EFFECTS OF INQUIRY-BASED LEARNING IN MATHEMATICS ON GROWTH MINDSET OF FIRST-YEAR STUDENTS IN CHINESE HIGHER VOCATIONAL SCHOOL

LI YUANYUAN

Graduate School Srinakharinwirot University

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LI YUANYUAN

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EFFECTS OF INQUIRY-BASED LEARNING IN MATHEMATICS ON GROWTH MINDSET OF FIRST-YEAR STUDENTS IN CHINESE HIGHER VOCATIONAL SCHOOL

LI YUANYUAN

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BY

LI YUANYUAN

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AT SRINAKHARINWIROT UNIVERSITY

(Assoc. Prof. Dr. Chatchai Ekpanyaskul, MD.)

Dean of Graduate School

ORAL DEFENSE COMMITTEE

.... Advisor	Chairperson
(Dr. Thammachot Aeamtussana)	(Assistant Professor Dr. Pinda Varasunun)
.... Co-Advisor	.... Committee
(Dr. Paradee Kambhu Na Ayudhaya)	(Associate Professor Dr. Pasana Chularut)

Title	EFFECTS OF INQUIRY-BASED LEARNING IN MATHEMATICS ON GROWTH MINDSET OF FIRST-YEAR STUDENTS IN CHINESE HIGHER VOCATIONAL SCHOOL
Author	LI YUANYUAN
Degree	MASTER OF EDUCATION
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Advisor	Dr. Thammachot Aeamtussana
Co-Advisor	Dr. Paradee Kambhu Na Ayudhaya

This study seeks to examine the effect of inquiry-based mathematics instruction on the cultivation of a growth mindset. The research objectives are twofold: (1) to compare growth mindset scores among participants in the experimental group before and after engaging in inquiry-based learning; and (2) to compare growth mindset scores between the experimental and control groups after the experiment. The study involved a total of 358 freshmen enrolled at Jiuquan Polytechnic College. From this cohort, 40 students with baseline growth mindset scores ranging from 30 to 60 were selected and randomly assigned to either the experimental or control group, with 20 students in each. The experimental group underwent structured inquiry-based instruction, while the control group received traditional instruction. Two instruments were employed in this study: (1) an inquiry-based mathematics learning program comprising five sequential phases—Engage, Explore, Explain, Elaborate, and Evaluate; and (2) the Growth Mindset Scale, which exhibited strong internal consistency reliability (Cronbach's α = 0.921). Data analysis encompassed descriptive statistics, paired-sample t-test and independent t-test.The research findings revealed the following: 1) the growth mindset of first-year students who participated in the inquiry-based learning program was significantly higher than before experiment at level of 0.001.; 2) the growth mindset of first-year students who participated in the inquiry-based learning program was significantly higher than students who participated in traditional instruction at the 0.001 level.

Keywords: Growth Mindset,Inquiry-Based Learning,Mathematics education

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CHAPTER 1
INTRODUCTION

1.1 Background

In the era of rapid development of information technology, high-quality talents with core literacy are an important force and driving force for national and social development. The development of information technology in the new era also requires a new way of thinking. A growth mindset meets the requirements of new talent training. It advocates overcoming difficulties and challenges with courage and facing setbacks with a positive attitude, essential qualities for new talents. Developing a growth mindset under today's core literacy talent training goals is of great significance. (Mo, 2023)

The Ministry of Education of China (2014) put forward the core quality system for the development of students in each school section, clarifying the essential character and key ability that students should possess to meet the needs of lifelong development and social development. Core Competencies and Values for Chinese Students' Development (Core Competencies and Values for Chinese Students' Development) considers cultivating all-around development as the core, including three aspects: cultural foundation, independent development, and social participation. Six qualities are cultural heritage, scientific spirit, learning, healthy life, responsibility, practice, and innovation (Ministry of Education,2016).

Among the six core qualities, learning quality emphasizes that students should have the learning consciousness of enjoying learning, being good at learning, and being able to reflect diligently. Specifically, it is described that students have a positive inquiry attitude, open thinking concept, and positive learning attitude and affirm the value of learning in the learning process. The characteristics of a growth mindset, such as a positive mentality, intellectually variable thinking concepts and self-development as a learning goal, are becoming increasingly important for students' development. Sound personality literacy proposes that students should have positive psychological qualities, be able to regulate their emotions and have self-control and anti-frustration abilities. The characteristics of a growth mindset, such as facing failure calmly and actively seeking strategies to solve difficulties, have their cultivation needs. Healthy life literacy proposes that students should be able to reflect and self-manage diligently, review their learning status, summarize the experience and adjust learning strategies, evaluate their personality potential, choose goals, allocate energy reasonably, and have continuous action power. The learning process reflection and self-management advocated by a growth mindset are of great significance to developing students' core literacy (Ministry of Education of China,2016). Therefore, a growth mindset plays an important role in promoting the cultivation of students' core literacy and development. It is also an important driving force for students' development in the information age under the goal of core literacy. (Mo, 2023)

As China enters a new stage of development, industrial upgrading and economic restructuring continue to accelerate, the demand for technical skills in all walks of life is becoming increasingly urgent. After graduation, most vocational college students are skilled workers struggling in the front line of production. Only those who are good at using a growth mindset to consider and solve problems encountered in work are more likely to make achievements in scientific and technological innovation and technological improvement and become great artisans (He,2022). According to research (Wang et al., 2020; (Kunene, 2023); Wahyuni, 2019), firstly, employees with a growth mindset are more likely to adapt to market changes. In today's era of frequent change, old business models and ways of thinking may not be able to cope with new market challenges. People with a growth mindset are more likely to adapt and succeed in demanding or stressful situations (Costa & Faria, 2018) because they believe they can overcome any difficulty and master any new skill if they put in the effort. Employees with a growth mindset are more willing to try new approaches and step out of their comfort zone. Even when faced with failure, they learn from it and continue to improve rather than give up (Dweck, 2006).

Furthermore, a growth mindset can also help improve team cohesion and collaboration. Employees with this mindset are more team-oriented and willing to share experiences with colleagues, learn from each other, and encourage each other (Alpay & Ireson, 2006). They do not retain knowledge for fear of losing their competitive edge, nor do they lose faith in their team because of a single failure. Such a team atmosphere can greatly improve the overall work efficiency and quality. Therefore, a growth mindset is very important for both employees and enterprises.

Higher vocational education is an important part of China's higher education and a special group in China's education system (Xu,2023). Compared with undergraduate students, higher vocational colleges are affected by the source of students (recruited secondary vocational graduates, failed college entrance examination students) and training goals (trained labour and technical talents), and people's ideas have long despised them. It is generally believed that only students with low academic levels, poor learning habits, no positive learning attitude and no optimistic future development will enter vocational colleges to study, and higher vocational and technical education is even considered to be "the education of losers" and "the education of eliminators" (He, 2023).

In addition to the negative evaluation from the public, the higher vocational students themselves also hold a pessimistic attitude, such as in learning enthusiasm is not high, think that they are not enrolled in the undergraduate poor students, no talent for reading and learning, no need to study hard, lack of motivation; Lazy and passive in life, imitating others, wasting time, lack of a sense of belonging to school and class; In practical activities, I do not have perseverance and perseverance to persist in training, and always tend to give up when encountering difficulties, setbacks and challenges, and even show avoidance of things within my power, lacking ambition and enterprise. The original intention of the research on growth mindset is to eliminate as much as possible the influence of "educational failure" on the inherent concept of most higher vocational students through such research. During the study period, students can learn to find problems, face problems, solve problems, reflect on problems, meet the needs of their growth and development, meet the needs of social employment standards, change their thinking, be optimistic, persevere in learning, enhance self-confidence, and take a long-term development perspective in the rapidly changing social environment.

