DEVELOPMENT MODEL OF CLOUD COMPUTING TECHNOLOGY APPLICATION IN THE EDUCATION INDUSTRY

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หัวข้อวิทยานิพนธ์	การพัฒนารูปแบบของเทคโนโลยีคลาวด์คอมพิวติ้งในการประยุกต์ใช้ในอุตสาหกรรมการศึกษา
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บทคัดย่อ

การวิจัยนี้มีวัตถุประสงค์เพื่อ 1) สำรวจปัญหาและความต้องการของห้องเรียนอัจฉริยะในวิทยาลัยและมหาวิทยาลัย 2) สรุปแนวคิดและโครงสร้างแบบจำลองของห้องเรียนอัจฉริยะที่เผยแพร่ทางสื่อดิจิทัล และ 3) สำรวจความพึงพอใจของนักศึกษามหาวิทยาลัยที่มีต่อความคิดสร้างสรรค์อัจฉริยะรูปแบบห้องเรียน

กลุ่มตัวอย่างในการวิจัยครั้งนี้เป็นนักศึกษา จำนวน 398 คน ที่กำลังศึกษาอยู่ที่มหาวิทยาลัยเทคโนโลยีเทียนจิน, ประเทศสาธารณรัฐประชาชนจีน ในปีการศึกษา 2565 เลือกกลุ่มตัวอย่างโดยการสุ่มอย่างง่าย เครื่องมือที่ใช้ในการวิจัย ได้แก่ 1) แบบสำรวจความคิดเห็นของผู้เข้าร่วมการวิจัยสำหรับนักศึกษาระดับปริญญาตรี และบุคลากร 2) แบบสอบถามอาจารย์ และ 3) แบบสอบถามความคิดเห็นสำหรับผู้เชี่ยวชาญเกี่ยวกับการพัฒนาห้องเรียนอัจฉริยะต้นแบบ สถิติที่ใช้ในการวิจัย ได้แก่ ค่าเฉลี่ย และส่วนเบี่ยงเบนมาตรฐาน

ผลการวิจัยพบว่า เทคโนโลยีคลาวด์คอมพิวติ้ง ถูกนำมาใช้อย่างแพร่หลายในห้องเรียนอัจฉริยะในวิทยาลัยและมหาวิทยาลัย คลาวด์คอมพิวติ้งเป็นเทคโนโลยีหลักของแพลตฟอร์มคอมพิวเตอร์ยุคใหม่ที่สามารถให้บริการพูลทรัพยากรแบบไดนามิก การจำลองเสมือน และความพร้อมใช้งานสูง ไม่เพียงแต่ยึดเอาผู้ใช้เป็นศูนย์กลางเท่านั้น แต่คลาวด์คอมพิวติ้งยังให้บริการพื้นที่เก็บข้อมูลและเครือข่ายที่ปลอดภัย รวดเร็ว และสะดวกอีกด้วย นอกจากนี้ คลาวด์คอมพิวติ้งยังทำให้อินเทอร์เน็ตกลายเป็นศูนย์ข้อมูลและศูนย์กลางการประมวลผลของผู้ใช้ทุกคน Cloud Computing ให้แนวคิดและโซลูชันใหม่สำหรับอีเลิร์นนิงจะเป็นสภาพแวดล้อมพื้นฐาน แพลตฟอร์มสำหรับอีเลิร์นนิงในอนาคต และอำนวยความสะดวกในการพัฒนาอีเลิร์นนิงผ่าน “บริการคลาวด์”

คำสำคัญ: ห้องเรียนอัจฉริยะ คลาวด์คอมพิวติ้ง แพลตฟอร์มอีเลิร์นนิง

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ABSTRACT

The objectives of this study were to: 1) explore the problems and demands of intelligent classrooms at colleges and universities, 2) summarize the concepts and model structures of intelligent classrooms published in digital media, and 3) explore university students' satisfaction with creative intelligent classroom styles.

The samples in this study were 398 students who are currently studying at the University of Tianjin University of Technology, People's Republic of China in the academic year 2022. The samples were selected by simple random sampling. The research instruments were: 1) a form of participants opinion survey for undergraduate students and staff, 2) a form of teacher questionnaire, and 3) an opinion questionnaire for experts concerning the development of model intelligent classrooms. The statistics used in the study were mean and standard deviation.

The research results show that Cloud Computing technology is widely used in intelligent classrooms in colleges and universities. Cloud Computing is the core technology of the next generation in computing platforms that can provide dynamic resource pools, virtualization, and high availability. It does not only take users as the center, but Cloud Computing also provides safe, fast, and convenient data storage and network services. Moreover, Cloud Computing makes the internet become the data center and computing center of every user. Cloud Computing provides new ideas and solutions for e-learning. It will be the basic environment, platform for e-learning in the future, and facilitate the development of e-learning through “cloud services”.

Keywords: intelligent classrooms, cloud computing, e-learning platform

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Yiran Wu

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CHAPTER 1
INTRODUCTION

1.1 Background and Statement of the Problem

With the rapid development of mobile Internet technology, new learning and teaching modes such as remote classroom, intelligent classroom and mobile office have brought more load to the data center, resulting in the rising cost of data center construction and maintenance, such as hardware purchase, management and energy consumption. How to deal with massive data and services and effectively provide users with convenient and fast network services has become a problem faced by the current development of colleges and universities.

In this context, cloud computing technology is widely used in intelligent classrooms in Colleges and universities. Cloud computing is the core technology of the next generation computing platform that can provide dynamic resource pool, virtualization and high availability. It takes users as the center, provides safe, fast and convenient data storage and network services, and makes the Internet become the data center and computing center of every user. Cloud computing provides new ideas and solutions for e-learning. It will be the basic environment and platform for e-learning in the future, and support and promote the development of e-learning through "cloud services".

With the continuous expansion of school teaching scale and the continuous transformation of teaching mode, the disadvantages of providing each student with an independent PC or graphics workstation are particularly prominent. Especially after the number of terminals has become a certain scale, it has brought great challenges to the daily management, equipment supervision and data security of school laboratory staff.

In recent years, with the development of cloud technology, productivity tools and production methods have gradually shifted to the cloud. Desktop virtualization technology has been able to meet the daily office and other applications. In the heavy GPU rendering teaching experiment scene, GPU virtualization technology is also needed to realize. Thus, deploying all GPU resources in the cloud, using cloud computing technology to replace high-performance graphics workstations, reducing management costs and meeting users' heavy GPU high-performance needs, has increasingly become a concern of school laboratory managers.

With the vigorous development of public cloud, private cloud and hybrid cloud in recent years, productivity tools and production methods in education, teaching, scientific research and other aspects have gradually shifted to the cloud. Desktop virtualization technology can meet the daily office needs. GPU virtualization technology is also needed to realize in geographic mapping, visual research, advanced modeling and other scenes. The related problems are gradually exposed in the upgrading of teaching equipment, terminal equipment management, personnel management of various roles and data security. This paper mainly studies the solutions to the above problems.

1.2 Objectives of the Study

1.2.1 To explore the problems and demands of an intelligent classroom at college and universities.

1.2.2 To summarize the concept and model structure of an intelligent classrooms . Publish through digital media.

1.2.3 Explore university students' satisfaction with creative intelligent classroom styles.

1.3 Research Questions and Hypothesis

The research hypotheses are as follows:

It is assumed that the target environment of the study has a basic multimedia teaching environment, has deployed a private cloud environment and has sufficient computing and storage resources, the infrastructure has three- tier network access capability, the terminal equipment has remote access capability, and the network security and data security have corresponding management standards.

1.4 Scopes and Limitations of the Study

1.4.1 research scope

Taking universities and scientific research institutions as the research subject, it focuses on the application directions of Surveying and mapping, modeling and so on.

1.4.2 effective time

Combined with the development law of GPU technology, the effective time of this study is from 2021 to the next 10 years.

1.4.3 research basis

This research is an industry solution based on the integration of super integrated GPU deployment schemes of multiple colleges and universities, which has certain technical guiding significance in the current technical stage.

1.5 Definitions of Terms

1.5.1 Private cloud: built in the enterprise's own data center, facing the internal organization of user services; It has the characteristics of high data security, strong IT infrastructure control ability and compliance;

1.5.2 Public cloud: it is built uniformly by cloud service providers to provide cloud services for any network users, with low initial investment cost and flexible flexibility;

1.5.3 Hybrid cloud: that is, private cloud is built inside the data center and public cloud services are used; It has the characteristics of safety, compliance, flexibility and low cost.

1.5.4 Machine room: we need to prepare for wind, fire, water and electricity, cabinet and site;

1.5.5 Basic hardware: we need to provide servers, switches, storage, networks, etc;

1.5.6 Operating system: windows, Linux

1.5.7 Operating environment: database, middleware, web application, etc.

1.5.8 Business system: program code, business data, etc.

1.5.9 IAAs service: that is, infrastructure is service, including computer room, basic hardware, operating system, etc. for users, they only need to build an operating environment and deploy business system;

1.5.10 PAAS service: platform is service. Based on the IAAs layer, it provides additional deployment at the operation environment level. Users only need to deploy the business system;

1.5.11 SaaS service: application is a service. Compared with PAAS layer, the application has also been deployed. Users only need to open an account to use it;

1.5.12 GPU: graphic processing unit, which is translated into "graphics processor" in Chinese. GPU is a concept relative to CPU. As graphics processing becomes more and more important in modern computers (especially home systems and game enthusiasts), a special graphics core processor is needed.

1.6 Conceptual Framework

Below is the conceptual framework model of the entire study. This model encapsulates the main variables to be tested in this study.

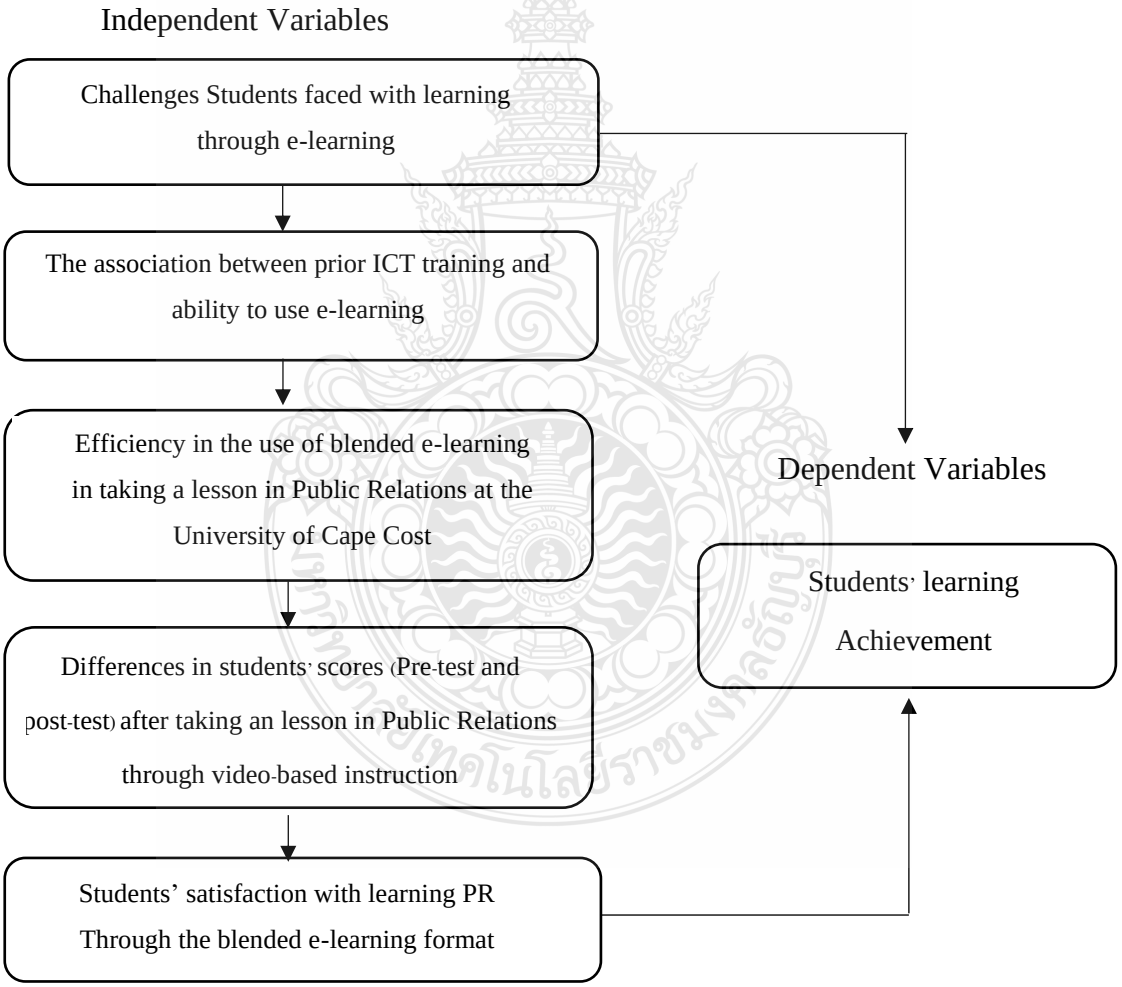

Figure 1.1 Conceptual Framework model of the study by researcher

1.7 Significance of the Study

1.7.1 Reduce the total cost of ownership (TCO) invested by users and improve the return on investment (ROI)

1.7.2 Improve operation efficiency, speed up the deployment of new servers and applications, and greatly reduce the time of server reconstruction and application loading.

1.7.3 System security: due to the advanced functions of virtualization technology, the business system is free from the shackles of a single physical hardware, can achieve higher-level business continuity requirements, and improve the security and reliability of the system.

1.7.4 For the integration of computing and storage, a high integration architecture is adopted to integrate the computing power and storage capacity of the server to form a unified virtual computing and integrated storage pool. It not only improves the IO efficiency of the system, but also saves the implementation cost of the whole system.

1.8 Contributions to Knowledge

The significance of this study includes the following:

1.8.1 Acknowledge the problems and demands of intelligent classrooms for teaching and learning to improve students' academic achievement.

1.8.2 Distribution the body of knowledge on the advantages of intelligent classrooms conceptual framework and model.

1.8.3 The research will also contribute to a better understanding of intelligent classroom model design to enhance teaching and learning process.

CHAPTER 2
REVIEW OF THE LITERATURE

The literature relevant to the study will be reviewed in this chapter, intelligent classrooms with cloud computing provides to service a data storage at college and universities. As a result, this chapter is divided into the following sections:

2.1 Cloud Computing
- 2.1.1 Definitions of cloud computing
- 2.1.2 Benefits and challenges of cloud computing
- 2.1.3 Cloud computing at college and universities in China
- 2.1.4 Benefits and Challenges of cloud computing in China

2.2 GPU high performance services under cloud computing architecture
- 2.2.1 Cloud computing solutions in universities
- 2.2.2 GPU transparent transmission
- 2.2.3 Desktop transport protocol
- 2.2.4 Remote access network and security control

2.3 Practical achievements and challenges

2.4 Intelligent Classrooms

2.5 Relevant research

2.1 Cloud Computing

2.1.1 Definitions of cloud computing

Cloud computing is a kind of distributed computing, which means that the huge data computing processing program is decomposed into countless small programs through the network "cloud", and then processed and analyzed through the system composed of multiple servers. These small programs get the results and return them to users. In the early days of cloud computing, in short, it was simple distributed computing, which solved the task distribution and merged the calculation results. Therefore, cloud computing is also called grid computing. Through this technology, tens of thousands of data can be processed in a very short time (a few seconds), so as to achieve powerful network services.

“Cloud” is essentially a network. In a narrow sense, cloud computing is a network that provides resources. Users can obtain the resources on the "cloud" at any time, use them according to the demand, and can be regarded as unlimited expansion. As long as they pay according to the usage, the “Cloud” is like a waterworks. We can receive water at any time, and there is no limit, According to their own water consumption, pay to the waterworks.

In a broad sense, cloud computing is a service related to information technology, software and the Internet. This computing resource sharing pool is called "cloud". Cloud computing gathers many computing resources and realizes automatic management through software. With the participation of few people, resources can be provided quickly. In other words, as a commodity, computing power can be circulated on the Internet, just like water, electricity and gas, which can be accessed easily and at a relatively low price.

In short, cloud computing is not a new network technology, but a new concept of network application. The core concept of cloud computing is to take the Internet as the center and provide fast and safe cloud computing services and data storage on the website, so that everyone who uses the Internet can use the huge computing resources and data center on the network.

Cloud computing is another new innovation in the information age after the Internet and computers. Cloud computing is a great leap in the information age. The future era may be the era of cloud computing. Although there are many definitions of cloud computing, generally speaking, although cloud computing has many meanings, in general, the basic meanings of cloud computing are the same, That is, cloud computing has strong scalability and needs, and can provide users with a new experience. The core of cloud computing is to coordinate many computer resources together. Therefore, users can obtain unlimited resources through the network, and the resources obtained are not limited by time and space.

2.1.2 Benefits and challenges of cloud computing

The value of cloud computing lies in its high flexibility, scalability and high sex ratio. Compared with the traditional network application mode, it has the following advantages and characteristics:

1) Virtualization technology.

It must be emphasized that virtualization breaks through the boundaries of time and space and is the most significant feature of cloud computing. Virtualization technology includes application virtualization and resource virtualization. As we all know, there is no spatial connection between the physical platform and the application deployment environment. It is through the virtual platform that the corresponding terminal operations are completed, such as data backup, migration and expansion.

2) Dynamically scalable.

Cloud computing has efficient computing power. Adding cloud computing function on the basis of the original server can rapidly improve the computing speed, and finally realize the dynamic expansion of the virtualization level, so as to achieve the purpose of expanding the application. [5]

3) Deploy on demand.

Computers contain many applications, programs and software. Different applications correspond to different data resource libraries. Therefore, users need strong computing power to deploy resources to run different applications, and cloud computing platform can quickly allocate computing power and resources according to users' needs.

4) High flexibility.

At present, most IT resources, software and hardware in the market support virtualization, such as storage network, operating system and development software and hardware. Virtualization elements are uniformly managed in the virtual pool of cloud system resources. It can be seen that the compatibility of cloud computing is very strong. It can not only be compatible with low configuration machines and hardware products of different manufacturers, but also obtain higher performance computing for peripherals.

5) High reliability.

If the server fails, it will not affect the normal operation of computing and applications. Because the single point server fails, applications distributed on different physical servers can be recovered through virtualization technology, or new

servers can be deployed for computing by using dynamic expansion function.

6) High cost performance.

The unified management of resources in the virtual resource pool optimizes the physical resources to a certain extent. Users no longer need expensive hosts with large storage space. They can choose relatively cheap PCs to form the cloud. On the one hand, the cost is reduced, and on the other hand, the computing performance is not inferior to the mainframe.

7) Scalability.

Users can use the rapid deployment conditions of application software to expand their existing and new businesses more simply and quickly. For example, the failure of equipment in the computer cloud computing system will not be hindered for users either at the computer level or in specific application. The dynamic expansion function of computer cloud computing can be used to effectively expand other servers. This will ensure that the task is completed in an orderly manner. In the case of dynamic expansion of virtualized resources, it can efficiently expand applications and improve the operation level of computer cloud computing.

With the rapid development of cloud computing, it also faces many challenges.

1) Access rights issues

Users can upload their own data at the cloud computing service provider. Compared with the traditional storage method using their own computer or hard disk, they need to establish an account and password to store and obtain virtual information. Although this method provides convenience for users to obtain and store information resources, users lose control of data resources, and service providers may have unauthorized access to resources, which makes it difficult to ensure the security of information materials.

2) Technical confidentiality

Information confidentiality is not only the primary problem of cloud computing technology, but also the main problem of current cloud computing technology. For example, users' resources are shared by some enterprises. The particularity of the network environment allows people to browse relevant salary resources freely. The

leakage of information resources is inevitable. If the technical confidentiality is insufficient, it may seriously affect the owner of information resources.

3) Data integrity issues

In the use of cloud computing technology, users' data is stored in different locations of cloud computing data center, rather than in a single system. The integrity of data resources is affected, making it difficult to play its role effectively. Another situation is that service providers do not properly and effectively manage users' data information, which affects the integrity of data storage and makes it difficult to play the role of information application.

4) Imperfect laws and regulations

The imperfection of laws and regulations related to cloud computing technology is also the main problem. If you want to play an effective role in cloud computing technology, you must improve its relevant laws and regulations. At present, laws and regulations are not perfect, and the role of cloud computing technology is still restricted. In terms of the current application of cloud computing technology in computer networks, it lacks perfect security standards, perfect service level agreement management standards, and no clear responsible person to bear the legal responsibility for security problems. In addition, the lack of perfect loss computer system and Responsibility Evaluation Mechanism of cloud computing security management, the lack of legal norms also restricts the development of various activities, and the cloud computing security of computer network is difficult to be guaranteed.

