, safety culture carriers must express the concepts of safety culture and their implications in a clear and vivid form.

#### (2) Means of safety culture construction

##### 1) Training

Training is the most direct means to publicize safety culture. During the training, the specific meaning of the elements of safety culture are explained to staff at all levels, deepening their understanding of safety culture. Cases can be used to demonstrate the role of the safety concepts.

##### 2) Quantitative measurement

Quantitative measurement is a kind of means to quantitatively track safety culture construction. Through the cycle of 'observation - training - management improvement-repeated observation', the safety culture of enterprises can be continuously improved.

### D. Chain of Precautions for the Plane Crash

By summarizing the above specific measures, the chain of precautions for the plane crash is shown in Figure 3.

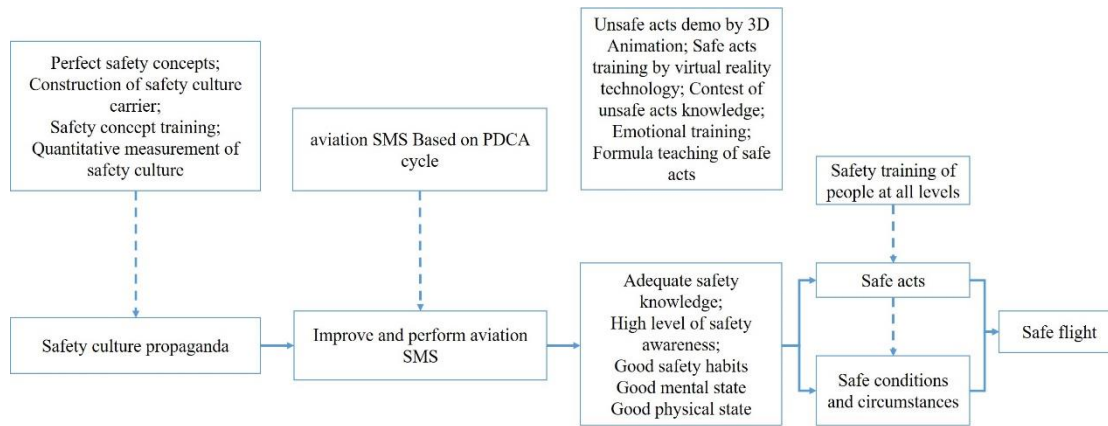


Fig. 3. Chain of precautions for the plane crash

## V. CONCLUSIONS

This article comprehensively analyses the causes of a particularly serious plane crash from the aspects of acts, habits, organizational behavior and organizational culture and draw the conclusions as following.

(1) The crew's illegal implementation of the approach and the absence of the go-around measures are the main direct causes of the crash. The person in charge of the flight technology management department did not rectify the long-term problems of the captain timely, such as careless maneuvering techniques and instability of approaching landing, etc. Head of the operation control center deployed the crew improperly, all of them took the mission for the first time. The two factors above are directly related to the occurrence of the entire accident. The crew did not command the evacuation of passengers and the crew members' lack of training lead to the expansion of the loss. The local civil aviation authority approved the operation permit illegally and the air traffic management bureau input the wrong special weather report address code buried the hazards for the accident.

(2) The analysis of unsafe acts bring the habit causes, organizational behavior and cultural causes of the accident and it shows that the problems of aviation company system which because serious consequences are the ultimate causes of the accident. The specific chain of causes of the plane crash is obtained.

(3) The paper proposes some safety habits training methods namely demonstration of unsafe acts with 3-D animation, safe acts training with virtual reality technology, contest of unsafe acts knowledge and the safety management system based on PDCA cycle. Advice of safety culture construction is also put forward. Chain of precaution for the plane crash is formed eventually.

## REFERENCES

- [1] Luo Yuchuan, Han Xinying, Luo Xiaoli, "Statistic analysis based on accidents and incidents of China civil aviation during 2006-2015", *Journal of Civil Aviation Flight University of China*, vol. 29, pp. 21-24, May 2018
- [2] GUO Peng, "Analysis of aviation unsafe incidents using REASON model", *Civil Aviation Management*, pp.85-87, April 2019
- [3] PENG Zhao-rong, "Study of the Application of REASON Model in Aviation Accident Analysis", *Journal of Changsha Aeronautical Vocational and Technical College*, vol. 17, pp. 83-88, September 2017
- [4] Xiaobin Luo, "Causes and Countermeasures of Unsafe Behavior," *Work Safety & Supervision*, pp. 52-53, June 2011
- [5] BAI Yuan-ping, FU Gui, GUAN Zhi-gang, "Analysis and Improvement of Accident Prevention Strategy in China Enterprises," *Coal Science and Technology*, vol. 37, pp.50-53, February 2009
- [6] FU Gui, LU Bai, CHEN Xiu-zhen, "Behavior Based Model for Organizational Safety Management," *China Safety Science Journal*, vol. 15, pp. 21-27, September 2005
- [7] RAN Hai-xia, "the Influence of Human Factors on Aviation Safety and Its Administration", *Science & Technology Industry Parks*, pp. 281, May 2018
- [8] FU Gui, ZHANG Su, DONG Ji-ye, GAO Shang-fei, "Discussions on Theoretical Understanding and Effects of Behavior Based Safety," *China Safety Science Journal*, vol. 23, pp.150-154, March 2013
- [9] HUO Hong, "The Application of 3D Studio Motion Picture Case to the Case Teaching," *Journal of Xiamen University (Natural Science)*, pp. 148-150, October 2003
- [10] YU Xue-yi, LI Rui-bin, YU Xi, et al, "Application of virtual reality technology in mining engineering," *Journal of Xi'an University of Science and Technology*, vol. 27, pp.5-10, January 2007
- [11] A.P.Squelch. Virtual reality for mine safety training in South Africa[J]. *Journal of the South African Institute of Mining and Metallurgy*, vol. 101, pp.209-216, April 2001
- [12] JIN Hui-yan, LIU Yan, HAN Yi, "Investigation of Introducing Knowledge Contest to Improve Physiology Teaching Methods," *Science & Technology Information*, pp.137,157, April 2009
- [13] LIU Quan-jin, et al, "Teaching Mode of 'Pithy Formula' for Course Communication Principles," *Journal of Anqing Teachers College (Natural Science Edition)*, vol. 17, pp.106-108,129, August 2011