After entering school, different thinking patterns of higher vocational students will have different influences on their growth in school, determining their attitude towards vocational school learning and the level of achievement they can achieve in vocati onal school (He, 2022). Therefore, the research object of this study is the first-year students in higher vocational schools.I am a vocational math teacher, and there is a belief among a large percentage of my students that math ability is innate - some have it, some do not, and no one can change their basic math ability. It is associated with maladaptive behaviours such as avoiding challenging work and giving up when things get tough. This belief may contribute to the persistence of relatively poor student performance and low interest in math (Boaler, 1998), and improving student math achievement requires a better understanding of the sources of this belief.

The concept of a growth mindset refers to our core belief that our talents can be developed through practice, which may influence our thinking and behaviour (Dweck, 2006). In a growth mindset, people believe that their most basic abilities can be developed through hard work and that brains and talent are just the starting point. This perspective creates a love of learning and a strong ability to adapt, which is necessary to achieve great things. According to Dweck (2006), there are two types of mindset: growth and fixed. People with a fixed mindset believe that intelligence is innate and cannot be changed, adopt performance goals, and are often helpless against setbacks. They prefer to do the work they are familiar with instead of enjoying the learning process; they only focus on the success or failure in front of them, easily give up in the face of setbacks, and are more likely to feel depressed after failure. However, people with a growth mindset believe intelligence is developable; they adapt to learning goals and have a mastering-oriented response to setbacks. They prefer accepting challenges, enjoying the learning process, and being unafraid of difficulties. After failure, they can better self-regulate and recover from failure faster (Dweck, 2006).

Researchers say students' academic success is rooted in their growth goals and growth mindset (Bostwick et al., 2020). Because students with a growth mindset are more motivated and work harder. As a result, these students are generally more academically successful (Auten, 2013). Students with higher academic achievement are more likely to have a growth mindset (Claro & Loeb, 2019). Students with a growth mindset have an easier time facing the challenges of real-world math problem-solving needs (Castiglione, 2019)

In terms of the methods of cultivating a growth mindset in the classroom, there is the SPOC curriculum (Cao,2024), project-based learning (Chen,2023; (Mo, 2023), transformational instructional design (Jinggang, 2022), and problem chain design (Hu,2022). 2020), inquiry learning (Dan Frezell, 2017; (Klein, 2020); Steurer, A. 2018).

The author would prefer to choose inquiry learning in the above teaching methods. Inquiry learning refers to a student-centred pedagogy that uses purposeful, extended investigation in real-life problems to improve student competence and as a feedback loop that increases teacher insight into student thought processes (Supovitz et al.,2000). Inquiry-based learning allows students to engage in courses by connecting with the real world through mathematical mastery. This type of learning will also help teachers better understand students' thought processes and their understanding (Marshall et al., 2009).

There are five stages of learning in guided inquiry to help provide guidance and modelling. The first stage is an introduction, where students start and open. This is followed by the exploration phase, in which students explore ideas and background information. Next is the Explain stage, where students share the methods and skills used in the exploration process in an all-round way. Then, there is Elaboration when the student understands the application. Finally, there is assessment, in which students assess their understanding and abilities (Hargreaves et al.,1998). Inquiry-based learning usually involves students working in small groups. Students' mathematical thinking and teaching strategies will contribute to students' success in mathematics (Bostwick et al., 2020). Open math tasks allow students to become interrogators. Students not only find answers but also think critically about math content. This helps students take ownership of their learning, which will help foster a growth math mindset (Dweck, 2015). Students' ability to learn from their mistakes is rooted in their growth mindset (Steurer, 2018).

The focus of this study is to explore the effect of mathematical inquiry learning on the growth mindset of first-year students in higher vocational colleges and to provide new educational methods and ideas for cultivating the growth mindset of first-year students in higher vocational colleges. At the same time, this study will also produce useful references for applying inquiry learning in other disciplines and promote the innovation and development of education and teaching in general.

1.2 Research Question

1.2.1 What is the level of growth mindset among first-year students in higher vocational institutions?

1.2.2 Does inquiry-based learning in math instruction foster a growth mindset in first-year students?

1.3 Objectives of Research

The purpose of this study is as follows:

1) To compare the difference in growth mindset scores before and after participating in inquiry-based learning in the experimental group.

2) To compare the difference in the growth mindset scores between the control and experimental groups after participating in inquiry-based learning .

1.4 Significance of Research

1. Theoretical significance

The essence of education is to point to the future. Education should not only provide students with knowledge and skills to learn but also help them change their thinking, cultivate their attitudes and ability to actively face problems, solve problems and reflect on problems to prepare for students' growth and progress in future study, work and life.

Through searching, sorting out and analyzing relevant literature on cultivating a growth mindset, this paper analyzes the relationship between a growth mindset and inquiry learning from the perspective of cultivating students' growth mindset. It has enriched the theoretical research results of cultivating a growth mindset with inquiry learning and provided specific practical cases for cultivating a growth mindset. In the mathematics curriculum of the higher vocational college, this paper studies the influence of the cultivation of a growth mindset in inquiring learning on students' learning and personal development, enriches the theory of inquiring learning, and provides new areas of concern and new ideas for improving the teaching quality of higher vocational mathematics curriculum and cultivating new talents under the core literacy.

2. Practical significance

Based on theoretical analysis, curriculum characteristics analysis and learning situation analysis, this paper designs a complete inquiring learning process for cultivating a growth mindset. It provides practical experience for cultivating a growth mindset through teaching practice research. It is conducive to localising a growth mindset and optimising the teaching effect of front-line mathematics teachers in higher vocational colleges. It can also provide experience for integrating a growth mindset into vocational and technical education in the future, which has certain exploration significance and reference value. The teaching practice of cultivating a growth mindset in inquiry learning and informing mathematics curriculum is conducive to transforming students' learning methods and thinking models and implementing core literacy. Through the inspiration of a growth mindset and progress in learning, students can quickly build self-confidence, improve their thinking level and learning effect, and help students develop comprehensively and balance.

1.5 Scope of Study

1. Population:

This research project mainly aims at 358 first-year students of the Civil Engineering College of Jiuquan Vocational and Technical College.Jiuquan Institute of Vocational Technology is in Jiuquan City, Gansu Province, Northwest China. It is a full-time specialized level general higher vocational institution for the record of the Ministry of Education of China.

2. Sample:

The samples in this study were first-year students from the School of Civil Engineering at Jiuquan Polytechnic College. Initially, a growth mindset assessment was administered to 358 first-year students. Subsequently, 40 students with scores ranging between 30 and 60 were selected for the experiment. These 40 participants were randomly assigned to either an experimental group or a control group, with 20 individuals in each group.

1.6 Research Variables

The independent variable of this study is inquiry-based learning, and the dependent variable is a student growth mindset.

1.7 Definition of Terms

The definitions of the above academic categories are explained below:

1.7.1 Growth Mindset

Growth mindset refer to a positive psychological orientation grounded in the belief that intelligence is malleable and can be developed through sustained effort. Individuals with a growth mindset exhibit a proactive attitude toward mastering challenges, demonstrate resilience in the face of setbacks, actively seek to learn from constructive criticism, and are easily inspired by the success of others.