2.1.3 Cloud computing at college and universities in China

The influence of cloud computing technology in the field of education is deepening and changing the form of education. Education bureaus, primary and secondary schools, universities and other institutions have set up education cloud platforms and built smart campuses. At the same time, new models such as live broadcast, flipped classroom, cloud classroom and AI double division are increasingly applied to teaching scenes. Cloud computing promotes educational administration and teaching to enter the digital era together.

1) Digitization of educational resources on the cloud platform, teaching no longer requires physical contact between people. School administrators and teachers

and students can access the Internet at any time to receive, watch, download or share the educational resources they need. Teachers can also store teaching materials, teaching courseware, teaching videos and other materials on the cloud platform, which can be easily obtained by students through mobile terminals. At the same time, the shared coverage of educational resources has become unprecedented. The educational resources of various schools or institutions can be gathered together, and the use efficiency of educational resources can be greatly improved.

2) The digitization of teaching management cloud computing can also realize the digitization of teaching management. By connecting various systems and terminals, centralized platform management is realized. At the same time, cross terminal data collection and information mining analysis are adopted to record students' learning trajectory, track the teaching content and teaching effect in the whole process, timely learn each student's learning situation, synchronously understand each student's learning state, provide more personalized teaching, and optimize the teaching effect.

3) The interactive education cloud platform of teaching and learning constructs a convenient and reliable education network environment. Through the design of virtual desktop cloud terminal, teachers and students can realize effective communication through the cloud platform anytime and anywhere, liberate teachers and students and education managers from the traditional teaching methods, and promote the comprehensive interaction between teaching and learning.

4) Another important advantage of the cloud platform for the security of educational information is security. Its encryption and disaster preparedness functions can achieve real-time automatic monitoring from the physical layer, network layer to application layer to ensure data security. When the equipment fails, storing the data in the cloud can effectively avoid information loss. The epidemic will eventually pass, but the changes brought by the epidemic to educational informatization will not stop. For teachers and students, cloud computing in the past was just an illusory concept. Today, the epidemic has forced teachers and students to gradually accept the experience of online teaching, teaching, interaction, homework correction... Everything is carried out in the cloud. I believe that with the development of cloud computing technology, it will bring greater driving force to online education in the future

2.1.4 Benefits and Challenges of cloud computing in China

Today, as a new generation of information technology means, cloud computing has been applied to more and more industries. With the clarification of the advantages of cloud computing, not only leading-edge enterprises such as Huawei have realized the commercial value of "cloud", but also many educational institutions around the world have recognized the educational value of "cloud", and cloud computing is applied more and more in college teaching. Co construction and sharing of teaching resources cloud computing can upload educational resources through the network to realize the opening and sharing of educational resources. Users only need a networked terminal device to easily obtain the required educational resources. Moreover, the professional technical team of the cloud service provider is responsible for the management and security of educational resources on the cloud. With the development and popularization of cloud computing in Colleges and universities, college education does not need to invest a lot of hardware and software, nor do they need to build their own network teaching platform. Through the cloud platform provided by service providers, virtual multimedia classroom, virtual 3D network classroom, virtual computer room and new digital library can be realized, Truly develop the construction of educational informatization in Colleges and universities. Help distance education apply various computing technologies and service concepts of cloud computing to distance education, which can reconstruct the logical structure, overall structure and core modules of distance education system, and effectively send its educational service ability, resource sharing, configurability and scalability, so as to ensure the smooth progress of large-scale distance teaching activities.

Social results are Greatly enrich the construction of high-quality teaching resources of the school; to promote the social sharing of high-quality educational resources; It will be a good demonstration and reference for other colleges and universities. Significance of promoting educational modernization. Information technology and teaching means and methods will be fully integrated; The application of cloud computing technology provides a more detailed and sufficient basis for the scientific decision-making of the school, and improves the modernization level of education management;

Economic benefits are significantly reduce operating costs, effectively reduce TCO and save investment; Improve resource utilization, extend the service life of hardware and protect investment; and green energy saving;

Management benefits are unified it planning and management window. Greatly reduce the workload of operation and maintenance and the number of operation and maintenance personnel. Effectively improve the operation and maintenance efficiency and reduce the system failure rate and failure recovery time. Information technology has a revolutionary impact on the development of education. While bringing a series of benefits, how to promote the comprehensive integration of information technology and modern education and drive educational modernization with educational informatization is a problem faced by many schools and educators.

At present, there are mainly the following problems in the informatization construction of colleges and Universities: The utilization rate of IT resources is low, generally between 5% - 20%. It is difficult to evaluate the effect and benefit of resource use. Inconvenient management, operation and maintenance, no unified management window. Teaching resources are scattered and difficult to share. Lack of fault location and defense measures. The new system has long online cycle and low efficiency

2.2 GPU high performance services under cloud computing architecture

2.2.1 cloud computing solutions in universities. The Physical architecture design are as the figure below.

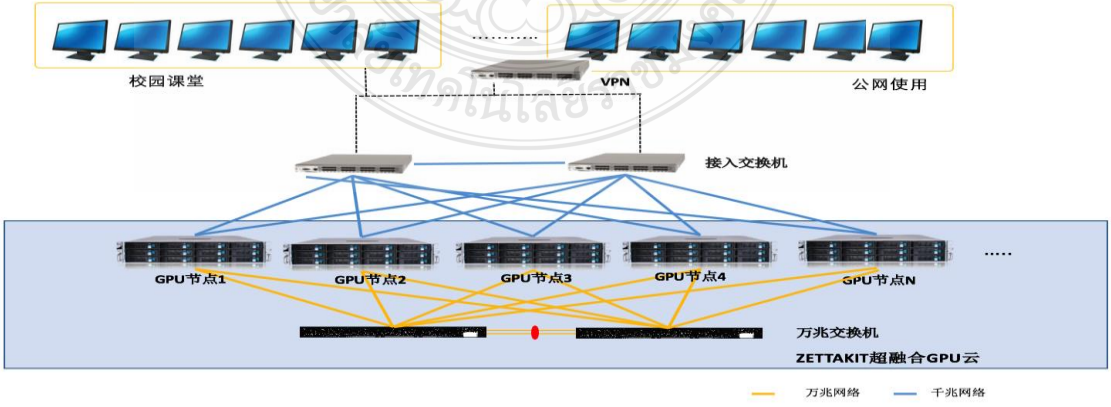

Figure 2.1 The Physical architecture design

The architecture is divided into three parts, as shown in the figure, namely virtual machine, server and client. The virtual machine obtains the GPU resources in the server. The GPU compresses and encodes the desktop image and sends it to the client. The client decodes and displays the received data.

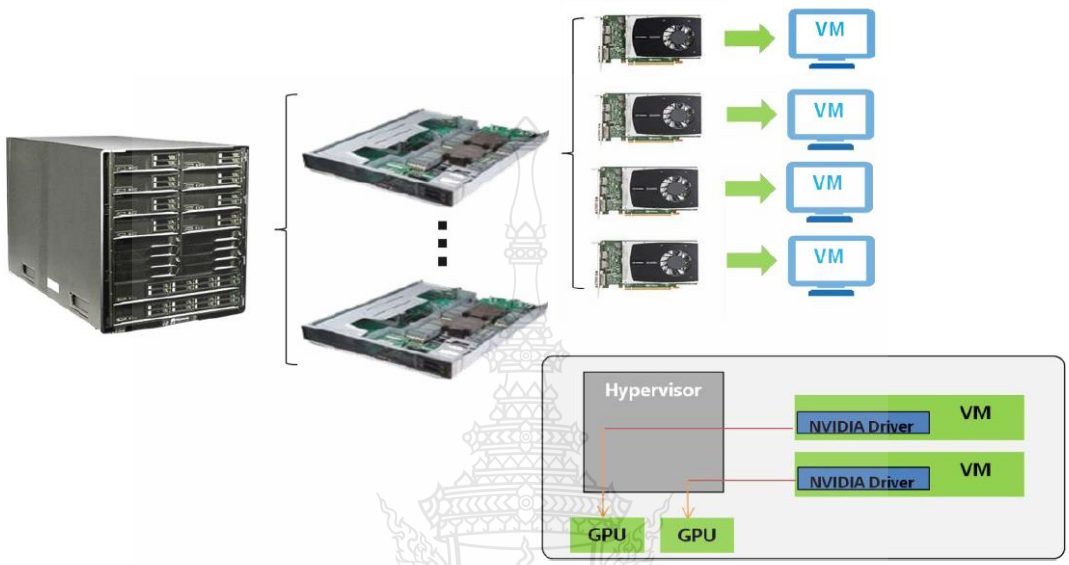

Figure 2.2 virtual machine, server and client

2.2.2 GPU transparent transmission

GPU virtualization technology gives the virtual machine running on the server more powerful performance. GPU virtualization supports device through. As shown in, it can meet the needs of heavy load GPU computing like a graphics workstation. GPU virtualization technology has the following characteristics:

2.2.2.1 Support NVIDIA, geforce, Quadro and others mainstream graphics card virtualization.

2.2.2.2 Support 1:1 and 1: n user usage modes. Where n is equal to the number of GPU physical cores.

2.2.2.3 DirectX, OpenGL, CUDA and OpenCL are fully supported.

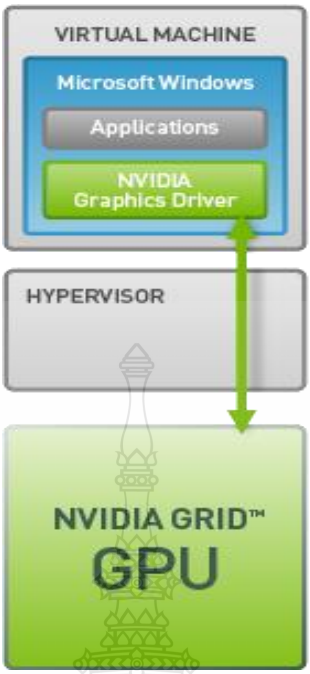

Figure 2.3 GPU virtualization technology

2.2.3 Desktop transport protocol

Desktop transport protocol is responsible for the connection and management of picture and data transmission between virtual machine and client. The protocol has the characteristics of small bandwidth occupation and low image delay. Its excellent performance ensures that the user's operation experience is consistent with the traditional graphics workstation.

Desktop Transport Protocol shall have the following features: Support h.264/h.265 coding standard, Hardware codec, QoS in UDP / TCP mode, USB device redirection and Support 4K display

2.2.4 Remote access network and security control

The necessary condition of remote office is reasonable access network design. This scheme uses the encrypted VPN network to connect the remote client with the zcloud cluster to provide a secure remote access link. The zvision client will connect to the virtual machine through this link for remote production jobs. Set the security group rules on the VPN gateway to allow only the IP address range and port access of zvision

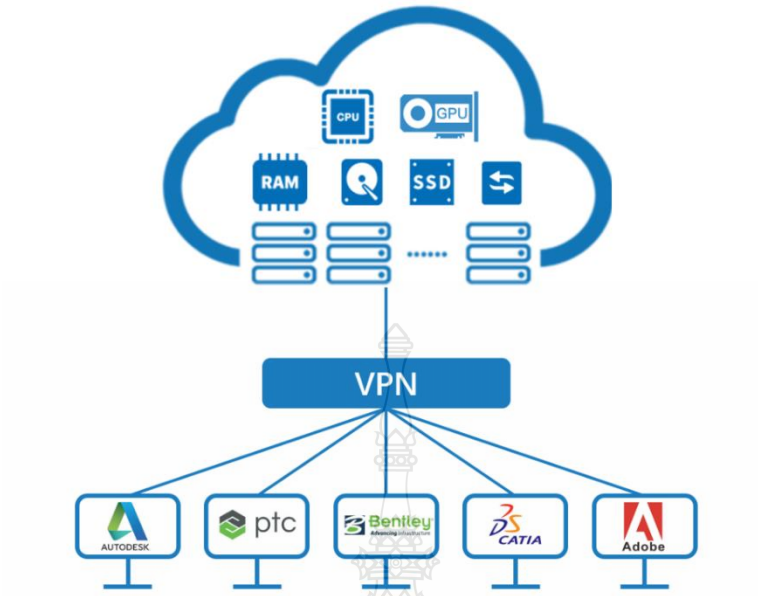

Figure 2.4 desktop transport protocol to further improve the security of remote access

2.2.5 Intelligent control of network bandwidth and QoS

Zvision desktop transport protocol has the function of network bandwidth adaptation. It can intelligently select graphics effects according to network conditions, so as to control bandwidth utilization. This scheme enables the "zvision remote" feature to achieve the best balance between bandwidth and effect in the environment of public network or remote connection.

In the scheme design, the client connection of the local LAN will automatically use the optimization effect, Large bandwidth is used (refer to blue traffic); while traffic passing through VPN gateway passes through protocol controlled bandwidth to obtain large remote connection concurrency capability (refer to green traffic). Generally, 5mbps bandwidth is considered to be configured for each client. In this scheme, zcloud cluster allocates 250mbps uplink bandwidth, and up to 50 remote client connections can be concurrent at the same time.

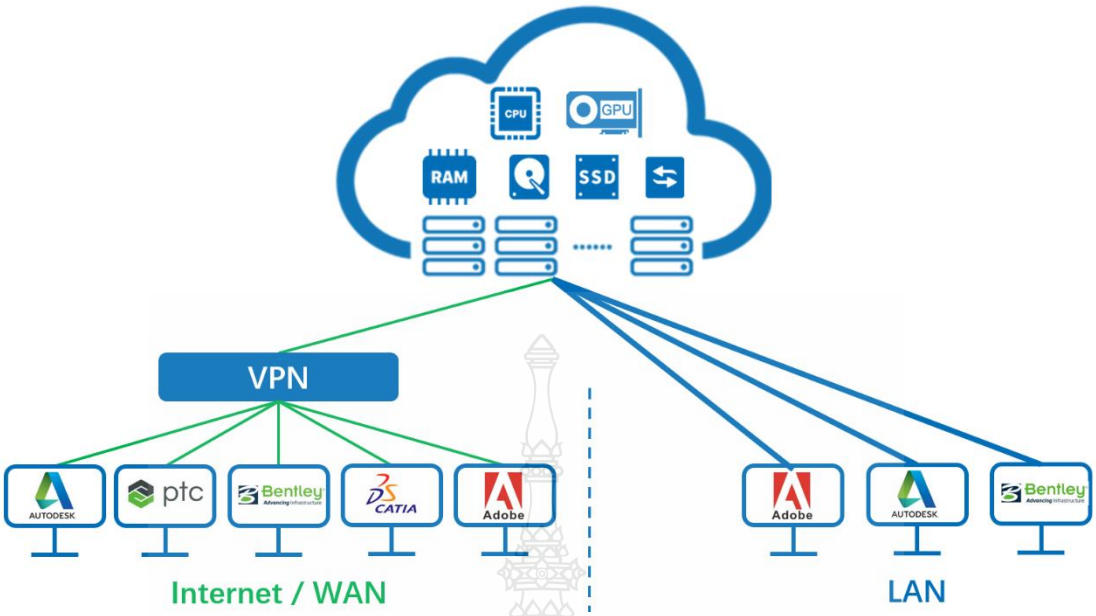

Figure 2.5 Underlying hyper fusion framework

The virtualization technology is used to pool the resources of the physical server, and the application system runs on the platform virtual machine. Compared with the traditional physical server scheme, this scheme will greatly improve the server utilization, improve the availability of the application system, reduce the application system downtime, reduce the application system deployment time, and simplify the server management. Realize the high sharing, centralized management and dynamic expansion of resources, so as to improve the utilization of resources and meet the needs of upper business for resources, so as to effectively save costs and improve the overall level of resource management. Integrate the existing resources and realize the unified management, operation and maintenance of resources through virtualization technology and automation technology. Based on hyper fusion, cloud computing data center is composed of multiple nodes. It is a standard node device, occupying 2U height. Each node is a standard x86 server. It provides 2-way Intel CPU computing power and 12 disk storage resources.

2.2.6 super fusion GPU framework scheme

2.2.6.1 Underlying hyper fusion framework

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2.2.7 Summary

Virtualized resource pool is to collect a large number of X86 servers through software through cluster application, grid technology and distributed technology, KVM virtualization and software defined storage technology, and make the constructed virtual servers, virtual switches and virtual storage provide low-cost and scalable computing, network and data storage services. The virtual of physical resources by VMM (virtual machine monitor) can be divided into three parts: CPU virtualization, memory virtualization and I / O device virtualization, among which CPU virtualization is the most critical. Classic virtualization method: modern computer architecture generally has at least two privilege levels (i.e. user state and kernel state, and x86 has four privilege levels ring0 ~ RING3) to separate system software and application software. Those instructions that can only be executed at the highest privilege level (kernel state) of the processor are called privileged instructions, which generally can read and write the instructions of key resources of the system (i.e. sensitive instructions) most of them are privileged instructions (there are cases in x86 where several sensitive instructions are non privileged instructions). If the processor state is not in the kernel state when executing privileged instructions, an exception will usually be thrown and the system software will handle the illegal access (TRAP). The classic virtualization methods are “privilege release” and “trap simulation” That is, guestos runs at the non privileged level, VMM runs at the highest privilege level (fully controlling system resources). After removing the privilege level of

guestos, most of the instructions of guestos can still run directly on the hardware. Only when the privileged instructions are executed, will it fall into VMM simulation execution (fall into simulation). “Fall into simulation” The essence of is to ensure that the instructions that may affect the correct operation of VMM are simulated and executed by VMM, and most non sensitive instructions still run as usual. Because several instructions in the x86 instruction set are sensitive instructions that need to be captured by VMM, but they are not privileged instructions (called critical instructions), the "privilege release" can not cause them to fall into simulation. When they are executed, they will not automatically "fall into" and be captured by VMM, which hinders the virtualization of instructions, which is also called the virtualization vulnerability of X86. Implementation of architecture Virtualization: X86 “hardware assisted virtualization”: its basic idea is to introduce new processor operation modes and new instructions, so that VMM and guestos run in different modes, guestos runs in controlled mode, and some original sensitive instructions will fall into VMM in controlled mode. In this way, the problem of "falling into simulation" of some non privileged sensitive instructions is solved, Moreover, the saving and recovery of context during mode switching is completed by hardware, which greatly improves the efficiency of context switching during "falling into simulation". Take Intel VT-x hardware assisted virtualization technology as an example, This technology adds two processor working modes in virtual state: root operation mode and non root operation mode (non root) operation mode. VMM operates in the root operation mode, while guestos operates in the non root operation mode. These two operation modes have their own privilege level rings, and the guestos of VMM and virtual machine run in the 0 ring of these two operation modes respectively. In this way, VMM can run in the 0 ring and guestos can run in the 0 ring, avoiding modifying the guestos. Root operation mode and The switching of non root operation mode is completed by adding CPU instructions (such as vmxon and vmxoff). Hardware assisted virtualization technology eliminates the ring conversion problem of operating system, reduces the virtualization threshold, supports the virtualization of any operating system without modifying the OS kernel, and is supported by virtualization software manufacturers. Hardware assisted virtualization technology has gradually eliminated the differences between software virtualization technologies, and has become the development trend in the future.

2.2.8 Vcpu mechanism

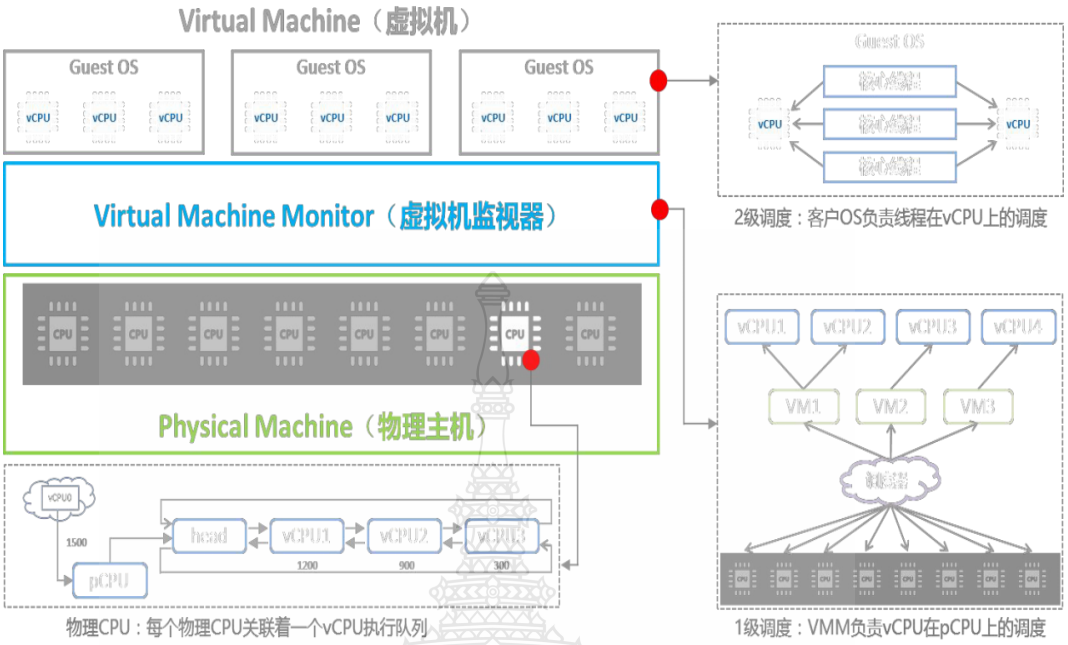

Figure 2.6 Virtual Machine monitor

2.2.9 Vcpu scheduling mechanism

For the virtual machine, the physical CPU is not directly perceived, and the computing unit of the virtual machine is presented through the vcpu object. The virtual machine sees only the vcpu presented to it by VMM. In VMM, Each vcpu corresponds to a VMCs (virtual machine control structure) structure. When the vcpu is switched from the physical CPU, its running context will be saved in its corresponding VMCs structure. When the vcpu is switched to the pcpu for running, its running context will be imported from the corresponding VMCs structure to the physical CPU. In this way, the independent operation of each vcpu is realized. From the structure and According to the function division, the guest operating system and virtual machine monitor.

Together, it forms a two-level scheduling framework of virtual machine system. As shown in the figure, it is a two-level scheduling framework of virtual machine system in multi-core environment. The guest operating system is responsible for Level 2 scheduling, That is, the scheduling of threads or processes on vcpu (map the core thread to the corresponding virtual CPU). The virtual machine monitor is responsible for the first level scheduling, that is, the scheduling of vcpu on the physical processing unit. There is no dependency between the scheduling policies and mechanisms of the two-level

scheduling. The vcpu scheduler is responsible for the allocation and scheduling of physical processor resources among virtual machines. In essence, the vcpu in each virtual machine is scheduled according to certain policies and mechanisms Scheduling can adopt any strategy to allocate physical resources on the physical processing unit to meet the different needs of virtual machines. Vcpu can schedule execution in one or more physical processing units (time-sharing multiplexing or spatial multiplexing physical processing units), or establish a one-to-one fixed mapping relationship with the physical processing units (restrict access to the specified physical processing units).

2.1.10 Memory virtualization

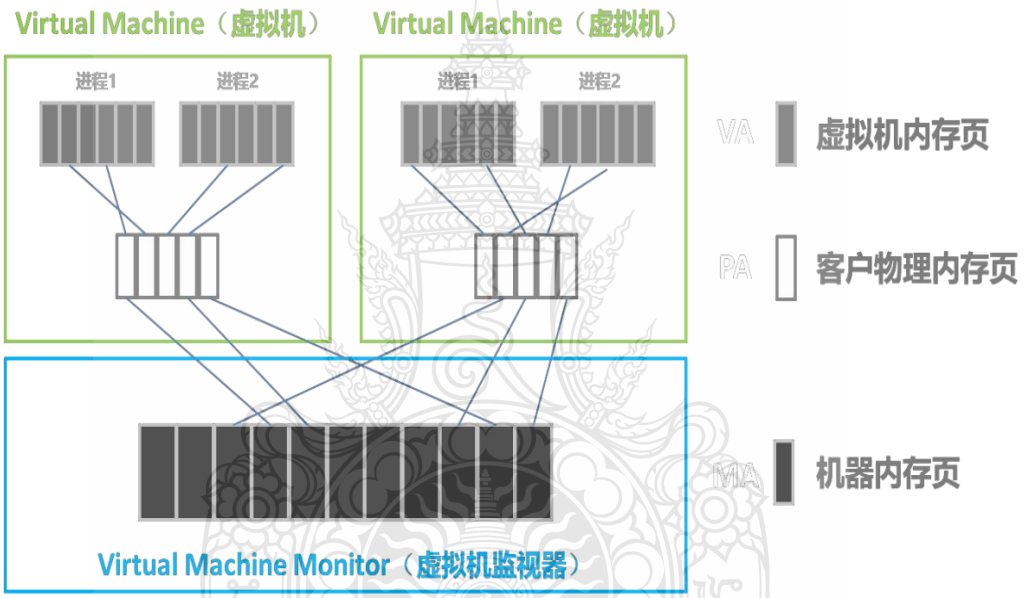

Figure 2.7 Memory virtualization three-tier model

Because VMM (virtual machine monitor) controls all system resources, VMM holds the entire memory resources, which is responsible for page memory management and maintaining the mapping relationship from virtual address to machine address. Because guestos also has a page memory management mechanism, the whole system with VMM has one more layer of mapping than the normal system:

A. Virtual address (VA) refers to the linear address space provided by guestos for its application;

B. Physical address (PA), a pseudo physical address abstracted by VMM and seen by virtual machine;

C. Machine address (MA), the real machine address, that is, the address signal on the address bus; The mapping relationship is as follows: guestos: PA = f (VA), VMM: Ma = g (PA) VMM maintains one

Page set table, which is responsible for the mapping from PA to ma. Guestos maintains a set of page tables, which is responsible for the mapping from VA to pa. In actual operation, the user program accesses va1, obtains PA1 through the page table conversion of guestos, and then intervenes by VMM to convert PA1 into MA1 using the page table of VMM.

Page table virtualization technology

Ordinary MMU can only complete the mapping from virtual address to physical address once. In the virtual machine environment, the "physical address" obtained by MMU conversion is not the real machine address. To get the real machine address, VMM must intervene and map again to get the machine address used on the bus. If VMM is involved in every memory access of the virtual machine, and the software simulates the address conversion, the efficiency is very low and has little practical availability. In order to realize the efficient conversion from the virtual address to the machine address, the commonly adopted idea is that VMM generates a composite mapping FG according to the mapping F and G, and directly writes the mapping relationship into the MMU. The current page table virtualization methods are MMU virtualization and shadow page table, which have been replaced by hardware assisted virtualization technology of memory.

MMUParavirtualization

Its basic principle is: when guestos creates a new page table, it will allocate a page from the free memory maintained by it and register the page with VMM. VMM will deprive guestos of write permission to the page table. Then guestos's write operation to the page table will fall into VMM for verification and conversion. VMM checks each item in the page table to ensure that they only map the machine pages belonging to the virtual machine and must not contain writable mappings to the page table pages. After that, VMM will replace the physical address in the page table entry with the corresponding machine address according to the mapping relationship maintained by itself, and finally load the modified page table into MMU. In this way, MMU can directly

complete the conversion from virtual address to machine address according to the modified page table.

2.2.11 Memory hardware assisted virtualization

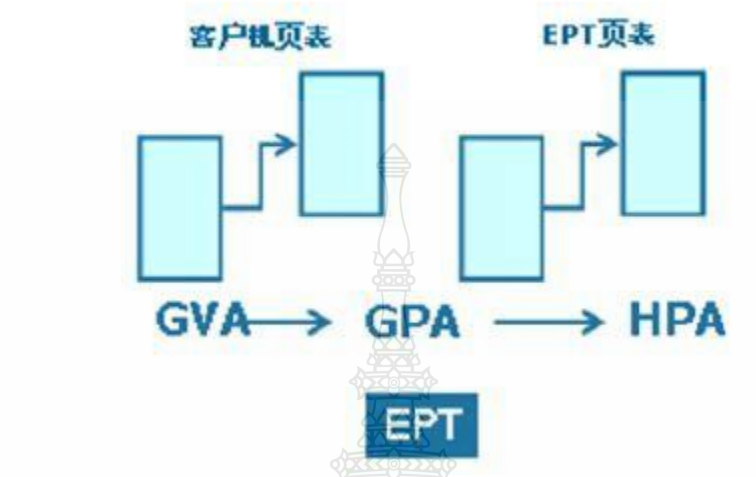

Figure 2.8 Schematic diagram of memory hardware assisted virtualization technology

The hardware assisted virtualization technology of memory is a hardware assisted virtualization technology used to replace the "shadow page table" implemented by software in virtualization technology, Its basic principle is: GVA (virtual address of the guest operating system) - > GPA (physical address of the guest operating system) - > HPA (physical address of the host operating system) two address transformations are automatically completed by the CPU hardware (software implementation has large memory overhead and poor performance) (EPT) as an example, firstly, VMM sets the EPT page table that converts the client's physical address to the machine address in advance to the CPU; secondly, the client modifies the client page table without VMM intervention; finally, during address conversion, the CPU automatically looks up two page tables to complete the conversion from the client's virtual address to the machine address. Using the hardware assisted virtualization technology of memory, VMM is not required during the operation of the client The intervention removes a lot of software overhead, and the memory access performance is close to that of the physical machine.

I / O device virtualization

VMM reuses limited peripheral resources through I / O virtualization. It intercepts the access request of guestos to I / O devices, and then simulates the real hardware through software. At present, there are three main virtualization methods of I/O devices: complete simulation of device interface, front-end / back-end simulation and direct division.

(1) Full simulation of equipment interface:

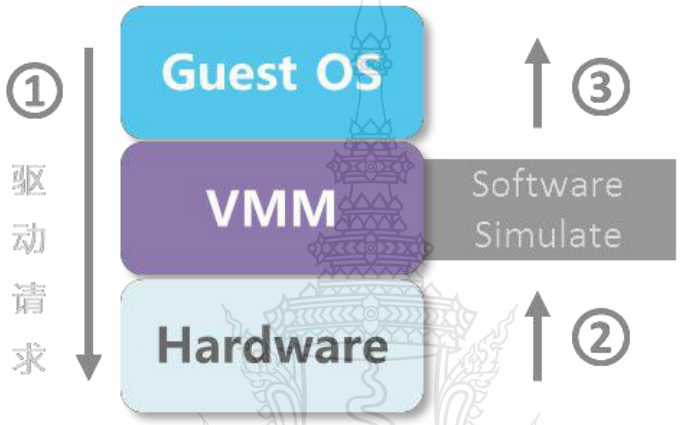

Figure 2.9 software accurately simulates

That is, the software accurately simulates the same interface as the physical device, and the guestos driver can drive the virtual device without modification. Advantages: there is no additional hardware overhead and existing drivers can be reused; and disadvantages: in order to complete one operation, multiple register operations are involved, so that VMM needs to intercept each register access and conduct corresponding simulation, which leads to multiple context switches; Due to software simulation, the performance is low.

(2) Front end / back end simulation:

VMM provides a simplified driver (back-end). The driver in guestos is the front-end (FE). The front-end driver directly sends requests from other modules to the back-end driver of guestos through a special communication mechanism with guestos. The back-end driver sends back a notification to the front-end after processing the request. VMM adopts this method.

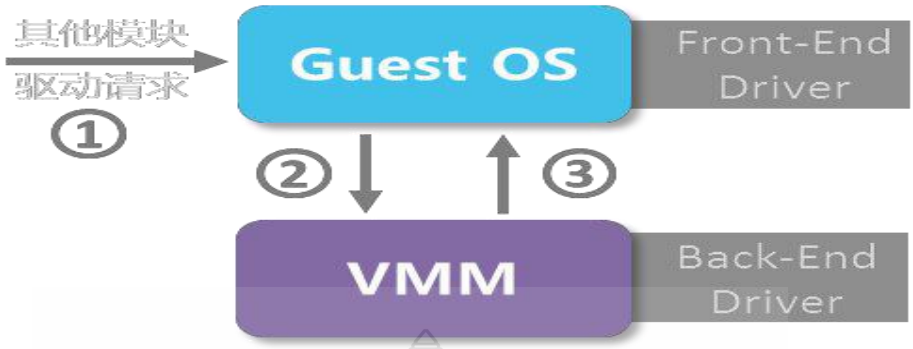

Figure 2.10 front-end driver

Advantages: the transaction based communication mechanism can greatly reduce the context switching overhead without additional hardware overhead;

Disadvantages: guestos needs to implement the front-end driver, and the back-end driver may become a bottleneck.

(3) Direct division:

That is, the physical devices are directly assigned to a guest OS, and the guest OS directly accesses the I / O devices (without VMM). At present, the related technologies include IOMMU (intelvt-d, SR-IOV of pci-sig, etc.), which aims to establish an efficient I / O virtualization direct channel.

Figure 2.11 physical device

Advantages: existing drivers can be reused, direct access reduces virtualization overhead;

2.2.12 Fully symmetric virtual architecture

"Symmetry" means that all nodes in virtualized storage can be completely equal, which can greatly reduce the system maintenance cost.

2.2.12.1 Unlimited scalability

The scalability here is divided into two aspects: one is that the data storage capacity is infinitely scalable; Second, the performance of virtualized storage (such as QPS, throughput, etc.) can be linearly improved. Because virtualized storage is a completely symmetrical architecture, it only needs to simply add new machines for capacity expansion, and the system will automatically complete data migration and other work, so that each storage node can reach a balanced state again.

2.2.12.2 No single point of failure

In the scenario of large-scale application of Internet services, the single point of storage has always been a difficult problem. For example, in database, the general ha method can only be the master-slave, and there is generally only one "master"; In the implementation of other open source storage systems, the storage of metadata information has always been a headache. Generally, it can only be stored at a single point, which can easily become a bottleneck. Once there is a difference at this point, it can often affect the whole cluster, such as HDFS. Swift's metadata storage is completely evenly and randomly distributed, and like object file storage, metadata will be stored in multiple copies. In the entire virtualized storage cluster, none of the roles is single point, and the architecture and design ensure that no single point of service is effective.

2.2.12.3 Simple and reliable

It is simply reflected in the streamlined architecture, neat code and easy to understand implementation. It does not use some advanced distributed storage theories, but very simple principles. Dependability means that after testing and analyzing the virtualized storage, you can confidently and boldly use the virtualized storage for the most core storage business. No matter any problem occurs, it can be solved quickly through logging and reading code.

The virtualization of storage function uses x86 PC server as the storage carrier, which has many advantages such as large capacity, low cost and high IPOs. At present, the mainstream solution is to use SSD card as cache to reduce IO delay. The minimum IO delay can be less than 1ms. In this phase of the project, the distributed storage server will be equipped with SSD card or SSD disk.

2.2.12.4 Advantages and usage scenarios of Server Virtualization:

1) Effectively improve the response speed of business requirements

Based on the virtual machine template and cloning function, the on-demand deployment of virtual machines can be realized to quickly respond to business online requirements, and the deployment time of new application systems can be shortened from n days to n minutes.

According to the change of business requirements, virtualization can provide flexible ability to adjust the specification of virtual machine resource configuration.

2) Server virtualization can reduce costs

It can effectively improve resource utilization and reduce the number of physical servers. Under the same performance and reliability requirements, reduce the construction cost and save the cabinet space, power, refrigeration, wiring, maintenance, manpower and other costs.

3) Improve operation and maintenance efficiency

It can easily realize the centralized monitoring and statistical analysis of resources and improve the ability to control resources.

The online host migration and storage migration functions can ensure that the system can achieve uninterrupted planned downtime, maintenance and capacity expansion.

When the virtual machine fails, the business can be quickly switched to the newly created virtual machine of the same specification, and the rapid business recovery can be realized in a few minutes.

Host and storage migration technology can ensure the upgrading of hardware equipment without redeploying the operating system and applications, and improve the maintainability of the application system.

Server virtualization is designed for multiple application systems to share the underlying physical server resources to improve resource utilization and improve the flexibility of application software deployment and resource scheduling. In theory, virtualization technology can be used except for special scenarios such as

special hardware board requirements (acquisition card, voice card, video card, etc.). However, from the perspective of business application characteristics, the following scenarios can give better play to the value of Server Virtualization:

1) Dynamic change of resource demand: due to the rapid growth of business volume, sudden business demand, periodic change of business when busy and idle, it is necessary to allocate and recycle resources flexibly and quickly. The characteristics of rapid deployment, deletion and dynamic configuration adjustment of virtual machines have great advantages over physical machines.

2) Small application system; For applications that require far less resources than the processing capacity of the current mainstream physical servers, share physical resources, improve resource utilization and reduce costs through virtualization.

3) Temporary application deployment: for example, R & D and test systems can be quickly deployed through virtualization, and resources can be quickly released after use.

2.2.13 Distributed storage

Super converged storage supports multi server cluster deployment, realizes efficient cluster storage through load balancing, ensures multiple redundant storage of data, and improves data security and reliability.

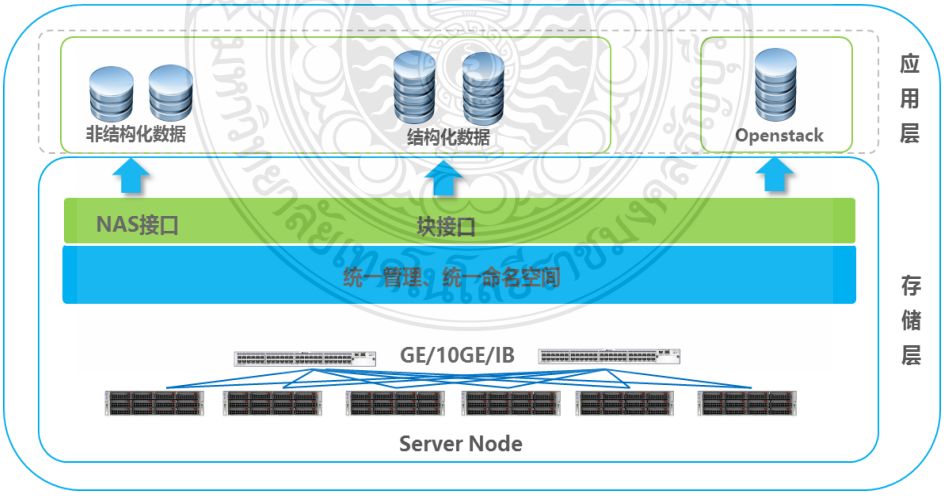

Figure 2.12 Distributed lock working mechanism for hyper fusion applications

The design principle shows the following characteristics:

1) It needs to meet the challenge of big data, and support the processing of metadata and data block;

2) Need different data modes that can support multiple applications;

3) Concurrent operations that can increase the efficiency of multi node IO are required.

Based on the above characteristics, the distributed lock mechanism realizes the synchronization of metadata and data blocks on the disk, and ensures the consistency of metadata cache on each node, It also ensures the consistency between multiple copies of data (even if the data does not end normally due to distributed system component failure). Set the distributed lock management node (the location of the distributed lock management node can be calculated by hash function) and the lock holder (applicants can also be divided into metadata nodes, data block nodes and other roles) two roles are physically distributed among the nodes in the cluster.

The role of distributed lock management node is responsible for arbitrating the application for lock and giving the corresponding control level, while the lock holder applies and makes corresponding operations to complete the data reading and writing operations.

2.2.13.1 Fine grained high availability distributed metadata management model

Metadata is the index information of data information data blocks, such as file size and modification time. It is an important guarantee information related to data retrieval. Compared with the commonly used metadata, it is saved separately by the master node, which has shortcomings in reliability and scalability, The hyper converged storage system uses a distributed way to ensure the dispersion and availability of data. Through distributed lock control, all files in the whole cluster system have their own metadata management role nodes, which makes the metadata management mechanism more flexible, and eliminates the horizontal expansion restrictions brought by the central metadata server or cluster.

The distributed metadata management model needs to instantiate the content according to the working principle of the distributed lock working

mechanism. The most typical is to accurately determine the level meaning of each lock mode, as well as the degradation and upgrade processing rules, especially the processing functions of the conflict domain. For example, when reading a file, you need to obtain the size and modification time of the operated file. In this case, other nodes that modify metadata need to send the update information to the distributed lock management node, and then update it to ensure the correctness of semantics.

Each node in the whole cluster will store a part of metadata information, and the information is fine-grained controlled based on file granularity. When the node closes the access to a file, or the metadata IO monitoring module finds that the amount of metadata operations of a node on a file is much greater than that of other nodes, the fine-grained metadata management role will automatically jump to the next node that is still accessing the file; At the same time, in the implementation process, we consider that the nodes of some operations (such as truncate for online adjustment of the size of cloud image files) need to be forcibly upgraded to the metadata management role to ensure the consistency of metadata. The system will preempt and upgrade the metadata management role of the node for these operations.