1.7.2 Inquiry-based learning

Inquiry-based learning refer to an inquiry process in which students discover problems, collect information, solve problems and demonstrate and explain issues under the guidance of teachers in teaching activities. In the learning process, students can independently construct knowledge, acquire knowledge, and apply knowledge, and they can improve their inquiry thinking, practical ability, and scientific literacy. Inquiry learning consists of the following five elements:

Step 1: Engage. To stimulate students' interest in learning tasks, teachers must create reasonable problem situations and connect mathematical knowledge with real-life examples and physical models to attract students' attention. Teachers should fully understand the pre-concepts that students have mastered for the task to be learned, analyze the differences between the original concepts and the scientific concepts and the reasons for the differences, and then create a problem situation that produces a cognitive conflict with the students' known pre-concepts so that students can have the willingness to explore.

The second step: Explore. Teachers should be able to choose exploration materials reasonably according to the actual situation and guide students to explore. In the process of inquiry, students should be in the main position, fully express their ideas through group cooperation and communication, and try to explore various ways to complete the inquiry task jointly. In the whole process, teachers listen to students' ideas, observe students' performance, give correct guidance to groups needing help, let students fully expose the pre-concepts they have mastered, and lay the foundation for forming subsequent new concepts.

The third step: Explain, students in the process of inquiry used in an all-round review of the skills of the method. The teacher encourages students to use their language to explain their knowledge and understanding of the concept and the problems they encounter, to present the inquiry results with accurate symbolic language and rigorous reasoning process, and to question each other on doubtful knowledge points. Finally, the teacher uses standardized mathematical language and symbols to explain new terms and definitions based on students' experiences. Correct the deviations formed in the minds of students in time.

The fourth step: Elaborate. Strengthening link, but also extension link. After students acquire new concepts, they use them to solve relevant mathematical problems and improve their mastery and application of new ideas.

The fifth step evaluating and reflecting on the link, is also the summary link and the end link. The evaluation standard is not only limited to the degree of knowledge mastery but also to the students' comprehensive ability. In terms of evaluation, from the diversified evaluation methods, multi-dimensional evaluation content, and diversified evaluation subjects, students' comprehensive ability is comprehensively examined so that they can correctly understand themselves and constantly reflect on themselves to obtain the joy of learning and success.

1.8 Framework of Study

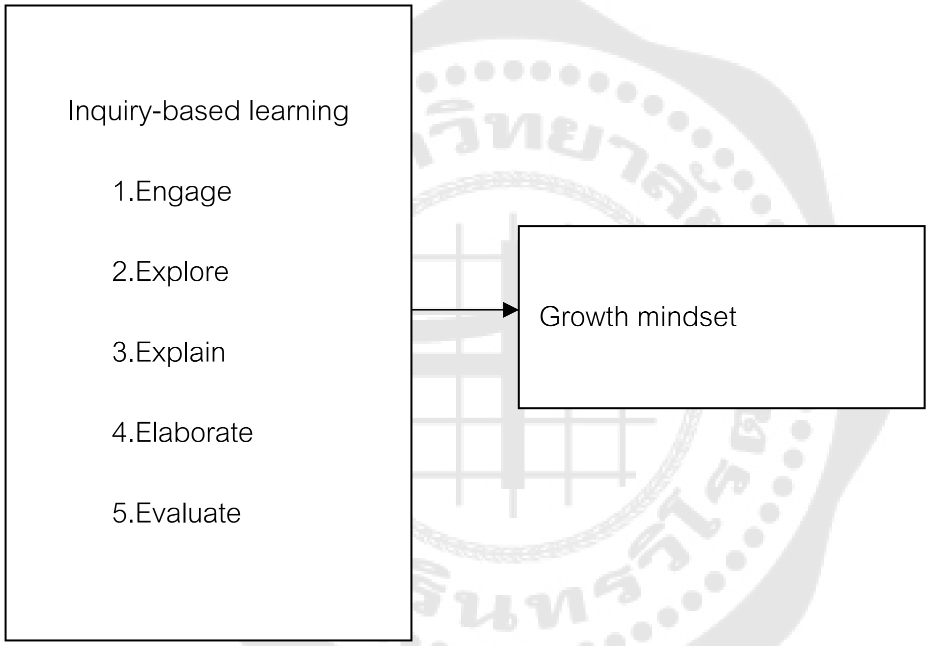

Figure 1 Framework of the Study

1.9 Research Hypotheses

1.9.1 . After participating in this experimental project, the average growth mindset score of the experimental group was higher than before participating in this experimental project.

1.9.2 After participating in this experimental project, the average growth mindset score of the experimental group was higher than that of the control group.

CHAPTER 2
LITERATURE REVIEW

This chapter will provide a comprehensive review and elaboration of the independent inquiry-based learning dependent variable growth mindset and the relevant theoretical underpinnings. Each variable will be examined in detail within the context of the relevant theoretical literature, specifically addressing:

2.1 Growth Mindset

2.1.1 The Definition of Mindset

2.1.2 The Definition of Growth Mindset

2.1.3 The Role of Growth Mindset

2.1.4 Influences on Growth Mindset

2.1.5 Intervention Practices for Growth Mindset

2.1.6 Measurement of Growth Mindset

2.2 Inquiry-based Learning

2.2.1 Concept of inquiry-based learning

2.2.2 Characteristics of inquiry-based learning

2.2.3 Models of inquiry-based learning

2.2.4 Effect of mathematical inquiry-based learning enhances growth mindset

2.1 Growth mindset

2.1.1 The Definition of Mindset

1. The definition of mindset

Mindset is creatively proposed based on the Implicit theory of intelligence. Dweck found that some people want to prove what they already have and want to keep improving their abilities. She believes this reflects two very different views of competence: those who want to prove that they already have competence believe that competence is an innate and fixed self-attribute, and those who wish to improve their ability believe that competence is a malleable and developable quality. Based on this, Dweck proposed implicit intelligence theory, that is, an individual's assumptions about whether their intelligence or abilities can be changed, which can be divided into Entity theory and Incremental theory, corresponding to people who want to prove their abilities and those who wish to improve their abilities. The specific content of the theory of implicit intelligence is shown in Figure 2 (Dweck et al.,1995).

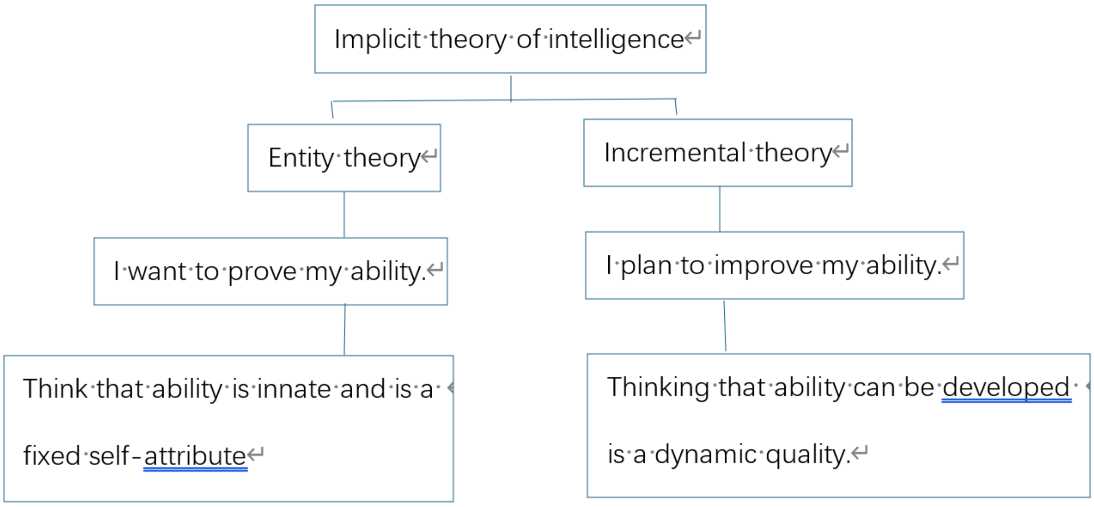

Figure 2 Specific content of the theory of implicit intelligence (Su-Ting, 2021)

Fixed mindset		Growth mindset
Intelligence is fixed	A view of intelligence	Intelligence can be improved
See effoet as fruitless or worse	A view of the effort	See effoet as the path to mastery
Avoid challenges	When challenged	Embrace challenge
Give up easily	When confronted with obstacles	Persist in the face of setbacks
Lgnore useful negative feedback	Views on criticism	Learn from criticism
Fee threatened by the success of others	When others succeed	Find lessons and inspiration in the success of others

Figure 3 Comparison between growth mindset and fixed mindset (Press, 2014).