2.2.13.2 Block multi copy allocation strategy

The multi copy mechanism strategy is developed for the data block. The data block is the stored data information. Its IO operation mode can be divided into sequential read-write and random read-write. This strategy mainly solves the problem of parallel IO operation. By determining the byte domain and lock mode hierarchical relationship of each node, concurrent read-write operations can be carried out at each node, The range of byte lock will also be adjusted accordingly. The distributed lock management node will determine the IO mode according to the IO request sent by each node and the task request decider. If the determination result is the sequential access mode, the byte prefetching window controlled by the byte lock will gradually increase until it conflicts with the byte locks of other nodes. At this time, the growth authorization of the byte lock will be stopped. In case of conflict, the strategy considers the use of the experience base of IO mode to intelligently determine the range adjustment requirements of byte lock control.

The data block replica allocation strategy takes into account the physical location of the whole system in the data center computer room, network performance, failure group relationship, etc. For the typical three replica strategy, considering that two replicas are in two non strong independent failure groups with relatively high network connectivity performance, the other replica will be placed in the strong independent failure group with relatively low network performance for allocation. This makes the fault tolerance of the whole system more reasonable.

2.2.13.4 High performance read and write

In the cluster storage environment, the metadata node undertakes all read-write access, and the access pressure is very large, which often becomes the performance bottleneck of the system. The number of metadata service nodes of the super fusion storage system expands dynamically with the addition of the client node. The client caches the metadata of the file that needs to be accessed at this node, The performance overhead caused by the client's access to metadata through the network is greatly reduced, and the hyper fusion storage system controls the modification of metadata and data by multiple nodes through the distributed lock mechanism, so as to truly achieve a high degree of concurrency in the reading and writing of data and metadata. In addition, a single file in the hyper converged storage system is fragmented and stored on multiple storage engines, which provide read-write capability concurrently, and can use the local affinity of the replica to achieve efficient read-write.

The read / write aggregation bandwidth of a single file of a hyper converged storage system is up to GB / s, and the total throughput of a single file system is up to TB / s.

The following is a set of customer examples (for virtualization applications, three servers are configured with one SSD and one SATA disk to form super converged storage). We use 4kdirect IO mode inside the virtual machine. The virtual machine performs DIO through ext4 file system. The image and data io of the virtual machine directly realize local read and three copy write through super converged storage. We get a series of performance data graphs:

2.2.14 Resource management framework

In this scheme, high-performance processing, super fusion and GPU cloud can be managed through a unified platform. Through the cloud management platform, all resources in the cluster such as computing, storage, network, GPU, virtual machine and physical machine can be managed. Through the cloud management platform, the management, allocation and monitoring of resources can be completed, reducing the number of on-site maintenances by operators.

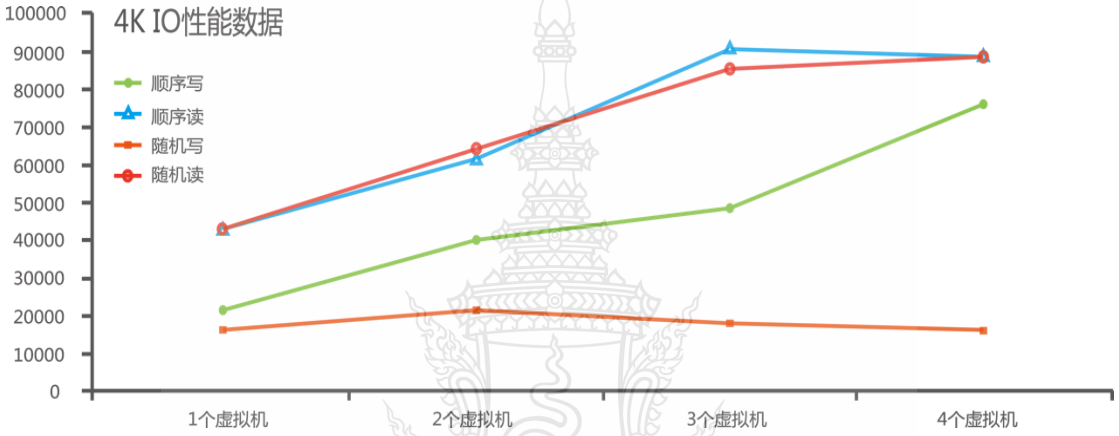

Figure 2.13 Resource management framework

2.2.15 Time division multiplexing

Allocate resources reasonably through the management platform, and join the high energy absorption node when the GPU node is idle. Policies can be set uniformly through the management platform, such as

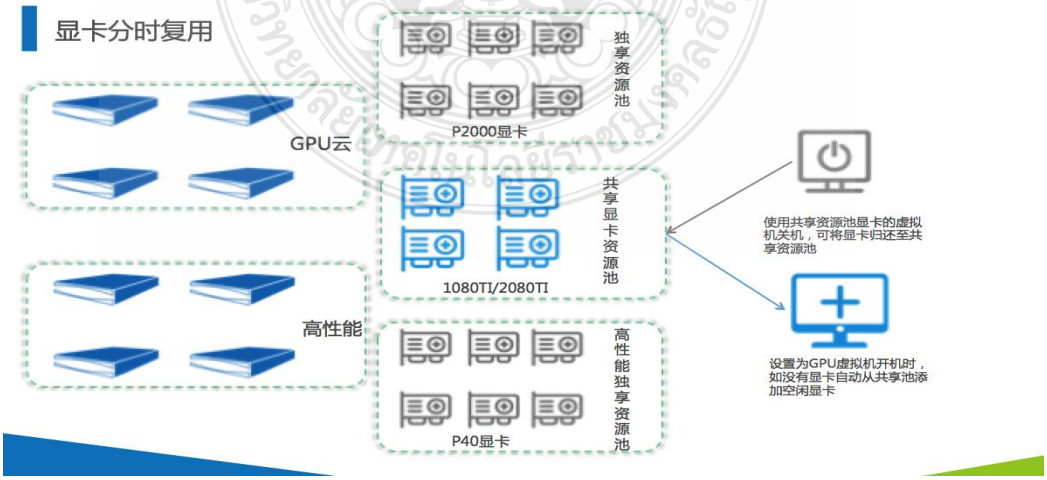

Figure 2.14 the management platform

When the production GPU virtual machine operator shuts down after work, if the graphics card uses the graphics card in the shared resource pool, the platform will automatically release the graphics card to the shared resource pool.

When a high-performance virtual machine is powered on, it will automatically load the shared resource pool graphics card on the virtual machine for high energy absorption. The same goes for shutdown. Using the exclusive resource pool resource, the graphics card will not be released when it is shut down

2.2.16 Authority management

Customer authority management is divided into system administrator, project administrator and project team member, with multi-level management role and multi-level authority management mechanism. The system administrator has the highest authority to allocate resources and issue project administrator permissions. The project administrator has a project specific permission management mechanism to allocate and manage resources and permissions to group members in the project.

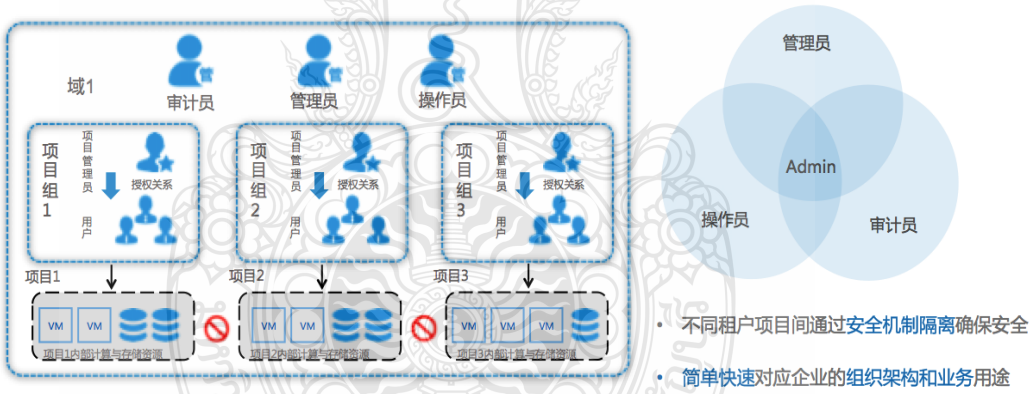

Figure 2.15 project administrator permission

2.3 Practical achievements and challenges

2.3.1 Data redundancy

Relying on the software defined storage SDS technology in the super fusion infrastructure, the data is scattered in the way of multiple copies and distributed in the storage devices of the whole cluster. In case of disk failure or server downtime in the cluster, the copy data will continue to be carried.

2.3.2 Build a mapping cloud computing platform

Allocate computing, storage and network resources according to business needs, provide GPU to designated users in the form of services, realize the operation mode of real-time infrastructure relying on the characteristics of cloud computing, and simplify management.

2.3.3 Resource pooling.

Integrate computing, storage, network and GPU resources into a resource pool that can be managed uniformly, flexibly scheduled and flexibly allocated. Each business system no longer occupies independent physical server, storage and network resources, but shares the resources in the cloud with other business systems and monopolizes part of the logical resources in the form of virtual machines.

2.3.4 Provide standardized resource services.

Reasonably divide computing storage resources, provide standardized and adjustable environment configuration packages for various business needs, carry out automatic deployment and maintenance of the environment, and quickly provide standard, safe and stable resource services. Manage all kinds of storage uniformly, and formulate storage resource pools at different levels according to the category of storage resources, so as to provide storage services at different service levels.

2.3.5 Allocate and recycle resources on demand.

In the future, new business systems or expansion and migration of business systems can be quickly completed by directly obtaining resources from the resource pool according to the demand without additional application for purchase. After the business system life cycle is completed, resources can also be released back to the resource pool. This not only improves the business deployment efficiency, but also improves the resource utilization and reduces the total cost of ownership.

2.3.6 Elastic expansion of resources.

The cloud computing platform meets the requirements of various application systems for computing storage resources, realizes the on-demand allocation and rapid deployment of hardware capabilities to applications, and can flexibly expand resources online when resources are insufficient to meet business needs and ensure service level

2.3.7 Centralized management

Integrate computing resources to achieve unified management, and the data processing work is more optimally distributed. All production system software does not need to be deployed separately by staff, but can be quickly created directly through the private cloud of the data center. Staff do not need to install operating systems, and install or do not install business software as little as possible.CPU, memory, and disk utilization have been improved to varying degrees. The performance of common software will be greatly improved.

2.3.8 GPU capability covers edge set terminal equipment

GPU cloud computing is stored in the cloud, and the business personnel's desktop only has display devices. After the client fails, it supports rapid replacement to ensure the continuity of production work. High performance GPU virtual machine. It can improve more performance than the traditional virtual desktop and obtain the computing power of the workstation.

2.4 Intelligent Classrooms

2.4.1 Definition of intelligent classrooms

By building a technology integrated learning environment, involving immersive multimedia experience, steam teaching courses, interactive Q & A and other systems, smart classroom enables teachers to display efficient teaching methods, enables learners to obtain personalized learning services and beautiful development experience, and creates a future classroom with intelligent system, immersive scene and deep interaction.

The wisdom classroom is the realization of learning wisdom from the perspective of teaching and learning. It emphasizes that the wisdom classroom integrates various resources, provides various teaching tools, supports flexible teaching and learning methods, supports rich learning experience, facilitates communication, cooperation and sharing, emphasizes not only the advanced nature of technology and facilities, but also how to flexibly apply technology to support learning process. Enhance learning effect. The "wisdom" of smart classroom involves the optimization and presentation of teaching content, the convenient acquisition of learning resources, the in-depth interaction of

classroom teaching, situational perception and detection, classroom layout and other aspects. Domestic researchers summarize it into five dimensions: content presentation, environmental management, resource acquisition, timely interaction and situational perception, These five dimensions just reflect the characteristics of smart classroom. The interactive mode supports teacher-student interaction and student student interaction. Students can log in to the classroom teaching application through mobile phone, express their personal and group views, and discuss and communicate with other groups in the way of praise. The group discussion results can be put on the big screen wirelessly, and teachers can see the key points of students' discussion at any time, or summarize the cooperation results based on students' feedback.

2.4.2 Factors that influence students with intelligent classrooms

The intelligent classroom information platform is composed of "cloud", "network" and "end". Its value core is online teaching and data-based aggregation and analysis.

The network is the OPS server of the smart classroom. It provides local network, storage and computing services. It creates a stable wireless local area environment based on the class, realizes high-speed and efficient three-dimensional interaction scenes, and solves the problem of network connectivity.End refers to the application tools of teacher end and student end.The specific functions are analyzed from three aspects: before class, during class and after class.

2.4.3 Smart classroom, lesson preparation before class

First, prepare lessons before class. Its value is reflected in efficient lesson preparation, which supports learning before teaching and teaching based on learning.

Specifically, lesson preparation before class is how teachers prepare lessons. First of all, our system realizes the synchronous push of high-quality resources to help teachers prepare lessons efficiently. At the same time, we can take into account our teachers' existing daily resources, including PPT and so on. In addition, we can directly import the cloud platform resources and school-based resource library to enrich classroom teaching, reduce the burden for teachers, improve the efficiency of teachers' lesson preparation and enrich classroom teaching.

2.4.4 Smart classroom lesson preparation resources

In addition, the system collects students' learning behavior and makes data analysis. Teachers master the learning situation in real time to optimize the teaching design. That is, we usually say that pre class lesson preparation should not only prepare resources, but also prepare the learning situation. The system carries out intuitive data analysis and promotion to teachers by collecting the results of students' micro class preview and homework detection, To sum up, it is more convenient for teachers to preview and check, master the learning situation in time and optimize the teaching design.

2.4.5 Smart classroom teaching

Before we finish the class, let's look at the class. In the class, with the support of information-based mobile devices, the value of smart classroom is mainly reflected in mobile teaching, three-dimensional interaction between teachers, students and students, and intelligent evaluation.

2.4.6 Smart classroom wireless projection

The first major feature of teaching in class is the realization of mobile teaching, that is, let teachers go off the podium and talk on the platform. Its core is to build an information environment with the classroom as the unit through micro cloud server to ensure stable interaction inside and outside the classroom, which is specifically reflected in: The first is barrier free interaction. The smart classroom can make 100 people online at the same time, and the wonderful transmission of 200K files! Many e-book packages are not normally used, that is, there is no breakthrough in the technical threshold. There is also the "whole network" connection, which enables normal teaching regardless of whether there is a network or not. These are real pain points in practical application. Because many applications of devices such as e-book bags must rely on the Internet. Without the Internet, it can't be used. This is the support in mobile teaching.

The second is the electronic textbook, which realizes the click to read content of Chinese, English and music textbooks; Support the oral evaluation practice of Chinese and English in the classroom, and feed back the evaluation results in real time, as well as the high-quality resources of the whole discipline from books to classes to locations. At the same time, teachers can only obtain them directly from the cloud, online disk, local disk and USB flash drive.

2.4.7 Smart classroom electronic textbook

The third thing to say is that it supports the teaching of a series of tools. In addition to the original playback of commonly used PPT and word courseware, it also supports the switching of various teaching methods of courseware, whiteboard and textbook, as well as photo explanation and physical booth, These are the most practical functions of teachers... (realize the original playback of PPT and word courseware; preview and edit at any time; support interactive courseware to realize interesting classroom through continuous viewing, time axis, flip card and oral evaluation; support the convenient switching of three teaching methods of courseware, whiteboard and textbook with multiple documents. Photo explanation: the generative resources before and during the class are presented in time, and multiple works are compared and explained to learn from and evaluate each other. Physical booth: the wonderful process of experimental course and comprehensive development course is displayed in real time throughout the whole process, taking care of every child.

2.4.8 Classroom interaction

The fourth aspect is classroom interaction, which supports a variety of interactive ways，Participation mode: Rush answer, random answer, group answer, all answer; Test questions: multiple choice questions, judgment questions, blank filling questions and subjective questions; Interactive report: the objective questions will be automatically corrected, and the statistical analysis report will be generated immediately, so that the overall situation of the class and the individual situation of students can be seen at a glance; Comparative evaluation: subjective questions support students' mutual evaluation, the comparative display of students' works and the joint appreciation of teachers and students. Fifth, there are classroom records, that is, one click recording of micro classes to form a teaching micro class integrating content, explanation and audio-visual, which helps the application of flipped classroom mode. There are also the control of students, the in-depth customization and all-round control of students in smart classroom, It is a green learning terminal for teachers and parents to rest assured!

2.4.9 Smart classroom after class application

After the lecture, let's take a look at the homework test, personalized counseling and students' review and consolidation after class. First, accurate data analysis.

For homework test, we can calculate the overall homework quality, homework doubts, difficulties and objective problem quality analysis from the perspective of teaching, and push the results to the front-end teachers and students, Realize the timely feedback of dynamic teaching data, quantify the effect of teaching and learning, and the smart classroom also supports personalized counseling. The first is one-to-one tutoring. One-to-one tutoring is based on audio one-to-one tutoring. It is very convenient to solve the problem of students doing homework at home and can't find someone to tutor through Internet transmission. There are also micro class tutoring, which are various personalized tutoring methods.

2.4.10 Online learning

Third, teachers can share courseware, micro lessons and learning expansion resources with one click, create a ubiquitous teaching environment, cultivate students' autonomous learning habits and improve their autonomous learning ability.

In conclusion, the function design from pre class to after class is also aimed at the problems and pain points of the education industry mentioned in our previous background analysis. The role is mainly reflected in three levels: the first is the change of interaction mode, the acquisition of teaching and learning content, and procedural big data support.

2.4.11 Benefits and Challenges of intelligent classrooms

Through the cooperation of hardware and software, we can break the limitations of the traditional classroom, turn the classroom into a "smart classroom", improve teaching efficiency and comply with the educational reform. The smart classroom breaks the traditional classroom layout and uses tables and chairs that can be flexibly moved and spliced to adapt to various discussion scenes. At the same time, it provides special discussion interactive display equipment for each group, allows students to use their own equipment to participate in the classroom, and provides a convenient way for the content display of students in groups, between groups and the whole class. The unique interactive design is different from the traditional classroom "row by row" mode. Although there is no careful guidance of moss, there are teachers who teach us patiently to maximize the use of classroom space and improve teaching quality. Smart classroom constructs the school teaching ecosystem. As the main battlefield of educational reform,

classroom is the key medium to realize educational modernization, cultivate innovative talents and create a learning society in the national medium and long-term education plan. It is also the core component of the framework of educational informatization system. "Smart classroom" deeply integrates teaching paradigm, information technology and teaching space, which not only meets the macro needs of national and social development, but also meets the needs of the school for teaching innovation and practice, constructs a learning ecosystem, improves teaching quality, and helps the school fully realize the strategic goal of "Three Promotions". The construction of smart classroom has opened a new model of smart teaching reform and played a positive role in promoting the development of online and offline hybrid teaching reform. Smart classroom improves the learning ecosystem. In order to meet the needs of talent training, promote the deep integration of information technology and education and teaching, promote the reform of teaching methods and means, and improve the quality of classroom teaching

2.4.12 Models of intelligent classrooms

Smart classroom is a form of digital classroom and future classroom. It is a new type of intelligent classroom, an effective way to promote the construction of intelligent and intelligent classroom, and an effective way to promote the construction of intelligent classroom and personnel attendance management system based on the Internet of things. The smart classroom mainly includes the following nine systems:

2.4.13 Teaching system

The teaching system is composed of touch projector with built- in electronic whiteboard function, power amplifier, speaker, wireless microphone, pickup, question answering device and supporting control software. The touch projector with built- in electronic whiteboard function is used to replace the traditional blackboard teaching to realize dust-free teaching and protect the health of teachers and students. The computer can be operated on the projection screen, and the question answering device is configured on each table to realize the interactive classroom teaching between teachers and students.

2.4.14 LED display system

The LED display system is spliced by the LED panel and installed on the top of the classroom blackboard. It is used to display the course name, professional

class, teacher, attendance rate and environmental data collected by various sensors in the classroom (indoor temperature and humidity, illumination, carbon dioxide concentration, etc.).

2.4.15 Personnel attendance system

The personnel attendance system consists of RFID attendance machine, attendance card and supporting control software. An RFID attendance machine is installed at the front and rear doors of the classroom. RFID tags (Campus All-in-one Card) are used to count the attendance of students, identify the personnel entering the classroom, count the attendance of legal users and warn illegal users. At the same time, it can monitor, count, archive and print attendance remotely through WiFi wireless coverage.