For ease of use, (Dweck, 2006) modified the implicit intelligence theory into the mindset, the ability entity views into a fixed mindset and the ability growth view into a growth mindset. Mindset refers to the belief or view of people's characteristics, which can be divided into two types: growth mindset and fixed mindset. People with a growth mindset believe that people's characteristics, such as intelligence and ability, can be changed through acquired efforts. In contrast, people with a fixed mindset believe that people's characteristics, such as intelligence and ability, are innate and fixed. Because cognition restricts behavioural responses, different mindsets allow individuals to have different behavioural responses. People with a growth mindset dare to accept challenges, make unremitting efforts, correctly attribute, learn from criticism, and believe that efforts will bring success. People with a fixed mindset tend to evade challenges, get used to giving up, fail to attribute correctly, and ignore negative evaluations. Think effort is useless. For details, see Figure 3. (Dweck, 2006)

After that, scholars define mindset from different perspectives, which can be summarized into two aspects: broad sense and narrow sense. A mindset is an attitude or interpretation of an individual. Other scholars define the concept from different perspectives. Some scholars are in the same vein as Dweck's idea, believing that mindset is an attitude towards an individual's basic characteristics (Wang & Bo,2003), while others explain it from the perspective of group relations. It is believed that mindset is an individual's explanation of the society in which they live (Gao et al., 2012). Some scholars interpret it from the perspective of interpersonal communication and believe that mindset is an individual's attitude towards the characteristics of the objects they communicate with (Cui, 2004).

Although different scholars have different definitions, most of them agree that mindset is an attitude or explanation held by an individual. In a narrow sense, mindset is combined with education to define the concept. From a cognitive perspective, Gu (2014) pointed out that mindset influences an individual's internal factors in problem analysis and solution. For chemistry, Liu (2020) believes that mindset is a belief system for learning ability in chemistry. Shengnan (2020) believes that mindset is a series of ways and methods adopted in biology learning that can reflect the mindset. The concept definition of subsequent scholars is based on Professor Dweck's view. Therefore, this study adopts the view of Dweck (1995), which believes that mindset is an individual's belief or view of a person's characteristics (intelligence). It can be divided into two types: the fixed mindset and the Growth mindset.

In this study, mindset is defined as an individual's belief or view on human characteristics (intelligence), mainly divided into fixed and growth mindsets.

2. The important theory of mindset

Over the years many studies have demonstrated the importance of mindset while solving challenging tasks (e.g. Blackwell, Trzesniewski, & Dweck, 2007;Burnette etal. 2012;Dweck 2006;Dweck, Chiu, andHong 1995; Dweck and Leggett

1988;Pauneskuetal. 2015). That is, the mindset will influence whether and how a student will face a new and challenging task. According to Dweck (2006) mindset comes in two forms, a growth and a fixed mindset. Students with a growth mindset, or an incremental theory of intelligence, believe that intelligence is malleable and can be developed by learning. They adapt learning goals and have a mastery-oriented response to setbacks. Students with a fixed mindset or an entity theory of intelligence, believe that intelligence is something you possess and cannot be changed. They adopt performance goals and often have a helpless response towards setbacks (Dweck and Leggett 1988).

Mindset develops from prior experiences with people in the environmentwhere they grew up, such as parents and siblings, peers or teachers at school (Dweck 2006;Good,Rattan,and Dweck 2012; Pomerantz and Kempner 2013). However, it is generally uncorrelated with prior education (Dweck, Chiu, and Hong 1995), Big Five personality factors, and intelligence (Spinath et al. 2003). Students with a growth mindset attach more value to learning than appearing smart, they like to work harder, and see setbacks as a challenge to cope with. Students with a fixed mindset prefer to look smart, work as little as possible and tend to stop when faced setbacks (Dweck and Leggett 1988)

Mindset theory suggests that students who possess a fixed mindset believe intelligence is stable and cannot change, while students with a growth mindset believe their intelligence can improve with work. Students who possess a fixed mindset are often preoccupied with the notion of high performance and will seek opportunities where they can prove their skills while avoiding situations where their weaknesses might be revealed. These students tend not to respond well to failure because they believe their abilities are fixed and incapable of change—they feel they are either smart or not. On the other hand, students employing a growth mindset believe that their abilities develop over time. Students who take this approach tend to seek out opportunities to gain new knowledge, broaden their skills, and do not shy away from challenges. They view the brain as a muscle that can be exercised and strengthened (Ames, 1992; Kaplan & Maehr, 2007; Pintrich, 2000; Dweck, 1975, 1999, 2006).

Adopting a growth or a fixed mindset can have important consequences as it predicts students' academic performance over time (Blackwell et al. 2007). This is particularly evident when students face challenging tasks, like difficult programmes (Davis et al. 2011; Mueller and Dweck 1998), difficult transitions such as going from elementary school to high school (Blackwell et al., 2007;Yeager et al. 2016), and in situations of underperformance of individuals who belong to negatively stereotyped groups (De Castella and Byrne 2015).

On the other hand, adopting a growth mindset leads to greater achievement and success. For instance, teaching themalleability of intelligence to seventh and eighth graders led to higher grades in mathematics (Blackwell et al., 2007), higher grade point average GPA of undergraduate college students (Aronson, Fried, and Good 2002), and led to an increase in GPA of underperforming high school students (Paunesku et al. 2015).

Although there is a large amount of research on mindset (Blackwell et al., 2007; Burnette et al., 2012; Dweck et al., 1995; Pauneskuetal. 2015), as far as we know, these few vocational education, vocational education mainly consists of students, who are more likely to experience problems in academic development. These experiences may have led to a fixed mindset (Davis et al., 2011; Rattan et al., 2012).

2.1.2 The Definition of Growth Mindset

Dweck first proposed the concept of a growth mindset, and it went through three stages: initial attribution division, intermediate goal pursuit division, and later ability essence division. Finally, the concept of a growth mindset was formed.

Dweck (2006) studied how to change children's attribution of learning difficulties and proposed attribution therapy, which divided learners into two types, attributed to ability and motivation, according to their different attributions of failure. To change individuals' responses to learning dilemmas, Dweck conducted experimental studies on how learners attribute when they fail at math problems, demonstrating the effectiveness of attribution therapy. By conducting experimental research on four sets of problems from easy to difficult for learners with two types of attribution, Dweck concluded that learners' different concerns would affect their strategy selection in the face of learning difficulties. According to the differences in cognitive, emotional and behavioural responses, we define the two types of learners as helpless children and mastery-oriented children.

Dweck and Diener (2006) conducted an in-depth study on the influence of ability attribution and motivation attribution on learners, pointing out that different goals pursued by individuals affect learners' interpretation and response to things, and defined the objectives pursued by helpless children and mastering oriented children as achievement goals focused by helpless children and learning goals focused by mastering oriented children.

Dweck and Elliott (2006) studied the two types of goals. They concluded that those who pursue achievement goals pay attention to external competency-related evaluation. Those seeking learning goals pay attention to their ability growth and elaborate on the psychological and behavioural performance of the two types of goal seekers. After concluding the above goal type, the research team conducted related research on the factors influencing goal formation, the psychological mechanism of goal type, and how to change learners' goal type. This paper predicts the formation of learners' goals through certain indicators and concludes that children have implicit ideas about the essence of ability. According to the psychological characteristics that human intelligence is subconscious, tacit, and difficult to know and express, Dweck divides the above children's different views on the nature of ability into the growth intelligence concept and the entity intelligence concept. The above helpless children who focus on achievement goals and mastery-oriented children who focus on learning goals are further defined as the holders of the growth intelligence and entity intelligence concepts.

Over a longer period, Dweck has expanded the study of concepts from intelligence to ego, personality, and social interaction. Dweck(2007) renamed the above intellectual concepts as Growth mindset and fixed mindset, arguing that mental models create people's inner world and are secular concepts. It explains people's joys and sorrows, shapes life goals and predicts life development. Thus, the idea of a growth mindset was formally formed.

Wang and Song(2018) proposed a growth mindset in their research on career success. They defined it as a mindset better than the starting point of one's development within a certain development time frame compared to objective conditions, opportunities, and other backgrounds. Psychological qualities, such as faith, courage, tenacity, and creativity, are shown in overcoming difficulties, transcending oneself, doing creative work, and finally achieving relevant results or achievements.

Wu (2011) pointed out in his research on the competitive advantage of human resources that a growth mindset refers to a stable cognitive schema in people's minds with lofty beliefs and ultimate value pursuit, strong sense of self-efficacy, initiative, openness, absorption, self-correction mechanism, continuous evolution from low level to high level, and sustainable development vitality. It is mainly composed of belief hypothesis and mindset.

Zhang (2017) pointed out in his research on mindset training for progressive web front-end design that Growth mindset refers to a mindset that believes that talent and intelligence can be improved through efforts, that new neuronal connections can be created through efforts to overcome difficulties, and that intelligence can be developed, which can be educated and shaped. Students with this mindset are not easy to give up, can enjoy the process, are easy to ask for help, and are more determined.

Mei and Jin (2018) believe that a growth mindset refers to a mindset that believes that intelligence and talent can be changed and cultivated and attaches more importance to the role of effort than intelligence, pointing out that this mindset is the internal driving force for students' positive development.

Li and Geng (2018) believe that a growth mindset is a concept that believes in intellectual development, tends to pursue self-improvement, regards failure as an opportunity to learn and improve, and is not afraid of difficulties and dares to challenge.

Song and Xu (2019) pointed out in their research on the effect of mindset on the mental toughness of college students with left-behind experience that A growth mindset is a mindset that believes that the brain is malleable, that efforts can improve intelligence, that challenges are meant to help people learn and grow, and most importantly, that they improve themselves in the process of trying.

In his research on the effect of mindset on consumers' new product adoption, Huang(2019) pointed out that a growth mindset refers to the belief that learning and experience can promote development and significantly change a person and their behaviour. A mindset that can be changed through learning and development.

Zhang(2020) pointed out in the literature on pursuing success or growth in education that a growth mindset is a progressive development that absorbs Chinese heritage and focuses on long-term vision, the future, the inner self, sincerity and reflection.

Wu (2021) points out in his study on the effect of parents' involvement in education on academic performance that a growth mindset refers to a mentality in which human intelligence has infinite potential and develops continuously with increasing experience.

To sum up, the concept of growth mindset at home and abroad is still dominated by Dweck's definition of the concept of growth mindset. Think of growth mindset mindset is a kind of thinking mode (mindset) that holds the idea of intellectual growth, is capable of self-examining and clarifying its strengths and weaknesses, conducts information screening and goal setting according to the needs of self-growth, attaches importance to the role of efforts and the results obtained by efforts, values behaviour evaluation and feedback more than score evaluation, and holds the idea that failure provides driving force for growth.

This paper defines a growth mindset as "a positive attitude that believes that intelligence is developable, strives to master everything, dares to meet challenges and resist setbacks, is good at learning from criticism, and is easily motivated by the success of others." Students with a growth mindset believe intelligence develops over time and can be changed through their efforts. Those with a growth mindset adopt an optimistic attitude when facing challenges, setbacks, and others' successes and criticism.

2.1.3 The role of growth mindset

A growth mindset encourages students to achieve goals through their efforts, dare to try when faced with challenges, reflect on shortcomings in the face of criticism, and face everything positively. Therefore, many experts and scholars believe that a growth mindset is significant for students' personal development.

Cultivating students' growth mindset is conducive to enhancing students' learning motivation and forming positive and good value concepts (Claudia et al.,1998), which can improve students' classroom motivation. Conclusions that bring significant improvement to students' academic performance (Blackwell,2007). Having a growth mindset has a positive effect on academic achievement (Boaler & Zoido,2016). Students with a growth mindset have much better academic performance than those with a fixed mindset (Dweck, 2006).

There is a significant positive correlation between a growth mindset and perseverance, and holding a growth mindset is conducive to training students' perseverance (West et al.,2015). When a child with a growth mindset makes a mistake in completing a task, he or she will pay more attention to the task in which he or she made a mistake, make timely improvements, and improve the accuracy in subsequent tasks (Schroder et al.,2017). Cultivating a growth mindset can help students have a higher sense of self-efficacy and a sense of belonging to a certain field or occasion (Jenil et al.,2018).

Aguilar (2014) found that intervention through mindset can effectively reduce the dropout rate of poor students. It can motivate students to form internal learning motivation and enjoy learning more. It can stimulate students' learning motivation and activate their learning potential to a greater extent. Robins (2002) found that a growth mindset enables students to form scientific attribution, attributing to methods, efforts and other reasons, rather than just using intelligence and talent as an excuse. Sen ko (2011) found that students with a growth mindset choose more challenging learning tasks, have more courage to face learning difficulties, and can achieve self-motivation through self-competition, thus stimulating their potential and achieving success. Schroder (2014) found that the growth mindset helps students strengthen their psychological resilience and increase their ability to resist setbacks, thus achieving better academic results and performance. Specifically, students with a growth mindset are more motivated to learn and take on more challenges than students with a fixed mindset (Blackwell et al., 2007).

O'Brien and Makar (2015) finds a growth mindset essential for effective lifelong learning. Students with a growth mindset are more willing to learn new things, take risks, and meet challenges. Compared to students with a fixed mindset, students with a growth mindset are more likely to adapt and succeed in demanding or stressful situations (Costa & Faria, 2018) Having a positive view of the benefits of group work (Alpay & Ireson, 2006), setting learning goals instead of focusing on grades (Robins & Pals, 2002), and having a greater sense of well-being (Ortiz et al.,2019), And support policies aimed at addressing social inequality (Rattan et al., 2012). When mistakes are viewed as learning opportunities rather than judgments about fixed characteristics, students are more willing to engage and demonstrate the perseverance and resilience required for creativity and innovation (Dweck, 2006). A growth mindset may also help retain engineering students. Heyman, Martyna, and Bhatia(2002) found that all female students who dropped a course after experiencing academic difficulties had a fixed mindset. Growth mindset interventions can buffer declines in student achievement during transitional periods, such as moving to high school and starting college (Blackwell et al., 2007; Yeager, Schneider et al., 2016).

To sum up, the importance of growth mindset to personal growth must be addressed. It can help us overcome difficulties, promote personal development, and improve competitiveness and happiness. Therefore, we should actively cultivate growth mindset and make ourselves more active, aggressive, and capable.