2.4.16 Asset management system

The asset management system consists of UHF RFID card reader, paper label, anti metal label and supporting control software. An UHF card reader is installed at the front and rear doors of the classroom to monitor and manage the access of experimental instruments, equipment and other assets in the classroom (RFID tags are pasted and the detailed information of equipment is stored on the tags), and give an alarm when unauthorized users bring the assets out of the classroom, so as to facilitate the unified management of classroom equipment by equipment managers.

2.4.17 Lighting control system

The lighting control system consists of lighting controller, lighting sensor, human body sensor, curtain control system and supporting control software. Firstly, the human body sensor is used to judge whether there is someone at the corresponding position in the classroom. If there is no one at this position, the light control system and curtain control system are closed; On the contrary, it is in working state.

2.4.18 Air conditioning control system

The air conditioning control system is composed of central air conditioning power controller, temperature and humidity sensor and supporting control software. The indoor temperature is monitored by the temperature and humidity sensor. By analyzing the data and according to the preset value of the software, the air conditioner will be automatically turned on when the indoor temperature and humidity is higher than

the maximum threshold value. When the indoor temperature and humidity is lower than the lowest threshold value, the air conditioner will be automatically turned off to realize the automatic control of indoor temperature and humidity.

2.4.19 Door and window monitoring system

The door and window monitoring system consists of window magnetic module and supporting software. The window door magnetic module is used to detect the opening and closing status of doors and windows, and upload the status information to the server in time. At the same time, sensitive periods are set to implement automatic monitoring and alarm of windows.

2.4.20 Ventilation system

The ventilation system consists of exhaust fan, CO2 sensor and supporting monitoring software. The indoor CO2 concentration is monitored through the CO2 sensor. By analyzing the data and according to the preset value of the software, when the indoor CO2 concentration is higher than the threshold value of the software, the exhaust fan is automatically started for ventilation, and the indoor CO2 concentration is reduced by supplementing outdoor air.

2.4.21 Video surveillance system

The video monitoring system consists of WiFi wireless camera and supporting monitoring software. Video monitoring can provide query basis for security system, asset warehousing and personnel access. A WiFi wireless camera is installed at the front and rear doors of the classroom to monitor the entry and exit of personnel and the entry and exit of assets. A WiFi wireless camera is installed in the classroom to monitor the real-time situation inside the classroom. The collected images are transmitted to the terminal management computer through the remote RF unit to provide real-time monitoring data.

2.5 Relevant research

Laura R. Winer (2002) to study in topic of The "Intelligent Classroom": changing teaching and learning with an evolving technological environment. Found that Putting technology to work to improve teaching and learning is the goal of the "Intelligent Classroom" project at McGill University. A hardware and software installation allows for the automated capture of audio, video, slides, and handwritten annotations during a live lecture, with subsequent access by students. The development process, a collaborative effort of computer engineers, educational specialists, professors and students, is described, as well as usage by students in four different classes following the initial deployment of the system. Students were found to access the systems as a review tool, and appreciated the changes to the in-class presentation as well as the opportunity for later access. Students' and professors' reactions are described, as well as suggestions for future developments.

Yang Gao (2022) To study in topic of intelligent structure design of learning seats in university smart classroom under the background of intelligent education. found that Under the background of intelligent education, the study chairs of intelligent classrooms in colleges and universities should reflect humanistic care and design and guide students to establish a healthy learning style. To realize the intelligent classroom learning, the intelligent seat can be applied to different sitting positions or different heights and weights. This paper designs a control system based on MC9S08DZ60 and realizes the communication between the control system and the mobile app by combining the Bluetooth module based on CSR8670. At the same time, this paper proposes an intelligent design that can adjust the seat height by voice. LD3320 speech recognition module is used for voice control, and a push rod motor with a rising speed of 7 mm/s is used to complete the lifting to meet the requirements of different sitting positions and different heights and weights. Then, the folding design of the intelligent seat for classroom learning is carried out. Infrared detectors are used at the armrests on both sides of the seat. When people have a tendency to sit down, they will speed up deployment. When a person leaves the seat, the seat will automatically retract. Finally, the objective evaluation method of pressure distribution test experiment is compared with the

subjective scale evaluation of students, which verifies the effectiveness of the shape design of the chair in keeping students' healthy sitting posture for a long time.

Guillermo Bautista and others (2013) to study in topic of Smart classrooms: Innovation in formal learning spaces to transform learning experiences. Found that Despite entering a new century where agents and elements in education have changed, students, teachers, curriculum, resources and so on, the classroom, as the learning space in the school, has experienced no change as regards configuration and structure. Traditional classrooms with rows of desks facing the teacher and the board do not fulfill present-day educational needs and expectations; therefore the learning space at school requires adaptation to the new contexts and roles in education. In this paper the authors outline general principles on the design and methodology of Smart Classrooms, new learning spaces which may better fit present and future learning needs and roles.

CHAPTER 3
RESEARCH METHODOLOGY

This is a research and development of an intelligent classroom at college and universities. The purpose are to explore the problems and demands of intelligent classroom. To summarize the concept and model structure of an intelligent classrooms and publish through digital media. Also explore university students' satisfaction with creative intelligent classroom styles. The related problems are gradually exposed in the upgrading of teaching equipment, terminal equipment management, personnel management of various roles, and data security. This paper mainly studies the solutions to the above problems. The numerous parts of the research approach that the researcher used are discussed in this chapter. It contains a thorough description of the research design, population, sampling methodologies, research instruments, and data collection and analysis procedures. This chapter will be presented in the following sections:

3.1 Research Design
3.2 Research Site
3.3 Population and Sampling Procedures
3.4 Research Instrument Development and Evaluation
3.5 Validity and Reliability of Research Instruments
3.6 Ethical Procedures
3.7 Data Analysis Procedurres

3.1 Research Design

In this investigation, a quasi-experimental quantitative design was adopted. To better understand the perspectives of participants on the usage of intelligent classrooms with cloud computing provides to service data storage at college and universities. This was followed by a quasi-experimental study of 30 individuals from the target population to determine the effectiveness of intelligent classrooms. Internal and external variables such as students' ICT proficiency. At the end of the study, a model summarizing the steps of the study was developed.

The first phase of the research took the model of an intelligent classroom study which was to test the effectiveness of learning from the usage of intelligent classrooms with cloud computing provides to service data storage at college and universities to the satisfaction questionnaire made up of 28 questions. And create Participants' satisfaction questionnaire was then analyzed for results. The survey by the questionnaire will collect data from population with cloud computing provides to service data storage at college and universities.

The second phase of the research will summarize conceptual framework and create a model of intelligent classroom appropriate for students in universities. Also publishing a model via website by suggestion and evaluation from experts. Finally, bring the model to try out experiment with an example group. Collect data mean average and standard deviation. And satisfaction from the target.

3.2 Research Site

The research took place at the University of Tianjin University of Technology and college of Computer Department.This location was chosen because the researcher was an undergraduate student residing in the University. making it simple to deliver questionnaires. Using the university as the study site was also the most convenient and cost-effective option to collect data for the study because the researcher has easy access to the university.

3.3 Population and Sampling Procedures

The study's population included all students at the University of Tianjin University of Technology .The survey participants were chosen using simple random and purposeful selection approaches. The survey participants were chosen using a basic random sample technique. The researcher planned to sample roughly 398 students for the survey, which is a figure indicative of the entire population, and about 30 participants for the quasi-experimental study. Due to the coronavirus and safety protocols, both the survey and experiment were conducted online. A link to the survey was shared on several students' chat platforms. Students were encouraged to fill the forms out of their own

volition. The sample size calculation was based on the finite population formula as postulated by Yamane (1967). See the figure below.

$$n = \frac{N}{(1 + Ne^2)}$$

Where
n = corrected sample size
N = population size and
e = margin of error (MoE), e= 0.05 based on the research conditions

Figure 3.1 Finite sample size formula (Yamane, 1967).

Given that the population is 74, 720. At 5% MoE, then the sample size will be:

$$n = \frac{N}{(1 + Ne^2)}$$

$$n = \frac{74,720}{(1 + 74,720\ (0.05)^2)}$$

$$n = \frac{74,720}{(1+186.8)}$$

$$n = 398.0820 = 398$$

Figure 3.2 Finite sample calculation results

3.4 Research Instrument Development and Evaluation

Closed-ended questions were designed to elicit responses from University of Tianjin University of Technology students about their experiences with using cloud computing. Finally, the study's final stage, which included administering a satisfaction test involved the rolling out of a new questionnaire via Google Forms to assess students' level of satisfaction with fill in a form.

The research instruments are therefore defined as follows:

3.4.1 Opinion questionnaire for students and staff.

3.4.2 Opinion questionnaire for the experts concerning the development of model intelligent classroom

3.4.3 Satisfaction questionnaire for undergraduate students who have learned from the intelligent classroom.

3.5 Validity and Reliability of Research Instruments

Validity involves the amount to which the research tests what it is designed to test, according to Cohen et al. (2007, pp.432). To ensure validity, the questionnaire and interview guide were shared with specialists who reviewed them for biases and inaccuracies to ensure that the study is both valid and reliable. In addition, before being used in the main study, both the questionnaires and interview items were piloted for accuracy. Additionally, both the pre-test and post-test were based entirely on the lesson taught in the video clip. Pre-test and post-test questions did not include any questions that were not irrelevant to the subject matter that was discussed.

Pre-test and post-test questions were also submitted to specialists in the field of Public Relations, such as teachers and practitioners, to get their feedback on the questions' validity. On the other hand, reliability refers to the level of trust that can be placed in the outcomes and data, which is frequently determined through statistical calculations and subsequent test redesigning. Given this, both questions were structured with care to avoid making it easy for participants to complete.

3.6 Ethical Procedures

Ethicsis a field of philosophy concerned with making decisions and determining what is right and wrong (Fouka & Mantzorou, 2011). Professional codes and legislation have been developed to prevent scientific abuses of human life during research, according to Fouka and Mantzorou (2011), and the Nuremberg code (1947) which is the main code for all subsequent codes made to protect human rights in research. To avoid severe ethical concerns when doing research, Fouka and Mantzorou argue that researchers must follow

professional rules such as informed consent, the right to withdraw from studies, and protection from bodily and emotional harm.

According to Family Health International, informed consent is a process for ensuring that individuals understand what it means to participate in a specific study so that they can make an informed decision about whether or not they wish to participate. Consent might be given verbally or in writing. For trials with low risk, an oral agreement is usually sufficient. As a result, participants in this study will be informed of the safeguards in place to ensure their identity and confidentiality. When a participant's identity cannot be linked to their comments, anonymity is preserved.

Given this, participants in the current study were informed of their right to withdraw from the study whenever they see fit or feel uncomfortable. Participants were also assured that their privacy will be maintained, which means that no private information about them was to be shared with others without their knowledge or consent.

3.7 Data Analysis Procedures

Descriptive statistics, Chi- squared Test of Association, and Paired Sample T-test (Dependent T-test) were used to analyze the quantitative data collected. The initial survey's quantitative data, as well as the satisfaction comments, was coded, and the IBM® Statistical Package for Social Sciences (IBM SPSS version 22) was used for analysis and interpretation of the results. Statistical summaries, means, and standard deviation was also used to analyze the data from the second and third phases of the study, which entail the administration of the intervention (Video clip lesson on YouTube) and study satisfaction feedback. The population's arithmetic means and standard deviations are displayed with descriptive statistical data in the form of tables and arithmetic mean charts.

The average scores were obtained from the formula below:

$$\overline{X} = \frac{\sum_{i=1}^{N} X_i}{N}$$

With $\overline{X}$ is arithmetic mean

X_i is the value of the data of the population i

i is the order of the population i by i = 1,2,3,…,N

N is the total number of people interested in studying

Standard Deviation

$$S^2 = \frac{\sum_{i=1}^{N}(x_i - \overline{X})}{N-1}$$

with *S.D.* is standard Deviation

$\overline{X}$ is Arithmetic mean

X_i is the value of the data of the population i

i is the order of the population i by i = 1,2,3,…,N

N is the total number of people interested in studying

CHAPTER 4
RESEARCH RESULTS

This chapter reports the descriptive analysis of the responses from the experts and students about development of digital learning space. Fully investigate and analyze the current situation of student management in a secondary vocational school. Satisfaction questionnaire for vocational students who have submit an intelligent classroom. The findings are presented as follows:

4.1 Analysis methods and tools

4.2 Student questionnaire analysis

4.3 Hypothesis verification

4.3.1 hypothesis test results of teacher questionnaire research

4.4 Summarize of this chapter

The adoption subjects in this study are college teachers and students. The theoretical model based on the toe analysis framework is used to divide the factor variables into four dimensions: technical factors, environmental factors, organizational factors and cloud supplier factors. Generally, in the process of the adoption of the cloud platform of educational resources in Colleges and universities, the factor variables of the organizational dimension and the cloud supplier dimension are related to the decision-makers of the cloud platform of educational resources in Colleges and universities, while the students in school lack the cognition of the influencing factors of these two dimensions. In order to ensure the validity of the questionnaire and the accuracy of the survey data, this study designed two types of measurement items for college teachers and online students. The sample data needed for the study were collected by questionnaire.

Because this study is in the epidemic period, all colleges and universities have carried out closed management and strictly restricted the access of personnel outside the school, so this survey can only be conducted online. Before the questionnaire was distributed, the author also simplified, optimized and condensed the questionnaire items in combination with the survey data accumulated in his daily work during the interview and exchange with the directors of information centers and laboratory management teachers of many local universities in the information construction project, so as to ensure

that the surveyed teachers can fill in the questionnaire quickly and accurately without taking up too much time. After the completion of the first draft of the questionnaire, the author also consulted with his college tutor on the questionnaire design. Combined with the suggestions of the tutor, the question method, question length, structural consistency of measurement items and explanation of concept terms were adjusted and increased to form the final questionnaire.

Based on the relevant research results of domestic scholars, this study designs the questionnaire, and designs relevant measurement items from the four dimensions of technology, environment, organization and cloud provider, including 22 teachers' questionnaires and 13 students' questionnaires. This research questionnaire was collected online through the "questionnaire star". A total of 16 valid teacher questionnaires and 105 valid student questionnaires were collected. The following empirical research part was conducted on the 121 questionnaires collected.

4.1 Analysis methods and tools

The data analysis methods and tools used in this study are shown in table 4.1 - 4.9 below:

Table 4.1 Data Analysis Method

Analysis method	function	analysis tool
Descriptive Statistics Analysis	Describe the basic information and behavior of the obtained samples	SPSSAU 20
Reliability Analysis	Test the internal consistency and structural validity to ensure the effectiveness and scientificity of the research	
Validity Analysis		
Pearson correlation analysis	Used to study the uncertain relationship between two or more variables	Validity Analysis
Multiple Regression Analysis	Measure the quantitative relationship of interdependence between two or more variables to verify whether the hypothesis is valid	

4.1.1 teacher questionnaire analysis

In order to more intuitively understand the characteristics and data distribution status of the survey samples, this study first uses descriptive statistics to analyze the sample data, including the basic information of the survey objects: gender and age range. The main objects of the teacher questionnaire for this study include leaders of the information center and secondary colleges and a number of university teachers. In order to ensure the respondents' willingness to participate and protect their privacy, the basic information in the questionnaire does not involve more details. The analysis results are shown in the table below.

4.1.2 basic information of University Teachers

The respondents to this survey are 16 teachers in the field of information technology in Colleges and universities. The author of this article has sent them questionnaires and conducted brief online communication and interviews. Many of the teachers in the information department are customers of the author's unit and have a certain degree of understanding of the cloud computing products provided by the author's unit. Among the respondents, there were 14 males, accounting for 87.50%, and 2 females, accounting for 12.50%. Most of the respondents were between 38 and 57 years old, accounting for 81.25%. The basic information of the respondents is consistent with the role orientation of the survey and research set in this study, including teachers related to the information field of colleges and universities, including the director and deputy director of the information center, the laboratory (experimental center) management teacher, the director and deputy director of the computer / software college, professors or teachers of education information technology related majors, etc. they directly participate in the decision-making activities for the adoption of the cloud platform of educational resources in Colleges and universities, Having some experience in the adoption of cloud computing related products is of key significance to this study.

Table 4.2 Descriptive Statistics of Teachers (Basic Information)

Item	option	frequency	percentage
Gender	Male	14	87.50%
	female	2	12.50%
age range	25-37 years	3	18.75%
	38-57 years	13	81.25%
	58-57 years and above	0	0

The questionnaire measurement table adopts Likert five grade scoring method to measure variables. "1" means totally disagree, "2" means somewhat disagree, "3" means average, "4" means somewhat agree, "5" means fully agree. Through the statistical analysis of the measurement items of university teachers, the average score of the measurement item matrix measured by the 19 measurement items is 4.20, which shows that the respondents' recognition attitude towards the influencing factors adopted by the cloud platform of university education resources is relatively high, with some agreement and full agreement.

Table 4.3 Descriptive Statistical Analysis of Teacher' s Questionnaires (N=16)

Measurement item (code)	minimum value	maximum value	mean value	standard deviation	variance
T1	3	5	4.5	0.632	0.4
T2	3	5	4.25	0.683	0.467
T3	2	5	3.75	0.856	0.733
T4	3	5	4.313	0.602	0.362
T5	4	5	4.625	0.5	0.25
T6	3	5	4.625	0.619	0.383
T7	3	5	4.5	0.632	0.4
T8	2	5	4.063	0.998	0.996
T9	1	5	3.625	1.088	1.183
T10	1	5	3.813	0.834	0.696

Table 4.3 Descriptive Statistical Analysis of Teacher' s Questionnaires (N=16)(Cont.)

Measurement item (code)	minimum value	maximum value	mean value	standard deviation	variance
T11	3	5	4	0.516	0.267
T12	2	4	3.063	0.574	0.329
T13	3	5	4.063	0.772	0.596
T14	3	5	3.875	0.719	0.517
T15	4	5	4.688	0.479	0.229
T16	4	5	4.5	0.516	0.267
T17	4	5	4.688	0.479	0.229
T18	3	5	4.375	0.619	0.383
T19	3	5	4.5	0.632	0.4

4.1.3 reliability and validity test of teacher scale

1) Reliability test

Reliability measurement is often used to test the social science questionnaire. Its principle is to test the consistency of the results by repeatedly measuring the same object with the same measurement method, so as to ensure the scientificity and accuracy of the research. For the questionnaire with good reliability, the answers of the tested objects should be very similar for different measurement items under the same variable, and there will be no great deviation. Referring to the research methods of other scholars, this study uses the cronbach's, a common measurement in the questionnaire reliability measurement α Value) to analyze the reliability of variable measurement items. Cronbach's coefficient α Value) is to estimate the extent to which the measurement indicators in a certain scale can represent the connotation of the measurement variables, [8]cronbach's α If the value is greater than 0.7, it means that the measurement items designed for a certain factor variable have good internal consistency. Specific cronbach's α The reliability evaluation criteria of the value are as follows:

Table 4.4 Reliability Evaluation Criteria of Cronbach's α Test

Cronbach's α Value range	reliability level
Cronbach's α＜=0.3	untrusted
0.3＜Cronbach's α＜=0.4	barely credible
0.4＜Cronbach's α＜=0.5	slightly believable
0.5＜Cronbach's α＜=0.7	trusted
0.7＜Cronbach's α＜=0.9	very credible
Cronbach's α＞0.9	very credible

In this study, the teacher scale has nine factor variables in total, and each factor variable designs 2~3 measurement items, a total of 22 measurement items. Because the total items and the number of items in each factor are small, this reliability test is only conducted for the questionnaire as a whole. The reliability of the student questionnaire was tested by spssau software, and the overall cronbach's α The value is 0.844, greater than 0.7, indicating that the questionnaire design of this study has good reliability, and the overall cronbach's α Values are as follows:

Table 4.5 Overall Cronbach's α Value (Teacher's questionnaires)

Number of measurement items	Sample size	Cronbach α coefficient
22	16	0.844

2) Validity test

Validity is to test the energy efficiency of each item, that is, whether each item has played a role in the scale. Validity can be divided into content validity and structure validity. Content validity refers to the applicability of measurement items to the sampling of the range of measured variables. Structural validity uses factor analysis to judge whether the scale is designed reasonably. [8] Because the sample size of the teacher questionnaire is small, the validity of the teacher questionnaire is measured by content validity. On the one hand, this research combines the results of previous studies and draws lessons from the mature and stable measurement project template in the

existing literature. On the other hand, in the early stage of the study, I conducted a structural interview with six information center directors and teachers from three universities in Guangdong, trying to understand their specific concerns about the variables related to the adoption of educational resources cloud platform.

In terms of compatibility, five teachers paid more attention to whether the privately deployed educational resource platform was compatible with the virtualization layer of local server clusters, and four teachers paid more attention to whether the cloud platform matched their own information management methods.

In terms of ease of use, the six teachers are very concerned about the ease of using the cloud platform. Mastering the time cost of using the education resource cloud platform and the ease of managing and maintaining the education resource cloud platform are the indicators that all teachers focus on. Some teachers give examples to illustrate that in laboratory management, some departments and colleges have deployed VMware horizon virtual desktop system before. Due to the complexity of operation, configuration and management, it is basically idle at present. It shows that ease of use has a great impact on College Teachers' cloud platform adoption decisions.

In terms of comparative advantages, the directors of the information centers of the three universities said that they valued the advantage that cloud computing architecture is conducive to the sharing of public resources anytime, anywhere. The three universities have built online course resource cloud platforms with school characteristics, which have played an important role especially during the epidemic period.

In terms of high-level support and resource readiness, teachers said that these two aspects have a certain impact on the adoption of cloud platform, but the impact is not high.

In terms of policy pressure and trend, as the policy is directly related to the support of the financial budget, all teachers said that it has a certain impact. In addition, the respondents stated that the informatization construction of colleges and universities will not follow the trend, but match their own needs.

Finally, in terms of cloud supplier dimension factor variables, teachers all pointed out that the solution capability, after-sales service level and successful cases of manufacturers will directly affect their adoption of cloud platforms.

As the most direct decision-makers and users of the cloud platform for educational resources, the directors and teachers of the University Information Center will have a direct impact on the adoption results of the cloud platform. Therefore, their questionnaire sample data is of great significance to the adoption research and has a strong persuasive support for the adoption research results.

4.1.4 descriptive analysis of Teacher Questionnaire

The subjects of the teacher questionnaire are all the direct decision-makers related to the adoption of university information systems, so the adoption intention reflected in the data of the teacher questionnaire sample is highly persuasive. However, since the teacher questionnaire in this study can not be collected on a large scale and as widely as the student questionnaire, the teacher data samples collected in this study are collected on the micro end by contacting the relevant teachers individually through the questionnaire star. A total of 16 teacher samples are collected in this study. The teachers are from the information centers, experimental centers, and The College of educational information technology and related departments of computer science, including 16 teachers from Guangdong University of technology, South China University of technology, Jinan University, South China Normal University, Shenzhen University, South China Agricultural University, etc.

Due to the limitation of the number of samples, there is a large error in the statistical analysis of data through correlation analysis and regression analysis. This study will use descriptive statistical analysis to analyze the data. The description and statistics of specific teacher samples are as follows:

Table 4.6 Sample Statistics of Teacher Questionnaires

Dimension	variable	option code	totally disagree	some disagree	general	some agree	totally agree	matrix mean
Technical factors	Compatibility	T1	0(0%)	0(0%)	1(6.25%)	6(37.5%)	9(56.25%)	4.17
		T2	0(0%)	0(0%)	2(12.5%)	8(50%)	6(37.5%)	
	Ease of use	T3	0(0%)	1(6.25%)	5(31.25%)	7(43.75%)	3(18.75%)	4.47
		T4	0(0%)	0(0%)	1(6.25%)	9(56.25%)	6(37.5%)	
		T5	0(0%)	0(0%)	0(0%)	6(37.5%)	10(62.5%)	
	Comparative advantage	T6	0(0%)	0(0%)	1(6.25%)	4(25%)	11(68.75%)	4.56
		T7	0(0%)	0(0%)	1(6.25%)	6(37.5%)	9(56.25%)	
Organizational factors	High level support	T8	0(0%)	1(6.25%)	4(25%)	4(25%)	7(43.75%)	3.84
		T9	1(6.25%)	0(0%)	7(43.75%)	4(25%)	4(25%)	
	Resource readiness	T10	1(6.25%)	0(0%)	1(6.25%)	13(81.25%)	1(6.25%)	3.9
		T11	0(0%)	0(0%)	2(12.5%)	12(75%)	2(12.5%)	
Environmental factor	Tide trend	T12	0(0%)	2(12.5%)	11(68.75%)	3(18.75%)	0(0%)	3.56
		T13	0(0%)	0(0%)	4(25%)	7(43.75%)	5(31.25%)	
	Policy impact	T14	0(0%)	0(0%)	5(31.25%)	8(50%)	3(18.75%)	4.29
		T15	0(0%)	0(0%)	0(0%)	5(31.25%)	11(68.75%)	

Table 4.6 Sample Statistics of Teacher Questionnaires (Cont.)

Dimension	variable	option code	totally disagree	some disagree	general	some agree	totally agree	matrix mean
Cloud supplier factor	Cloud provider service quality	T16	0(0%)	0(0%)	0(0%)	8(50%)	8(50%)	4.6
		T17	0(0%)	0(0%)	0(0%)	5(31.25%)	11(68.75%)	
	Cloud provider success stories	T18	0(0%)	0(0%)	1(6.25%)	8(50%)	7(43.75%)	4.44
		T19	0(0%)	0(0%)	1(6.25%)	6(37.5%)	9(56.25%)	
	Willingness to adopt	T20	0(0%)	0(0%)	2(12.5%)	8(50%)	6(37.5%)	4.25
		T21	0(0%)	0(0%)	3(18.75%)	10(62.5%)	3(18.75%)	
		T22	0(0%)	0(0%)	0(0%)	8(50%)	8(50%)	
		小计	2(0.57%)	4(1.14%)	52(14.77%)	155(44.03%)	139(39.49%)	

The Likert five level scale is divided into five levels from completely disagree to completely agree in the form of scoring, and each level corresponds to 1-5 points. Therefore, the Likert questionnaire can describe the overall trend of each variable in the way of descriptive statistics. For this study, the influence of each independent variable on the dependent variable "adoption intention" can be judged by calculating the matrix mean of each variable.

Conclusion criteria:

In this study, we mainly investigate the influencing factors of teachers' adoption of the cloud platform of educational resources in Colleges and universities. In the statistical table of teachers' questionnaire in this study, if the matrix mean value of each variable is greater than 4 points, it is considered that this variable has a significant impact on Teachers' adoption of the cloud platform of educational resources; More than 3 points and less than or equal to 4 points are considered to have a certain impact, but the impact is not significant; If the score is less than or equal to 3, it is considered that there is no influence relationship between them. The specific analysis is as follows:

According to the above table, the matrix mean values corresponding to the nine factor variables of compatibility, ease of use, comparative advantage, high-level support, resource readiness, trend, policy impact, cloud supplier service quality and cloud supplier success cases in the questionnaire statistics are as follows:

Table 4.7 Mean Value of Sample Matrix of Teacher Questionnaire

Variable	matrix mean
Compatibility	4.17
Ease of use	4.47
Comparative advantage	4.56
High level support	3.84
Resource readiness	3.9
Tide trend	3.56
Policy impact	4.29
Cloud provider service quality	4.6
Cloud provider success stories	4.44

The matrix mean values of compatibility, ease of use, comparative advantage, policy impact, cloud provider service quality and cloud provider success stories all exceed 4 points (some agree), which means that these six factor variables will significantly affect college teachers' adoption of educational resources cloud platform. The average value of the three factor variables matrix of high-level support, resource readiness and trend pressure is between 3 and 4 (excluding 3 points), which means that these three factor variables have a certain degree of impact on College Teachers' adoption of educational resource cloud platform, but the overall impact is not significant.

1) Result analysis of compatibility, ease of use and comparative advantage

The overall analysis data is also consistent with our exchanges and interviews with teachers. In the interviews or exchanges with six information center directors and teachers from different universities, and in the interviews with the influencing factors of the three technical dimensions of compatibility, ease of use and comparative advantage, all teachers showed great concern. These three variables come from the attributes of the cloud platform. Is the teacher useful for the products to be adopted, Whether it is good or not will directly determine whether teachers will adopt it as an educational tool, which is consistent with the overall trend of the matrix mean value in the sample data.

2) High level support and resource readiness result analysis

In terms of high-level support and resource readiness of the organizational dimension, the interview results are consistent with the overall trend of the matrix mean in the sample data: there is a certain impact, but it is not significant. This may be related to the administrative organization relationship of the University. The information center of the University and the secondary colleges are relatively independent in the administrative organization relationship, and each has its own independent right to use funds. In this study, the subjects of the questionnaire are mainly the directors of the information center and the secondary colleges. They themselves are one of the main decision makers of the administrative agencies at the same level, so the support of the senior management of the university is not their key consideration. In addition, in terms of resource readiness, colleges and universities are public institutions with fixed staffing. Some large university information centers also outsource operation

and maintenance services, and teachers are only responsible for managing outsourcing companies. In addition, many cloud platforms adopt public cloud deployment, which may not bring a great burden on Teachers' management tasks. Therefore, the influence of high-level support and resource readiness on College Teachers' adoption is not very significant.

3) Analysis of trend and policy impact results

In terms of the trend of the environmental dimension, the interview results are consistent with the overall trend of the matrix mean in the sample data. Many colleges and universities say that they generally do not follow the trend and adopt a certain information system. The adoption of information systems in Colleges and universities should go through strict demonstration procedures. Instead, they prefer to adopt mature and stable information system solutions. In the variable of policy pressure, there is a measurement item entitled: "whether relevant departments have corresponding budget support is my consideration in using the education resource cloud platform". Policy support is directly related to the direction and allocation of financial funds in Colleges and universities. Therefore, generally, the information construction supported by policies, the support of financial funds are relatively good, and the project application and approval rate is also high, The support of financial funds is directly related to the adoption of the platform, which is a factor that teachers pay close attention to. This is consistent with the overall trend of the matrix mean in the sample data.

4) Analysis of cloud supplier service quality and successful cases

The author of this article, XY company, as a provider of the cloud platform for educational resources in Colleges and universities, has found in the long-term cooperation, communication and interviews with college teachers that the information management department of colleges and universities, as the information construction party and leading Party of many colleges and universities, attaches great importance to the service level and quality of cloud suppliers, because the service level and quality of cloud suppliers are directly related to the success or failure of the project, which is the place that college teachers focus on. Suppliers with good after-sales service, high level of scheme design and many successful cases in the industry will often get more favor, which is consistent with the overall trend of the matrix mean value in the sample data: a significant positive correlation.

4.2 Student questionnaire analysis

4.2.1 basic information of students in school

There are 105 samples of students in this study, including 46 boys, accounting for 43.81%, and 59 girls, accounting for 56.19%. Among the respondents, 94 were aged 18-22, accounting for 89.52%, 11 were aged 23-28, accounting for 10.48%, and none were aged 29-35 or above. Judging from the age distribution, the vast majority of respondents are undergraduate students.

Table 4.8 Descriptive Statistics of Students (Basic Information)

Item	option	frequency	percentage
Gender	Male	46	43.81%
	female	59	56.19%
age range	18-22 years	94	89.52%
	23-28 years	11	10.48%
	29-35 years and above	0	0

Through the statistical analysis of the students' measurement items, the average value of the 11 measurement items (i.e. the average score of the measurement item matrix) is 3.01, which shows that the respondents' recognition attitude towards the influencing factors adopted by the cloud platform of higher education resources is in general and some agree with it.

Table 4.9 Descriptive Statistical Analysis of Student' s Questionnaires (N=105)

Measurement item (code)	minimum value	maximum value	mean value	standard deviation	variance
S1	1	5	3.448	0.888	0.788
S2	1	5	3.41	0.874	0.763
S3	1	5	3.533	0.899	0.809
S4	1	5	2.486	0.822	0.675
S5	1	5	2.286	0.948	0.898
S6	1	5	2.524	0.962	0.925
S7	1	5	2.867	0.951	0.905
S8	1	5	3.067	0.912	0.832
S9	1	5	2.733	1.059	1.121
S10	1	5	3.305	1.186	1.406
S11	1	5	3.448	1.16	1.346

4.2.2 reliability and validity test of student scale

1) Reliability test

In this study, there are four factor variables in the student scale. Each factor variable designs 2~3 measurement items, a total of 13 measurement items. Because there are not many total items, this reliability test is only conducted for the questionnaire as a whole. The reliability of the student questionnaire was tested by spssau software, and the overall cronbach's α The value is 0.814, greater than 0.7, indicating that the questionnaire design of this study has good reliability. The overall cronbach's α Values are as follows:

Table 4.10 Overall Cronbach's α Value (Student's Questionnaires)

Number of measurement items	Sample size	Cronbach α coefficient
13	105	0.814

2) Validity test

Structural validity analysis is used to test the degree of the content to be investigated reflected by the measured values of the scale. The more consistent the measured results with the content to be investigated, the higher the validity; Otherwise, the validity is lower. Structural validity analysis is generally verified by factor analysis. Before factor analysis, kmo value test and Bartlett spherical test should be performed on the data to judge whether the data is suitable for factor analysis. The kmo statistic value is between 0 and 1, and the effect is better when the kmo statistic value is above 0.7; When kmo is less than 0.5, factor analysis is not suitable. In Bartlett's spherical test, if the p value is less than 0.05, the data show a spherical distribution. When the conditions of kmo statistics and Bartlett's spherical test are satisfied at the same time, factor analysis is suitable for the data. In this study, kmo statistics and Bartlett ball test were performed on 105 student questionnaire samples. The data are as follows:

Table 4.11 KMO and Bartlett Reliability Test of Student Questionnaires

Kmo value		0.721
Bartlett sphericity test	Approximate chi square	478.839
	DF	55
	P value	0.0000

Through kmo and Bartlett's test, the kmo value of the student questionnaire is 0.721, greater than 0.7, and the p value is 0, less than 0.05, indicating that the questionnaire sample is suitable for factor analysis.

In this study, the validity of student questionnaire samples was analyzed by spssau software. The specific data are as follows:

Table 4.12 Validity Test of Student Questionnaires

Measurement item (code)	Factor load factor				Commonality (common factor variance)
	Factor 1	Factor 2	Factor 3	Factor 4	
S1	0.805	0.101	0.186	-0.092	0.701
S2	0.879	0.248	0.098	-0.035	0.845
S3	0.866	0.243	0.154	0.026	0.833
S4	0.21	0.038	0.787	-0.04	0.666
S5	0.035	0.355	0.782	-0.184	0.772
S6	0.134	-0.029	0.74	0.062	0.57
S7	0.156	0.855	0.119	0.019	0.77
S8	0.424	0.752	0.12	0.063	0.764
S9	0.127	0.827	0.028	-0.005	0.701
S10	-0.013	0.03	-0.013	0.912	0.833
S11	-0.062	0.014	-0.068	0.9	0.819
Characteristic root value (before rotation)	3.889	1.784	1.366	1.236	-
Variance interpretation rate% (before rotation)	35.356%	16.216%	12.417%	11.233%	-
Cumulative variance interpretation rate% (before rotation)	35.356%	51.572%	63.989%	75,222%	-

Table 4.12 Validity Test of Student Questionnaires (Cont.)

Measurement item (code)	Factor load factor				Commonality (common factor variance)
	Factor 1	Factor 2	Factor 3	Factor 4	
Characteristic root value (after rotation)	2.457	2.242	1.88	1.696	-
Variance interpretation rate% (after rotation)	22.336%	20.379%	17.088%	15.419%	-
Cumulative variance interpretation rate% (after rotation)	22.336%	42.715%	59.803%	75.222%	-
Kmo value	0.721				-
Bart spherical value	478.839				-
DF	55				-
P value	0.0000				-

Note: if the numbers in the table have color: Blue indicates that the absolute value of load factor is greater than 0.4, and red indicates that the commonality (common factor variance) is less than 0.4.

It can be seen from the above table that the characteristics of each of the four groups of variables are quite obvious, which are formed into four factors, and the variance interpretation rate values of the four factors are 22.336%, 20.379%, 17.088%

and 15.419% respectively. The cumulative variance interpretation rate after rotation is 75.222%>50%, which means that the amount of information of the research items can be effectively extracted, the validity of each variable is good, and each item plays an important role in the scale.

4.2.3 correlation analysis of student questionnaires

Correlation analysis refers to the study of the correlation between two or more variables, including whether there is correlation, the direction of correlation (positive, negative, no correlation) and the degree of correlation. In the research of questionnaire scale, the data of Likert scale are generally regarded as continuous numerical variables. Usually, Pearson correlation analysis is used to study the correlation between the items of each scale. Before the correlation analysis, the scores of all measurement items in each factor variable in the Likert scale need to be averaged to generate a group of mean data of each factor variable, and then the correlation analysis and statistics with the mean data of the target variable are carried out.

Table 4.13 Correlation Analysis of Student Questionnaires

		Willingness to adopt	relevance
Tide pressure	Correlation coefficient	-0.047	No correlation
	P value	0.637	
comparative advantage	Correlation coefficient	0.494**	Positive correlation
	P value	0	
ease of use	Correlation coefficient	0.319**	Positive correlation
	P value	0.001	
compatibility	Correlation coefficient	0.959**	Positive correlation
	P value	0	

* p<0.05 ** p<0.01

According to the Pearson correlation coefficient results in the above table, the willingness to adopt is related to the tide pressure, comparative advantage, ease of use and compatibility. The specific analysis is as follows:

The correlation coefficient between willingness to adopt and tide pressure is -0.047, close to 0, and the p value is 0.637>0.05, which indicates that there is no correlation between willingness to adopt and tide pressure.

Secondly, the correlation coefficients between willingness to adopt and comparative advantage, ease of use and compatibility are 0.494, 0.319 and 0.959 respectively, and both show a significant level of 0.01 (* * p<0.01), which indicates that there is a significant positive correlation between willingness to adopt and comparative advantage, ease of use and compatibility

Therefore, the correlation analysis conclusion between each influencing factor and adoption intention is as follows:

1) There is no correlation between tide pressure and adoption intention;

2) Compatibility, ease of use, comparative advantage and adoption intention are significantly positively correlated.

4.2.4 regression analysis of student questionnaire

1) Regression analysis

Regression analysis refers to a statistical analysis method to determine the causal relationship between two or more variables. Regression analysis is usually used to deal with the validation of assumptions made by models that contain only one dependent variable. The dependent variable of this study is "adoption intention", and the model structure is relatively simple, so the regression analysis method is selected for hypothesis verification. [8] Regression analysis can be divided into linear regression, logistic regression and Poisson regression. Their corresponding dependent variables are: continuous variables, classified variables and counting variables. In this study, the data samples measured by litck scale are usually used as continuous variables, and linear regression is used to analyze their causal relationship.

The previous correlation analysis has verified that there is no correlation between tidal current pressure and adoption intention, so the regression analysis of this study only focuses on the three independent variables of compatibility, ease of use and

comparative advantage and the dependent variable "adoption intention". Regression analysis can be divided into: multiple linear regression and univariate linear regression. Regression analysis involving multiple independent variables is called multiple linear regression. The questionnaire of middle school students in this study is designed with three independent variables: compatibility, ease of use and comparative advantage. Therefore, this study uses spssau software to conduct multiple linear regression Analysis on student samples. The results are as follows:

Table 4.14 Regression Analysis of Student Questionnaires (n=105)

	Denormalization coefficient		Standardization coefficient	t	p	VIF	R^2	Adjust R^2	F
	B	Standard error	Beta						
constant	-0.104	0.12	-	-0.864	0.389	-			F
Comparative advantage	0.049	0.033	0.048	1.503	0.136	1.327	0.921	0.919	(3,101)= 392.954,
Ease of use	-0.025	0.035	-0.022	-0.72	0.473	1.162			P=0.000
compatibility	1.009	0.035	0.943	28.694	0.000**	1.382			

Dependent variable: willingness to adopt

D-V value:1.839

*p<0.05 ** p<0.01

Table 4.15 Regression Coefficient of Student Questionnaires (n=105)

Regression coefficient (n=105)

	on coefficient		Standardization coefficient	t	p	95%CI	VIF
	b	Standard error	Beta				
constant	-0.104	0.12	-	-0.864	0.389	-0.338~0.131	-
Comparative advantage	0.049	0.033	0.048	1.503	0.136	-0.015~0.113	1.327
Ease of use	-.0.025	0.035	-0.022	-0.72	0.473	-0.094~0.044	1.162
compatibility	1.009	0.035	0.043	28.694	0.000**	0.940~1.078	1.382

Dependent variable: willingness to adopt

*p<0.05 ** p<0.01

Table 4.16 ANOVA Table

ANOVA Table

	Sum of squares	df	Mean square	F	P value
regression	68.081	3	22.694	392.954	0
Residual error	5.833	101	9.058		
total	73.914	104			

From table 4.15 student questionnaire regression analysis results (n=105), it can be seen that the adjusted R-square value is 0.919. From table 4.16 ANOVA, it can be seen that the significance level P value of the regression is less than 0.05, indicating that the regression model is effective, which means that the compatibility, ease of use and comparative advantage of the independent variables participating in this study are the influencing factors affecting the adoption intention of the dependent variables, and the explained contribution rate reaches 91.9%.