2.1.4 Factors that influence Growth mindset

In the research on the theory of implicit intelligence, there are more detailed studies on the influencing factors of a growth mindset. Stevenson (2016) studied the learning performance of children in different cultural backgrounds and proved that cultural background effects children's intellectual concepts. Chinese children attach importance to changing their fate and having a growth mindset, while Western children attach more importance to the stability of ability and intelligence. Have a fixed mindset. By comparing Americans and Hong Kong people with different cultural backgrounds, Chi and Ying (1997) found that the proportion of Hong Kong people with a growth mindset was much larger than that of Americans. Dweck and Molden (2006) found through their research that different parenting styles (praise focusing on personality and praise focusing on the process) would lead children to develop in different directions of belief and goal, resulting in different coping behaviours and the formation of different concepts. Dweck(2016) proposed three relationships that affect mindset formation: parents to children, teachers to students, and coaches to athletes. The stronger parents and teachers have the idea that "failure will limit development", the easier it is for students to form a fixed mindset. Otherwise, it is easy to create a growth mindset. Susanna, Claro and Dweck(2016) found through their research that their family's social status affects students' self-cognition. The lower the family's social and economic status, the stronger the fixed mindset, and the more difficult it is for students to form a growth mindset.

Feuerstein (1991) believes that their families and teachers influence students' fixed mindsets. General teaching activities may also form a fixed mindset for students. For example, the lack of mobility between ability groups leads to the formation of a fixed mindset for students (Davies et al.,2003). Gunderson (2013) believes that the way of learning and communication between teachers and students in schools is also one of the important reasons for the prevalence of fixed mindset. Boaler(2015) pointed out that school teaching is usually designed based on students' ideas with a fixed mindset, for example, grouping activities according to ability or rewarding students according to learning achievements rather than learning processes. Inability grouping activities, some groups usually complete more difficult tasks, which leads students to believe that some students have higher abilities than others.

So, to innovate students' mindset and realize students' growth, how do we cultivate students' growth mindset? Cultivating Cultivate students' Growth mindset mode mainly starts with teachers, students, parents, peers, campus and other aspects. Grusec and Goodnoe et al. (1994) proposed that it is necessary to develop parents' growth mindset first to cultivate children's growth mindset. Children usually accept and internalize their parents' beliefs, behavioural standards and values. In an interview with subjects in an elementary school, Diana M. Fraser (2018) found that cooperative learning was an important factor for success and task continuity. Dweck(2019) believes that when a school's cultural system supports students in seeking challenges, the growth mindset is more likely to take root in students' minds. In addition, parents can lead students to jointly establish "growth family rules", establish mindset assessment files, etc., to encourage family and friends to motivate each other and make progress together.

Research on the factors influencing the growth mindset has begun in China recently. Li and Geng (2018) point out through their research on growth mindset theory that Parents' and teachers' evaluation of students' behaviour has the most significant effect on growth mindset. Compared with feedback on personal orientation information, process-oriented evaluation can make students more aware of the power of diligence, effort, and persistence. In their study, he and Sang (2021) mentioned that parents' views on failure can be transformed into specific educational behaviours and effect children's mindsets. Niu and Li (2022) found that in the teacher evaluation article on promoting growth mindset development, students' growth mindset can be developed through various ways, such as knowledge teaching guidance, subtle guidance, and model guidance. Among them, teachers' evaluation of students in daily teaching is the most efficient way to cultivate students' growth mindset.

To sum up, foreign research views on the factors affecting growth mindset can be summarized as follows: growth mindset is jointly affected by internal and external factors such as information disseminator, information feedback mode, family status, cultural background, etc. Under the joint action of various factors, people's mindsets will be inclined to one end like a balance, thus forming a fixed mindset or growth mindset. However, domestic research on the factors influencing growth mindset is in the early stages, and the research has yet to go beyond the scope of the factors proposed by

Dweck. The main scope of practice verification is still parental rearing style, teachers' teaching evaluation method, family and cultural background.

2.1.5 The intervention practice of a Growth mindset

Dweck and her team have conducted many intervention experiments and practical studies in recent years. JA Mangels and Dweck (2006) took 464 undergraduate students as research objects and used event-related potential technology (ERP) to study the feedback of holders of different mindsets on failure information. This paper analyzed the relationship between a growth mindset and problem-solving strategies and conducted a learning intervention study on cultivating a growth mindset with students in grades 4-9 as subjects. By setting four units, namely, brain foundation, brain behaviour, brain construction and brain plasticity, Each unit includes courses of connection, testing, practice and application, group discussion and sharing, personal reporting, practical operation and exploration, integration of online and offline courses and other learning activities, and implementation of learning intervention programs to understand the brain mechanism, internalize brain science knowledge and activate growth mindset, with remarkable results.

Blackwell (2011) tracked 99 seventh-grade students with learning difficulties in a public school in New York City, and the results showed that the math scores of students in the intervention group were significantly improved compared with the control group, and the student's achievement motivation was effectively stimulated.

Dweck (2006) took seventh-grade junior high school students as research objects and conducted a learning intervention with a growth mindset. After long-term tracking, it was found that students' performance after learning under the guidance of a growth mindset for one year significantly improved and far exceeded that of other students.

Yeager (2016) selected ninth-grade students from 65 ordinary public schools in the United States to conduct a 20-day interval controlled experiment of online course intervention, and the study showed that the students in the intervention group had significantly developed and improved their growth mindset tendencies.

In 2010, Chinese scholars began to pay attention gradually to research and exploration in mindset. Xin and Yu et al. (2011) explored the mindset of senior primary school students in China by using Raven's reasoning test questions to create a situation and implement different ways of praise for 101 children in grade 5.

Li and Peng (2017) selected 885 students from grades 3 to 9 from two schools in Shanghai to carry out the intervention practice of growth mindset with praise and story reading as intervention means and achieved remarkable results.

Zhang (2019) selected 123 science and engineering college students at a university in Beijing to conduct an intervention experiment on a growth mindset. The subjects were asked to read materials about two types of mindsets respectively and then carried out the task of team innovation design. The research showed that The innovation team with a stronger growth mindset believes in the plasticity of team scientific creativity and actively initiates innovation activities. In this process, the team's sense of innovation efficacy is also improved.

Lai(2022) conducted four experimental interventions on 72 students in a high school using observation learning and category learning judgment, and the research results proved that a growth mindset has a higher effect on self-regulated learning. The group with a growth mindset also performed relatively well in category learning.

To sum up, after theoretical research has formed a systematic system, foreign scholars have conducted many practical intervention studies on the cultivation of a growth mindset and its effect on the learning effect, confirming the effectiveness of the intervention of a growth mindset and its promoting effect on the learning effect. The total amount of research on growth mindset intervention projects in China is small, and the duration is short. Some domestic researchers have introduced a growth mindset and conducted relevant practical research. However, systematic and large-scale practical studies on the intervention practice of growth mindset have yet to be carried out. Although the total number of studies is small, its development momentum is rapid, and the future research prospects are promising.

2.1.6 Measurement of Growth mindset

The measurement of a growth mindset mainly adopts the scale method, which developed a growth mindset measurement tool. Dweck et al. (1995) compiled a 3-item scale of the implicit Theory of Intelligence to measure individuals' beliefs about competence using a 6-point scale. The higher the score, the more inclined to fixed thinking. In a new study, Dweck(2013) re-formulated the growth mindset scale (GMS) to measure the intellectual development concept of the subjects. The scale has 20 items, 10 of which are reverse-scoring questions with a 4-point score. A higher score on the scale means that an individual is more inclined to a growth mindset. With high reliability and validity and good cultural adaptability, this scale (GMS) has been widely used in research on growth mindset.

With the further promotion and deepening of the research on growth mindset, other Chinese scholars have also revised and supplemented the growth mindset scale according to their own research needs and domestic cultural background. Cheng and Hou (2002), referring to Dweck's definition of implicit outlook and relevant scales and combined with the interview results of primary and secondary school students, compiled the implicit outlook scale for primary and secondary schools, which divided implicit outlook into five dimensions of morality, personality, intelligence, creativity, and emotional intelligence, with a total of 40 items. Chen et al. (2021) summarized the growth mindset into six dimensions, including motivation, attitude, effort, adversity, challenge, and positive mentality, with 18 items.

2.2 Inquiry-based Learning

2.2.1 The rise and development of inquiry-based learning

The National Science Education Standards of the United States once defined inquiry as a learning activity conducted by learners in which learners can acquire scientific knowledge, feel scientific ideas and experience scientific methods. Wu(2005) defines inquiry as a problem-driven learning process involving scientific investigation, recording and interpreting text or data, and summarizing and communicating findings. However, the definition of inquiry-based learning is controversial among scholars from various countries. The author selects several representative scholars at home and abroad to provide their understanding of its meaning.

Joseph (1962) defined inquiry-based learning as an activity in which students acquire knowledge through independent participation in education. In this process, students can master the inquiry ability necessary for understanding nature, form corresponding scientific concepts, and develop a positive attitude towards exploring the world.

Blumenfeld (1991) pointed out that inquiry-based learning focuses on teachers encouraging students to participate in investigation. In this process, students ask questions, exchange views, make bold predictions, design experiments, collect and analyze data, draw conclusions, explain their ideas and findings to others, propose new problems and seek solutions to new problems.

Field et al. (2007) pointed out that in inquiry-based learning, students develop critical thinking (mindset) by exploring loosely structured mathematical problems and evaluating and constructing mathematical arguments.

Zhang (2011) believes that inquiry-based learning refers to a learning mode in which students acquire scientific knowledge and skills using methods similar to scientific research under the guidance of teachers.

Lu (2000) believes that inquiry-based learning means that learners learn science by imitating the scientific research process to grasp the scientific content while experiencing the scientific research methods and improving their scientific research ability. Scientific research is very similar to the teaching situation; students independently choose research questions and explore with techniques similar to scientific research, take the initiative to discover rules and experience the success and failure of exploration.

It can be seen that "inquiry learning" is a way of learning and a view of learning. As a learning method, inquiry-based learning often occurs in classroom teaching. Teachers and students work together to solve a subject problem, improve students' active thinking and hands-on inquiry ability, and cultivate their unity, cooperation and innovative inquiry spirit. As a learning concept, inquiry learning emphasizes that students should hold a positive learning attitude, which is good at finding and solving problems, not only in learning but also in their daily lives. In the whole learning process, students can, with the help of teachers or others, construct new experiences or knowledge based on original experience, achieve appropriate connections and integration of old and new knowledge and acquire corresponding skills.

This study defines inquiry learning as a teaching form in which, under the guidance of teachers, students explore content based on teaching materials through independent learning and cooperative discussion, provide students with opportunities to question, explore and discuss, allow students to solve problems through independent thinking and group communication and discussion, and apply theoretical knowledge to practice.

2.2.2 Characteristics of Inquiry Learning

The points mentioned below are noted as the fundamental features of classroom inquiry in the “Inquiry and the National Science Education Standards”:

1. Learners are engaged by scientifically oriented questions.
2. Learners give priority to evidence, which allows them to develop and evaluate explanations that address scientifically oriented questions.
3. Learners formulate explanations from evidence to address scientifically oriented questions.
4. Learners evaluate their explanations in light of alternative explanations, particularly those reflecting scientific understanding.
5. Learners communicate and justify their proposed explanations. (National Research Council, 2000)

2.2.3 Research on the model of inquiry learning

The literature review found several major inquiry learning models, including John Dewey's five-step inquiry model, Joseph J. Schwab's scientific inquiry model, the 5E learning ring model and Richard Suchman's inquiry training model.

John Dewey(1896) is the earliest educator to apply inquiry methods to teaching. He also applies this method to K12 teaching. As the central content of his educational philosophy, he believes that the best way to apply inquiry is to learn by doing. John Dewey also proposed five stages of the reflective thinking process: puzzle-problem-hypothesis-inference-verification. One is the difficult situation; The second is to determine the problem; the Third is to put forward various hypotheses to solve the problem; The fourth is to infer these assumptions; the Fifth is to verify or modify the hypothesis. Doubt and hypothesis are the core of his thinking method, and the five-step thinking process corresponds to his theoretical thought.

Joseph J. Schwab (1958) proposed an inquiry-based learning operation that follows five basic steps: Step 1: Introduce students to the field of study and research methods; The second step: clarify the problem and identify the difficulties in the research process; Step 3: Think about the situation and make hypotheses; Step 4: Try to solve the problem, or reorganize the data from different angles and redesign the experiment until the problem is solved smoothly; Step 5: Derive conclusions. He believes there ar e two main ways in the teaching activities in the form of inquiry: one is the understanding of science itself, that is, science is inquiry; the other is the research of teaching and learning, that is, inquiry teaching and learning.

The 5E learning loop is a theoretical model proposed by Piaget and later extended into a teaching model through the development of R. Beebee (1989). The 5E learning loop also has five corresponding teaching links: Engage, Explore, Explain, transfer and Evaluate:

Step 1: Engage. The beginning link is the introduction of classroom teaching. From students' perspective, teachers create meaningful teaching scene activities, use interesting and diverse ways to attract students' attention to the classroom, and fully mobilize students' learning interest and desire for knowledge.

Step 2: Explore. The central link, the mastery of theoretical knowledge and skills, is completed in this link. Teachers guide students to think actively, use old knowledge, explore and solve problems.

Step 3: Explain. The key part is to test whether the student understands the content. After the inquiry, the teacher will provide opportunities for students to explain and analyze the results and use their language to explain them. The teacher then guides the students to use mathematical language to explain their findings according to the students' explanations so they can have a deeper understanding of mathematical concepts.

Step four: Elaborate. The strengthening link is also an extension link. After students acquire new concepts, they use them to solve relevant mathematical problems and improve their mastery and application of new ideas.

Step 5: Evaluate. The reflection link is also the summary link and the end link. The evaluation standard is not only limited to the degree of knowledge mastery but also to the students' comprehensive ability. In terms of evaluation, from the diversified evaluation methods, multi-dimensional evaluation content, and diversified evaluation subjects, students' comprehensive ability is comprehensively examined so that they can correctly understand themselves and constantly reflect on themselves to obtain the joy of learning and success.

To sum up, inquiry-based learning has experienced a long process, and the inquiry-based learning model has gradually improved. In this study, the 5E learning loop model was adopted.

2.2.4 Effect of inquiry-based learning enhances growth mindset

Cobb, Wood and Yackel(1993) describe inquiry-based learning as an apprenticeship in which a mindset is developed in the classroom. Support students in solving ambiguous and ill-structured problems (Makar,2012). Poorly structured issues must be clarified, and some open restrictions must be negotiated (Reitman,1965).

The teacher provides the student with questions or queries and necessary materials in the guided inquiry form. Students must find appropriate problem-solving strategies and methods (Bruder & Prescott,2013). While solving an inquiry problem, students are asked to plan, identify, and provide mathematical evidence. The need for consultation, decision-making, reasoning, and collaboration differs from the usual practice of school mathematics, which centres on clarity, structure, and lack of ambiguity (Baber, 2011). Working with ambiguity and openness requires flexibility and a willingness not to know. See learning as an opportunity to build new knowledge and new ways of thinking, and be prepared to take risks and work collaboratively in creating and testing ideas and solutions.