In addition, from the regression coefficient table of student questionnaire (n=105) in table 4.15, among the three independent variables compatibility, ease of use and comparative advantage, only compatibility is less than 0.05, and the corresponding significance p value of ease of use and comparative advantage is greater than 0.05, indicating that ease of use and comparative advantage are not factor variables that significantly affect adoption intention.

The regression coefficient value of comparative advantage is 0.049 (t=1.503, p=0.136>0.05), which means that comparative advantage will not affect the adoption intention. The regression coefficient of ease of use is -0.025 (t=-0.720, p=0.473>0.05), which means that ease of use will not have an impact on adoption intention. The regression coefficient of compatibility is 1.009 (t=28.694, p=0.000<0.01), which means that compatibility will have a significant positive impact on adoption intention.

Through the above analysis, we can get the verification results of the theoretical model of this study. Compatibility will have a significant positive impact on adoption intention. However, comparative advantage and ease of use will not affect the adoption intention.

Through the above research and analysis, it is finally concluded that the model of influencing factors on the adoption of students' questionnaires is shown in the following figure:

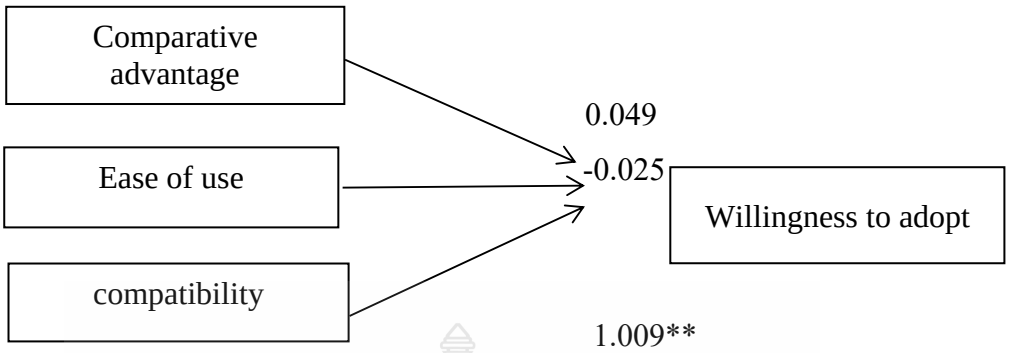

Figure 4.1 Adoption influencing factor model of Student Questionnaire

2) Model diagnosis

(1) Multicollinearity

Multicollinearity means that the independent variables in the linear regression model have a high degree of correlation, which affects the reliability and accuracy of the model. Usually, the variance inflation factor (VIF) is used to test whether there is a high correlation between explanatory variables. Generally, if Vif＜5, it indicates that there is no obvious correlation between explanatory variables. If Vif＞10, there is a serious correlation within the independent variables in the regression model.

Conclusion:

According to table 4.15 regression coefficient table of student questionnnaire (n=105), if the Vif mean of each independent variable is less than 5, it indicates that there is no multicollinearity between independent variables. Therefore, the results of multiple regression analysis are reliable.

(2) Residual diagnosis

Residual refers to the difference between the observed value of the dependent variable and the fitting value of the estimated regression equation. In the regression analysis, the normal distribution of residuals is tested for judgment. The residuals can be used as the grade correlation coefficient between the standardized residuals and the independent variables to judge whether the regression model has the phenomenon of residuals. The larger the value of the grade correlation coefficient, the existence of non-homogeneous variance. [8] It is also possible to check the dependent variable test residuals through the normal P-P diagram. In the normal P-P diagram, if the scatter points of residuals fall near the diagonal, it indicates that the residuals obey the

normal distribution. The normal P-P diagram of the dependent variables in the questionnaire of the project is as follows:

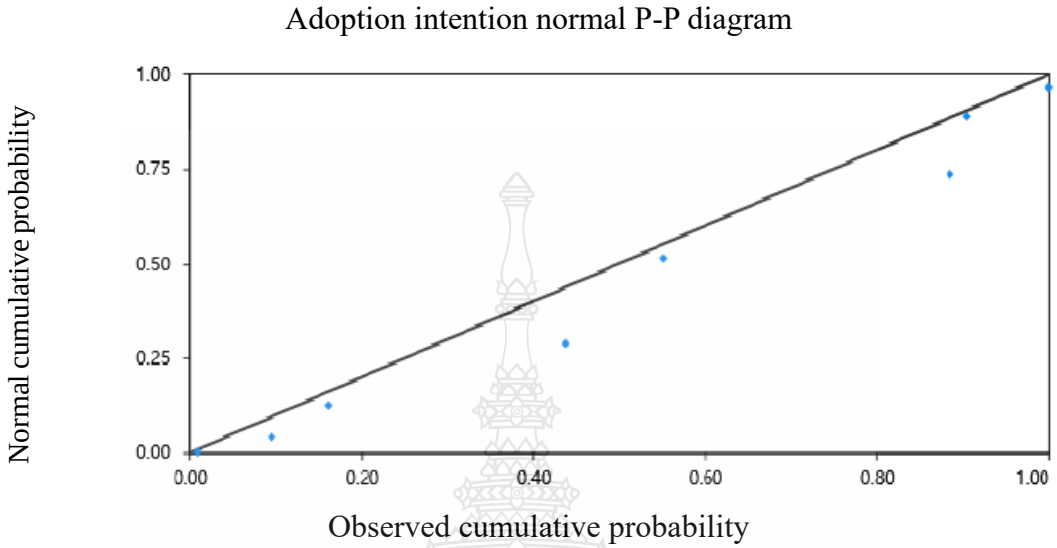

Figure 4.2 Normal P-P chart of the dependent variable of student questionnaires

As shown in Figure 4.18 normal P-P diagram of dependent variables in the student questionnaire, the scattered points of the residuals fall near the diagonal, indicating that the residuals of the regression model in this study obey the normal distribution and pass the residuals test.

(3) Sequence correlation

Sequence correlation can also be called autocorrelation, which often exists in time series. There is a correlation between every two adjacent values in a group of random variables, and the value of the latter variable has a correlation with the cardinal value of the previous variable. Generally, it is tested by DW value of regression model. Because the data in this study are not time series data, DW value test is not required.

Conclusion:

Through the above analysis, it can be proved that the construction of the model meets the preconditions, and the construction of the model is true and reliable.

4.3 Hypothesis verification

4.3.1 hypothesis test results of teacher questionnaire research

Through the descriptive analysis of the teacher questionnaire, combined with my interviews with 16 college teachers, the following hypothesis verification results can be obtained:

Table 4.17 Research Conclusion of Teacher Questionnaires

Research hypothesis	teacher questionnaire conclusion
H1A: compatibility has a significant positive impact on the adoption intention of university education resource cloud platform	assumption is established
H1B: ease of use has a significant positive impact on the adoption intention of university education resource cloud platform	assumption is established
H1C: comparative advantage has a significant positive impact on the willingness to adopt the cloud platform of educational resources in Colleges and Universities	assumption is established
H2A: the trend pressure has a significant positive impact on the adoption of the cloud platform of educational resources in Colleges and Universities	the assumption is not tenable
H2B: policy impact has a significant positive impact on the adoption of university education resource cloud platform	assumption is established
H3A: the support of senior leaders has a significant positive impact on the adoption of university education resource cloud platform	the assumption is not tenable
H3B: resource readiness has a significant positive impact on the adoption of university education resource cloud platform	the assumption is not tenable

Table 4.17 Research Conclusion of Teacher Questionnaires (Cont.)

Research hypothesis	teacher questionnaire conclusion
H4A: the service quality of cloud providers has a significant positive impact on the adoption intention of university education resource cloud platform	assumption is established
H4B: successful cases of cloud providers have a significant positive impact on the willingness to adopt the cloud platform of educational resources in Colleges and Universities	assumption is established

4.3.2 hypothesis test results of student questionnaire research

Through the correlation analysis and regression analysis of the student questionnaire research, the following research hypothesis verification results can be obtained:

Table 4.18 Research Conclusion of Student Questionnaires

Research hypothesis	student questionnaire conclusion
H1A: compatibility has a significant positive impact on the adoption intention of university education resource cloud platform	Hypothesis established
H1B: ease of use has a significant positive impact on the adoption intention of university education resource cloud platform	Assumption does not hold
H1C: comparative advantage has a significant positive impact on the willingness to adopt the cloud platform of educational resources in Colleges and Universities	Assumption does not hold
H2A: the trend pressure has a significant positive impact on the adopt ion of the cloud platform of educational resources in Colleges and Universities	Assumption does not hold

4.4 Summary of this chapter

This chapter has carried on the questionnaire design and the survey implementation. Before the design of the questionnaire, the necessity of designing the questionnaire by role in the study is discussed. In this study, two different sets of questionnaires were designed for college teachers and students to measure the research objects. Combined with the interview results of our work and college teachers' attitude towards cloud platform adoption, we hope to obtain more accurate adoption intention. In addition, we distributed the scale, and collected 16 valid questionnaires for college teachers and 105 valid questionnaires for college students. Provide effective data samples for the next data analysis.

Then we made descriptive statistics on the basic information of the collected teacher samples and student samples. The reliability and validity of the teachers' and students' questionnaires are tested. Because the number of teachers' questionnaires is small, the validity analysis adopts the content validity analysis method, and combines the interview data in the previous work. The questionnaire data analysis of teachers adopts the matrix mean analysis of the scale to verify the hypothesis of significant influencing factors of teachers' adoption of the cloud platform of higher education resources. The analysis of student questionnaire data adopts correlation analysis and regression analysis to analyze the influencing factors of students' adoption of university education resource cloud platform. Through the empirical research in this chapter, the factors that significantly affect the adoption of educational resources cloud platform by college teachers and students are finally obtained, and the model has certain explanatory power.

CHAPTER 5
CONCLUSIONS AND RECOMMENDATIONS

In the study of the application of cloud computing integration GPU technology in the education industry. there are three major objectives 1) To explore the problems and demands of an intelligent classroom at college and universities. 2) To summarize the concept and model structure of an intelligent classrooms publish through digital media. and 3) Explore university students' satisfaction with creative intelligent classroom styles. The first phase of the research took the model of an intelligent classroom study which was to test the effectiveness of learning from the usage of intelligent classrooms with cloud computing provides to service data storage at college and universities to the satisfaction questionnaire made up of 28 questions. And create Participants' satisfaction questionnaire was then analyzed for results. The survey by the questionnaire will collect data from population with cloud computing provides to service data storage at college and universities. The second phase of the research will summarize conceptual framework and create a model of intelligent classroom appropriate for students in universities. Also publishing a model via website by suggestion and evaluation from experts. Finally, bring the model to try out experiment with an example group. Collect data mean average and standard deviation. And satisfaction from the target. The conclusion, discussion and suggestion of the research are as follows:

5.1 Summary of college teachers' adoption of educational resource cloud platform

5.2 Suggestions on products and solutions for teachers' and students' concerns

5.3 Recommendation

5.4 Suggestion

5.1 Summary of college teachers' adoption of educational resource cloud platform

According to the hypothesis test results of teachers' questionnaire research, six factors, namely, compatibility, ease of use, comparative advantage, policy impact, service quality of cloud providers and successful cases of cloud providers, will significantly affect whether teachers adopt the cloud platform of educational resources.

Trend pressure, support from senior leaders and resource readiness will not significantly affect whether teachers adopt the education resource cloud platform. Combined with the interview with university teachers, the rationality of the hypothesis test results can be explained. For university teachers or information department managers, they are usually demand-oriented. Whether the technology is adopted or not is the most important consideration factor is whether it matches the teachers' educational, teaching and scientific research needs. For the attributes of the technology itself: compatibility, ease of use and comparative advantage are directly related to the teachers' educational, teaching and scientific research needs. Therefore, when adopting the information system, these three influencing factors are the core concerns of university teachers. In Colleges and universities, the impact of policies will be directly related to the support of financial funds related to information construction. Therefore, for college teachers, whether the policies support the construction of educational resources cloud platform is also a factor to be considered.

Finally, in the whole process of information construction and project operation and maintenance, suppliers not only provide products, but also provide a series of services for school users, including scheme writing during the project application period, scheme design during the scheme demonstration period, technical support in the bidding process and after-sales service during the project operation and maintenance period. Their service quality will directly affect users' evaluation of suppliers and the adoption decision of their products. The investigation of suppliers' successful cases is the most direct and effective inspection method for their products, which can reduce the probability of failure of information construction projects. It is also an important aspect for university users to investigate suppliers. To sum up, the content of the teacher interview and the research hypothesis test results support each other. For XY company, in order to better obtain the recognition of college teachers, its product improvement and promotion strategies can start from the above points.

5.1.1 summary of students' adoption of education resource cloud platform

According to the hypothesis test results of student questionnaire research, it can be concluded that among the four influencing factors of compatibility, ease of use, comparative advantage and trend pressure, only compatibility significantly

affects students' adoption of the cloud platform of higher education resources. It is not difficult to find that the considerations adopted by college students are relatively simple and clear, and demand-oriented. If you need to use the cloud platform of educational resources for learning, you will adopt it, even if it is not easy to use. As a graduate student, it is understandable to start from my own experience. On the one hand, many software needed for learning and scientific research are not necessarily simple and convenient to operate, but they will still choose when necessary. On the other hand, due to the strong learning ability of students, the general problems and difficulties in software operation can be overcome. In addition, the object of this study is the resource cloud platform that must be used by college students in their study and built by the University, such as curriculum resource center, experimental training cloud, computing center, etc. it is not the software that students can independently choose to use or the alternative system platform, so the relative advantage and trend pressure are not the main factors that college students consider in this study. Even so, from the perspective of user satisfaction and continuous use, XY company should improve and perfect the product itself.

5.2 Suggestions on products and solutions for teachers' and students' concerns

The starting point of this study is to help XY company, a cloud provider, accurately grasp the needs and concerns of College users and obtain better market recognition by improving its own products and services. Through the above research and analysis, it is not difficult to see that cloud providers, including XY company, the author's own enterprise, should improve and upgrade their own cloud computing platform products from the following aspects:

5.2.1 strengthen the compatibility awareness of software products

According to the conclusion of this study, the product compatibility has a significant impact on the adoption of educational resource cloud platform by college teachers and students. Software compatibility not only refers to the compatibility of software products with customers' existing information systems and infrastructure, but also with customers' business processes and value needs. Both of them have an important impact on the success of the adoption of new information systems. The desktop

virtualization technology in XY's experimental training cloud platform is based on Citrix's Xen desktop solution. One of its characteristics is that it has good compatibility with the mainstream server virtualization technology in the infrastructure layer. Whether it is Citrix's own Xen server or VMware's vSphere virtualization platform, the most widely used server virtualization platform in University data centers is VMware's vSphere, For this compatibility advantage, XY company should strengthen users' perception of the compatibility of the underlying server virtualization platform in the pre-sales platform publicity strategy, provide users with trial accounts and platform compatibility testing services for different underlying technology solutions, so that users can truly experience their compatibility advantages, and build a new experimental training cloud platform on the underlying architecture of the original infrastructure, Ensure the consistency of users' IT infrastructure architecture and make better use of IT infrastructure resources. At the access end of the platform, flexible access methods can also be used to strengthen the accessibility awareness of the platform and reduce the use threshold of teachers and students. For example, currently only student ID and password login can be supported, and multiple login methods such as wechat scanning login and mobile phone number SMS verification are added to improve the user's login experience and enhance the user's value perception.

5.2.2 continuously improve product usability

According to the research conclusion, the ease of use of products will significantly affect the willingness of college teachers to adopt, especially in the field of virtual desktop products based on cloud computing technology, there are many products of the same type on the market. In the interview, some teachers said: after the adoption of some brand virtual desktop systems, due to the complexity of system operation and management, the operation and maintenance work is heavy and idle. The underlying technology of XY company's experimental training cloud products adopts the Xen desktop virtual desktop platform, and has made in-depth customization for the experimental teaching scenarios of computer related professional courses in Colleges and universities. It has developed the necessary functional modules in the teaching process, such as screen broadcast, assignment distribution and recycling. The platform workflow matches the experimental teaching business process. In general, compared

with Citrix Xen desktop The ease of use of native virtual desktop applications such as VMware horizon has been greatly improved. However, in the interview with the university computer laboratory management teachers, the teachers also put forward higher requirements in terms of ease of use, including the speed of batch generation of virtual desktops, the docking of virtual desktop creation strategies with curriculum schedules, the automatic switching of virtual desktop templates according to curriculum scheduling, and the creation of desktop environment. According to customer feedback, college users' core demand for the experimental training cloud platform is to simplify the operation and maintenance management through the information platform.

To provide a business platform matching the experimental teaching process. XY company's experimental training cloud products have already made initial accumulation in terms of ease of use. In the next step, we should further polish the functions of the products according to the college experimental teaching business process and the core concerns of teachers and students, deeply explore the pain and itch points in the college experimental teaching process, and extract the key, core and universal value needs from the needs of many users. From the perspective of product ease of use, we should not only improve the product functions, To add products, we should constantly optimize business processes, subtract products, and make the experimental training cloud platform more convenient to serve college experimental teaching.

5.2.3 enhance the perception of product comparative advantage

It can be found from the teacher questionnaire data that the matrix mean value of comparative advantage is 4.56, which is only second to the matrix mean value of cloud provider service quality. It means that college teachers generally value the comparative advantages of the cloud platform of college education resources based on cloud computing. Among them, 68.75% strongly agreed that the educational resource cloud platform has the advantage of resource sharing, and 56.25% strongly agreed that the educational resource cloud platform has the advantage of accessing resources anytime and anywhere, indicating that resource sharing and anytime and anywhere access are the core influencing factors for college teachers to adopt the educational resource cloud platform. Through the above research data, it is not difficult to find that

XY company should focus on publicizing users for the sharing and access advantages in the marketing strategy of its experimental training cloud products, including deploying the demonstration platform in the enterprise and providing the mobile login demonstration of the demonstration platform during customer visits, so that customers can more intuitively understand the access performance of the experimental training cloud products and their adaptability to complex network environments, Increase awareness of product advantages. On the product side, it can provide SaaS services for experimental training cloud, avoid the complicated work of user localization deployment and maintenance of cloud platform, strengthen users' value perception of cloud platform operation services, and guide users to communicate. The purchase of services replaces hardware procurement, so as to achieve a greater degree of resource sharing ability, and help XY company experiment and training cloud products to give full play to the advantages of cloud computing technology.

5.2.4 strengthen policy interpretation and link user needs with policies

In the process of informatization construction in Colleges and universities, the government policy environment will directly affect the decision-making of colleges and universities on the adoption of education resource cloud platform, because the government policy determines the project approval, budget, special funds, subsidies, etc. of colleges and universities in informatization related procurement. The informatization construction supported and encouraged by the government policy will get more capital budget support, and it will be easier to pass in the process of project approval. XY company's publicity and marketing strategy for experimental and training cloud products should be interpreted closely around the government policies, sort out the relevant policy support, and make it a "specified action" in the user information construction. At the marketing level, we can also combine the policies and guidelines related to products, education, and put a reasonable cap on the adoption of informatization.

5.3 Recommendation

To improve the service quality of cloud providers

From the overall trend of the teachers' questionnaire, the average value of the service quality matrix of cloud providers has reached 4.6 points, which is the highest score. It shows that among the nine factor variables, college teachers attach the most importance to the service quality level of cloud providers. 68.75% of the teachers agree, and 31.25% agree that the after-sales service quality of cloud providers will affect their adoption of the cloud platform of educational resources. The conclusion is consistent with the results of the author's work and the practice of University projects. Cloud suppliers with good after-sales service level will greatly affect whether university customers adopt products. Cloud suppliers with poor after-sales service level are difficult to be trusted by users again.

The service quality level is directly related to the user experience and has a far-reaching impact on the business development of a company. At present, XY company performs fairly well in the overall market of colleges and universities in Guangdong. However, due to the business differences in various regions, there are also some remote customers and users with less business cooperation who are dissatisfied with the service of XY company. The main reasons are that the after-sales service response time is long, the problems are not solved, and there is no regular after-sales service tracking. For the above practical problems and difficulties, XY company must first always put the "customer-centric" value into the whole operation and management activities, and always think for the users. Secondly, various service methods can be adopted to solve practical difficulties, such as the combination of remote after-sales service and on-site support service, and the combination of regular inspection and emergency support. In addition, for XY company's experimental training cloud products, there is only one landing mode for localization deployment at present. In the future, SaaS service mode can be increased to provide users, reduce the operation and maintenance workload of university users, and also solve the after-sales service problems in remote areas.

5.4 Suggestion

To create typical cases to provide stronger persuasion

The trust of customers not only comes from the technical strength of the enterprise, but also from the project cases with good results. Not only is the conclusion of this study, but many college teachers attach great importance to project cases in the actual project operation process of XY company. Project cases can make customers intuitively feel the use effect of products, and also make customers truly feel the delivery ability of the company's project team. XY company has accumulated rich customer case resources in the Pearl River Delta region and even Guangdong Province, but there are few benchmark cases of experimental and training cloud products. On the one hand, in future projects, XY company can focus on creating several typical benchmarking cases and industry models. In the pre-sales stage of the project, it can allow customers to go to the benchmarking cases for field investigation and visit in person, so that old customers can endorse the products and enhance user confidence. On the other hand, the "operation" of existing project cases is also crucial. Benchmarking cases should not only come from new projects, but also from existing projects. The most specific is the secondary sales of the project, which is exactly the best proof of the strength of the enterprise.

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APPENDICES

APPENDIX A

- List of experts reviewing research instruments

- Invitation Letter to experts to examine research instruments

List of experts who reviewed research instruments

Content Specialists

1. Associate Professor Zhao Gang,

   School of computer science and engineering, Tianjin University of Technology
2. Professor Zhang Fan

   Department of computer science, art college, Inner Mongolia University
3. Ms. Wang Zhihui

   Teacher, School of management, Tianjin University of Technology

Media Specialists

1. Assistance Professor Dr.Nattakorn Papan

   Faculty of Education, Chandrakasem Rajabhat University
2. Assistance Professor Direk Akkahard

   Faculty of Education, Bansomdejchaopraya Rajabhat University
3. Dr. Kittisak Paen-Ngam

   Nakhonnayok Primary Educational Service Area Office

Assessment Specialists

1. Associate Professor Lin Gu

   Teacher, School of management, Tianjin University of Technology
2. Associate Professor Ping Tang

   Teacher, School of management, Tianjin University of Technology
3. Professor Jiahui Ding

   School of computer science and engineering, Tianjin University of Technology

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9 June, 2022

Dear Associate Professor Zhao Gang
School of computer science and engineering, Tianjin University of Technology

Subject: Respectfully Requesting for letter of Invitation of Experts for M.Ed.Thesis

I am writing to request your assistance as an honorary external research reviewer in evaluating the research instruments of Mr.Yiran Wu, Master of Education Program in Technology and Learning Innovation Rajamangala University of Technology Thanyaburi, who has been working on the thesis titled "Research on The Application of Cloud Computing Integration GPU Technology in The Education Industry". under the supervision of Assistant Professor Dr. Tiamyod Pasawano. In this regard, I would like to request your valuable time to evaluate the research instruments as I strongly believe that your expertise will be of great value in improving the research instruments.

If you have any questions or need further information, please feel free to contact Mr.Yiran Wu, on the e-mail: yiran_w@mail.rmutt.ac.th

Yours sincerely,

(Assistant Professor Arnon Niyomphol)
Dean of Faculty of Technical Education

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Department of computer science, art college, Inner Mongolia University

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Yours sincerely,

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Dear Ms. Wang Zhihui
Teacher, School of management, Tianjin University of Technology

Subject: Respectfully Requesting for letter of Invitation of Experts for M.Ed.Thesis

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Yours sincerely,

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Dear Asst.Prof.Dr.Nattakorn Papan

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Dear Asst.Prof.Direk Akkahard

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Yours sincerely,

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Dear Professor Jiahui Ding
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Yours sincerely,

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APPENDIX B

Research design

Research design

The design of the questionnaire is the basis of empirical research. The quality of variable design will directly affect the reliability and validity of the questionnaire. The questionnaire with poor reliability and validity will lead to the experimental data can not truly and accurately reflect the objective facts. This chapter will combine the four dimensions of technical factors, environmental factors, organizational factors and cloud supplier factors in the theoretical models and assumptions studied in Chapter 3 to design the measurement items and empirically test the theoretical models and assumptions proposed in the previous chapter.

Firstly, for the classical technology acceptance model and the factor variables in the theoretical framework of toe, this chapter will try to learn from and select the measurement items in the widely used and verified authoritative literature. For those factors and variables that cannot be used for reference and are directly selected from existing studies, this chapter will design new measurement items in combination with the previous research and the subjective experience accumulated in the communication with university teachers in their own work.

Secondly, the design of the questionnaire should not only cover enough accurate and appropriate respondents to obtain more comprehensive and objective survey data, but also design measurement items according to different respondents' different cognitive perspectives on the use level of the educational resource cloud platform.

1. necessity of role-based questionnaire design

The subjects of cloud platform adoption of educational resources in Colleges and universities should include students and teachers. Teachers can be divided into two different roles. One is teaching teachers, who are similar to students and have intuitive feelings and evaluation on cloud platform adoption at the use level. The other is the decision-makers and managers who adopt the cloud platform of educational resources in the information management departments of colleges and universities. Typical decision-makers include the director and deputy director of the information center, Managers include teachers in charge of information system operation and maintenance and

laboratory management in the information center. During the adoption of educational resource cloud platform, as the owner in the early stage of adoption, the decision-maker in the middle stage of adoption and the information system maintenance manager after adoption, they also have an intuitive feeling and evaluation on the adoption of educational resource cloud platform from the perspective of information system decision-making, use and management. As a cloud provider, the author of this paper has frequently communicated with the directors of information management departments and operation and maintenance management teachers of colleges and universities in the process of many years of college education resource cloud platform projects. Therefore, in this study, the objects of the questionnaire include five roles: Director of information center of colleges and universities, operation and maintenance management teacher of information center, laboratory management teacher, teaching teacher and students in school. Through the education resource cloud platform

The measurement of the attitudes and evaluations of various roles in the adoption process attempts to more comprehensively reflect the influencing factors of different users at different stages of the adoption process of the cloud platform for educational resources in Colleges and universities.

Due to different roles, different stages in the adoption process, and different levels of using the educational resource cloud platform, the cognitive perspective in the adoption of the educational resource cloud platform is also different. If the unified measurement items are used to investigate, the questionnaire will lose its basic validity. [52] therefore, the items to be measured in the questionnaire cannot be identical. Therefore, it is impossible to design the same set of measurement items to cover all roles.

To sum up, this study will design two different sets of measurement items, one for students and the other for teachers and information center directors.

The attitude questionnaire designed in this study uses the current international general Likert five level scale to measure variables. [53] "1" means totally disagree, "2" means somewhat disagree, "3" means average, "4" means somewhat agree, "5" means fully agree. The questionnaire consists of three parts:

The first part is a brief introduction to the questionnaire, introduces the purpose of the survey, and defines and explains the relevant concepts, including the definition of cloud computing and the definition of cloud platform for college education resources. This study also lists some commonly used education resource cloud platform products to assist the respondents in understanding and helping them make accurate evaluation.

The second part collects some basic information of the respondents, including gender and age, on the premise of fully protecting the privacy of the respondents.

The third part is the main part of the questionnaire. Measure the factor variables in the theoretical model proposed in Chapter 3.

2. Technical factor measurement items

Thanks to the continuous evolution and maturity of cloud computing technology, the university education resource cloud platform based on cloud computing technology has been widely used in recent years. As an innovative technology, the process of its introduction by universities conforms to the general law of Rogers' innovation diffusion theory. An innovation should have five factors: comparative advantage, compatibility, complexity, testability and observability. [10] Many scholars also use it to measure the process of innovation adoption. Including the research of Ligang [6], lipinyi [8], xiongxiaoxi [11], sun Qihang [26], etc. The adoption subjects of their research focus on enterprises and the government. These subjects are similar to and different from the mechanism of innovation diffusion in Colleges and universities. Enterprises pay more attention to perceived benefits and performance, while the government pays more attention to supervision and evaluation. Therefore, they have higher requirements for testability and observability. The main sources of the adoption drivers of the technology dimension also include the technology acceptance model. Davis expounds the impact of external variables on behavior intention from two aspects: perceived ease of use and perceived usefulness. [27]

In this study, three factor variables of comparative advantage, compatibility and complexity are selected for the research on the adoption of the cloud platform of higher education resources. Among them, the measurement purposes of complexity and ease of use are the same, and both depend on the attributes of the technology itself. In

order to facilitate the understanding of teachers and students, this study uses ease of use instead of complexity. In order to ensure the reliability and validity of the measurement items, the three factor variable item designs of this study refer to the measurement items that have been fully verified by many scholars in authoritative literature, and make appropriate adjustments to match the research object and the investigated population. Among them, the reliability measurement value cronbach's in the research of Ligang [6] on compatibility and comparative advantage α It is 0.92 and 0.865 respectively, and the reliability measurement value is cronbach's α Greater than 0.7 indicates good consistency within the measurement items. In sunqihang's research, the reliability measurement items of platform technology dimension include items related to perceived ease of use, and the reliability measurement value cronbach's α Is 0.87.

Table app1.1 Technical Factor Measurements (Teacher's Questionnaires)

dimension	Variables	Coding	Measurement items	Reference source
Technical factors	compatibility	T1	Whether the education resource cloud platform is compatible with education and teaching practice is the factor I consider when using the platform	YiLi（2006）[21] XiaoXiong（2013）[11] GangLi（2016）[6]
		T2	Whether the education resource cloud platform matches my teaching (Management) mode is my consideration in using the platform	
		T3	Whether the education resource cloud platform is compatible with the existing information system is my consideration in using the platform	

Table app1.1 Technical Factor Measurements (Teacher's Questionnaires) (Cont.)

dimension	Variables	Coding	Measurement items	Reference source
Technical factors	Ease of use	T4	Mastering the time cost of using the education resource cloud platform is my consideration in using the platform	GangLi（2016）[6] PingLi（2014）[8] QiSun（2017）[26]
		T5	The difficulty of managing and maintaining the education resource cloud platform is a consideration for me to use the platform	
	Comparative advantage	T6	Educational resource cloud platform has the advantage of resource sharing, so I prefer to use this kind of platform	YiwenLi（2006）[21] XiaoXiong（2013）[11] GangLi（2016）[6]
		T7	The education resource cloud platform has the advantage of accessing resources anytime, anywhere, so I prefer to use this kind of platform	
	compatibility	S1	Whether the education resource cloud platform conforms to my operating habits is my consideration in using the platform	YiLi（2006）[21] XiaoXiong（2013）[11] GangLi（2016）[6]
		S2	Whether the education resource cloud platform matches my learning style is my consideration in using the platform	
		S3	Whether the education resource cloud platform can support multiple ways to access resources, such as PC browser, client software, mobile phone, tablet, wechat applet, etc., is my consideration in using the platform	

Table app1.1 Technical Factor Measurements (Teacher's Questionnaires) (Cont.)

dimension	Variables	Coding	Measurement items	Reference source
Technical factors	Ease of use	S4	Whether the educational resource platform is easy to master and operate is my consideration in using the platform	PinLi（2014）[8] QihangSun（2017）[26]
		S5	Mastering the time cost of using the education resource cloud platform is my consideration in using the platform	
		S6	Whether the education resource cloud platform is easy to operate is my consideration in using the platform	
	Comparative advantage	S7	The education resource cloud platform has the advantage of accessing the cloud learning resource library anytime and anywhere, so I prefer to use this kind of platform for learning	YiLi（2006）[21] XiaoXiong（2013）[11] GangLi（2016）[6]
		S8	Using the cloud platform of educational resources is conducive to improving my learning efficiency, so I prefer to use this kind of platform for learning	
		S9	Educational resource cloud platform has intelligent applications such as resource recommendation and learning data statistics, so I prefer to use this kind of platform for learning	

3. environmental factor measurement items

In the framework of toe theory, environmental factor variables refer to the external factors received by the adoption behavior subject from the organization

Market environment, policy environment and other formal or informal

pressures, including the industry, competitors, policy support, trends, etc. Abrahamson et al. Put forward the concept of trend pressure in their research on organizational adoption innovation, that is, when an innovation is adopted by more and more organizations and benefits from it, it will have an impact on other individuals or organizations that do not adopt the innovation, and urge these individuals or organizations to follow this trend and include the innovation in the adoption issue. [6]

In the theoretical framework of toe, it is also believed that the adoption behavior of organizations is affected by the government policies from their industries. Ligang pointed out in his research on the adoption of provincial E-government that informatization policy is the planning, management and guidance of government organizations on the informatization development of a country or region at the level of policies and regulations. [6] In organizations where financial funds such as government organizations and public institutions account for the main source of information construction resources, the support of government policies means the support and allocation of relevant financial funds, and also greatly affects the approval of information construction projects. We believe that the informatization construction of colleges and universities is also influenced by government policies. As a public institution, colleges and universities provide higher education public services for the society and support the development of national politics, economy, society, science and technology. Their nature, the main sources of funds and administrative management of information construction are the same as those of government organizations. Therefore, the innovation and adoption of colleges and universities are the same as those of government organizations and are affected by government information policies. Li Gang [6] in the research on the adoption of provincial E-government Based on cloud computing, cronbach's measured item reliability of influencing factors at the government policy level α Is 0.715, which has reached a good level of credibility. Xiong Xiaoxi [11] relevant measurement questions related to environmental characteristics in the research on Cloud Computing Adoption of small and medium-sized enterprises cronbach's α The values are more than 0.7, with good reliability. The measurement items of environmental factor variables in this study will refer to the existing research results of the above two.

Table app1.2 Environment Factor Measurements (Student's Questionnaires)

dimension	Variables	Coding	Measurement items	Reference source
Environmental factors	Tidal current pressure	S10	Whether other people are already using the cloud platform of educational resources for learning is my consideration in using the platform	GangLi（2016）[6]
		S11	The trend of using the cloud platform of educational resources for learning is my consideration in using the platform	

4. organizational factor measurement items

Whether a new technology is adopted by the organization is not only affected by the characteristics of the new technology itself and the formal or informal pressure from the external market environment and policy environment in which the organization is located. It is also affected by various factors within the organization, including whether the top leaders within the organization provide recognition for the overall informatization development plan of the school, the support of school level resources that the top management can coordinate, and the perception of self-efficacy of members in the technology adoption department.

In the dimension of organizational factors, this study mainly focuses on the two factor variables of high-level support and organizational resource readiness. There have been a large number of scholars' research results for reference in the design of organizational factor variable measurement items. Fieldwork [54] in the research on the influencing factors and action mechanism of enterprise resource planning (ERP) assimilation, the top management support dimension includes five measurement indicators, and the reliability measurement value is cronbach's α It is 0.8637, and the questionnaire items have good reliability. In Xiong Xiaoxi [11]'s research, in terms of

enterprise characteristics, the measurement indicators are designed from two factor variables: resource readiness and high-level support. There are five measurement items in total, and the reliability measurement value is cronbach's α They are 0.728 and 0.726 respectively, exceeding 0.7, both reaching a very reliable level. In the research of liyiwen [21], cronbach's measured the reliability of the measurement items of organizational readiness and high-level support design α It reaches 0.82 and 0.91 respectively, providing a high degree of credibility. Therefore, the measurement indicators of the organizational factor dimension of this study will be designed based on the research results of the above scholars.

Table app1.3 Organization Factor Measurements (Teacher's Questionnaires)

dimension	Variables	Coding	Measurement items	Reference source
Organizational factors	High level support	T12	Whether the senior management of the school provides necessary support and help in the construction of the educational resource cloud platform will affect whether I use the platform	YiwenLi（2006）[21] XiaoxiXiong（2013）[11] YeTian（2008）[54]
		T13	Whether the senior management of the school understands the functions and prospects of the educational resources cloud platform will affect whether I use the platform	

Table app1.3 Organization Factor Measurements (Teacher's Questionnaires) (Cont.)

dimension	Variables	Coding	Measurement items	Reference source
Organizational factors	Resource readiness	T14	Within the Department, whether other relevant users of the education resource cloud platform have the experience or ability to use, operate and maintain the platform is my consideration in using the platform	YiwenLi（2006）[21] XiaoxiXiong（2013）[11]
		T15	Whether the personnel allocation supporting the use, operation and maintenance of the education resource cloud platform within the Department is sufficient is my consideration in using the platform	

In addition to university teachers, the subjects of this study include: Director of University Information Center, operation and maintenance management teacher of information center, laboratory management teacher, teaching teacher, and university students. The factor variables of the organizational dimension mainly involve the managers and decision makers of the information system in the process of the adoption of the cloud platform of educational resources in Colleges and universities. Therefore, this part of the questionnaire does not survey the students in school, so it does not design measurement items for students.

5. cloud supplier factor measurement items

In the process of the adoption of university information systems, cloud providers often have been deeply involved in the decision-making process of university information system construction projects before the establishment of university information system construction projects, and provide the university information management department with project scheme planning and design, product introduction, project establishment application document writing and other services. Generally, cloud providers participate in the whole process of university information system construction projects and provide technical and service support for all aspects of university information system construction. Therefore, in the process of adopting the cloud platform of educational resources in Colleges and universities, cloud providers gradually affect their willingness to adopt information systems through service support to the information management departments of colleges and universities, and ultimately affect their decision-making behavior. In this process, many factors of the cloud supplier will affect the decision-making behavior of the adopter, such as the design quality of the technical scheme provided by the cloud supplier, the successful cases of the cloud supplier, the after-sales service level, the industry reputation and the enterprise qualification of the cloud supplier. Li Gang [6] proposed in his research the impact of cloud supplier qualification and cloud supplier service level on the adoption of government organizations. The reliability measurement value of the measurement items designed by him is cronbach's α It reached 0.877 and 0.856, respectively

Provides a high degree of credibility. The factor variable "success case" appears in the organizational factor dimension of Ligang's research, which refers to the impact of the same type of success cases within the government organization on the existing adoption, and its measurement items provide good reliability. In this study, we explore the impact of successful cases of cloud suppliers on the adoption of university information systems from the perspective of cloud suppliers. Therefore, the measurement items of this dimension will learn from Ligang's measurement index design and make some adjustments. GUI Yanjun [51] designed evaluation index items based on professional evaluation and service level agreement (SLA) evaluation in the research on Enterprise Cloud Computing Adoption Decision. Yangchaojun [27] put forward the

impact of service quality on SaaS adoption in his research. In this study, the measurement indicators of the influencing factors of cloud supplier dimension will be adjusted and increased or decreased appropriately based on the existing research results of the above several and in combination with the characteristics of information technology adoption in Colleges and universities.

Table app1.4 Vendor Factor Measurements (Teacher's Questionnaires)

dimension	Variables	Coding	Measurement items	Reference source
Cloud supplier factor	Service quality	T16	Whether the supplier can provide excellent scheme design is one of the criteria for me to choose the education resource cloud platform	ZaojunYang（2014）[27] GangLi（2016）[6] YanjunGun（2014）[51]
		T17	Whether the supplier can provide good after-sales service support is one of the criteria for me to choose the education resource cloud platform	
	Success stories	T18	Whether the supplier has a good industry reputation is one of the criteria for me to choose the education resource cloud platform	
		T19	Whether the supplier has a successful case of education resource cloud platform is one of the criteria for me to select the education resource cloud platform	

In this study, the influencing factors of the supplier dimension are not applicable to the questionnaire of school students, so the cloud supplier factor does not design measurement items for school students.

6. measurement items of adoption intention

The measurement index design of adoption intention in this study will refer to the relevant design of lipinyi [8] on SaaS adoption of small and medium-sized enterprises and Ligang [6] on the adoption of provincial E-government.

Table app1.5 Adoption Intention Measurements (Teacher's Questionnaires)

Variable	code	measurement item	reference source
Willingness to adopt	T20	I am interested in education resource cloud platform	PinyiLi[8] GangLi[6]
	T21	I have a considerable understanding of the connotation of the education resource cloud platform	
	T22	in general, I will / will consider using the education resource cloud platform	

Table app1.6 Adoption Intention Measurements (Student's Questionnaires)

Variable	code	measurement item	reference source
Willingness to adopt	S12	I like to use the cloud platform of educational resources to learn	PinyiLi[8] GangLi[6]
	S13	it is a good thing to promote the use of education resources cloud platform for learning	

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