Inquiry-based learning allows for flexibility in the learning environment, as students can learn in a way that best suits their learning style (Kogan et al., 2014). Inquiry-based teaching allows students to learn through personal interests (Harlen,2013). Students learn more when engaging in authentic, active forms of learning (Tawfik et al., 2018). Through guided inquiry learning, students can acknowledge their feelings and thoughts. In the process, students can understand their learning and transfer it to future learning (Kuhlthau & Maniotes,2010). Inquiry-based learning enables students to apply their knowledge to other aspects of life. During this learning process, students can think more deeply about acquiring information by synthesizing, analyzing, and evaluating their knowledge (Richmond et al., 2015).

Cooperation is beneficial to the success of students. Inquiry-based learning allows students to collaborate. Through this collaboration, students can help each other and offer advice to each other. This process can not only improve students' understanding of knowledge but also help to shape their mindset. These strategies help foster a growth mindset in students (Dweck, 2015). Inquiry-based learning can help students better understand what they are learning, enabling them to use these skills more practically in their daily lives (HARLEN, 2013).

Inquiry-based learning allows students to grow in areas not available in traditional classrooms. In their research, Goodnough and Cashon(2006) identified three areas where students can grow from research-based learning. Students improve their ability to work and make decisions in a team environment. Students also mentioned doing a better job researching and presenting information to their classes (Goodough & cashon,2006). Inquiry-based learning helps prepare students for future studies and potential careers. This study allows students to gain experience in developing ideas and executing plans. Students can gain innovative experiences through this learning process (Acar & Aybars, 2019). Students who have experienced inquiry-based learning in the classroom enjoy it because they are active participants. As a result of this ownership, students are more engaged in their studies (Goodough & cashon,2006).

Inquiry-based learning classrooms have been shown to do a better job of creating a supportive classroom atmosphere where students receive continuous feedback about their work (Kogan & Laursen, 2014). Inquiry-based learning provides students with opportunities for multiple forms of knowledge, including course content, information literacy, learning how to learn, literacy, and social skills (Kuhlthau & Maniotes, 2010). Research-based learning prepares students for all types of situations. These situations include traditional classrooms where students would be in middle school (Kogan & Laursen, 2014).

According to Cox and Walton et al. (cited in Auten, 2013), students' interactions with peers and teachers in the classroom environment effect each student's mindset. The classroom environment can determine students' sense of belonging and confidence in the content. This shows that the classroom environment can affect students' mentality. The classroom environment helps shape students' mindsets about academic outcomes (Auten, 2013). Teachers are essential in creating a classroom environment that prepares students for success. Creating an environment where students want to learn and are willing to work hard is crucial. In this environment, teachers must provide students with the necessary tools to use when encountering difficult work (Auten, 2013). In an inquiry-based learning environment, teachers need to ensure that an environment of trust is established. In this trusting environment, students are more likely to make mistakes and reflect (Steurer, 2018).

Inquiry-based learning creates a student-centered learning environment. In such an environment, students should be let know that it is okay to make mistakes and should be allowed time to reflect on their mistakes (Steurer, 2018). Students' ability to learn from their mistakes is rooted in their growth mindset (Steurer, 2018). An essential part of inquiry-based learning is that making mistakes is part of the learning process. This type of learning allows students to escape difficult situations (Steurer, 2018). In this context, there is a link between a growth mindset and inquiry-based learning.

Inquiry-based learning empowers students and allows them to grow differently than traditional classrooms. Inquiry-based learning allows students to grow in areas not available in traditional math classrooms. In their research, Goodnow and Cashin (2006) identified three areas where students can grow from research-based learning. The students improved their working and decision-making skills in a group environment. Students also mentioned doing a better job researching and presenting information to their classes (Goodnow & Cashin, 2006). These types of skills will help prepare students for their future careers. Research-based learning helps prepare students for future studies and potential careers. This study allows students to gain experience in developing ideas and executing plans. Students can gain innovative experiences through this learning process (Acar & Aybars, 2019).

Studies have shown that students more involved in learning are more likely to develop a growth mindset (Dweck, 2015). Wiggins et al. (2017) found success in students' mindsets after completing inquiry-based learning. Inquiry pedagogy in the mathematics classroom can enable teachers to become models and scaffolding and enable students to experience firsthand what it means to embrace challenge, persevere, mobilize effort in the pursuit of mastery, learn from criticism, and find lessons in the learning and success of others (O'Brien & Makar, 2015).

In summary, inquiry may provide students with an engaging learning experience that offers a degree of openness, challenge, and autonomy. If properly underpinned and supported by reinforcement of skill development and related tendencies such as evidence-based reasoning, mastery learning, and resilience in the face of challenges, research-based learning can further enhance and promote growth mindset. It is an opportunity to learn how to face the unknown confidently and learn from and with others. Take risks, explore ideas, reflect on your learning process, and question assumptions and ideas. In this paper, we identify teaching practices that, while inherently inquiry-based learning, can promote and support a Growth mindset in the research-based classroom.

CHAPTER 3
RESEARCH METHODOLOGY

This chapter will discuss the methodological framework used in our study to examine the effect of mathematical inquiry learning on the growth mindset of first-year students in higher vocational colleges. This chapter will provide a detailed overview of our research, data collection, and analysis methods.

3.1 Research design

This study adopted a quasi-experimental design, with inquiry-based learning as the independent variable and growth mindset as the dependent variable. The research design divided the samples into experimental and control groups. After the pre-test, the experimental group adopted inquiry-based learning, while the control group adopted traditional imparted learning. The two groups compared the post-test results to investigate the effect of mathematical inquiry learning on the growth mindset of first-year students in higher vocational schools.

3.2 Population and sample selection

1. Population:

This research project mainly aims at 358 first-year students of the Civil Engineering College of Jiuquan Vocational and Technical College.Jiuquan Institute of Vocational Technology is in Jiuquan City, Gansu Province, Northwest China. It is a full-time specialized level general higher vocational institution for the record of the Ministry of Education of China.

2. Sample:

The samples of this study were 40 first-year students enrolled in the School of Civil Engineering at Jiuquan Polytechnic College. Prior to the experiment, a preliminary assessment of growth mindset was conducted among 358 first-year students. Based on this assessment, 40 individuals with scores ranging from 30 to 60 were selected as the research sample. These participants were then randomly assigned to either the experimental group or the control group, with 20 participants in each group, to enhance the representativeness and reliability of the findings. All selected participants possessed basic computer literacy, voluntarily agreed to participate in the study, and provided written informed consent.

3.3 Research Instrument

Two sets of instruments were employed in this study for data collection. The Inquiry-based learning program was implemented, and quantitative data were obtained via pre- and post-tests of the growth mindset scale. All instruments were rigorously validated by domain experts to ensure their validity and suitability for the study.

1.Inquiry-based learning program

Inquiry-based learning is an educational approach in which students, under the guidance of teachers, identify problems, gather resources, solve issues, and analyze and explain problems within teaching activities. Through this process, students independently construct, acquire, and apply knowledge. Furthermore, inquiry-based learning enhances students' critical thinking, practical skills, and scientific literacy. This method typically involves the following five steps:

Step 1: Engage. Teachers should design meaningful problem scenarios by integrating mathematical concepts with real-world examples and physical models to capture students' attention and stimulate their curiosity.

Step 2: Explore. Teachers should carefully select appropriate materials for exploration based on the specific context and guide students through the investigative process. During this phase, students take the lead by engaging in group collaboration and communication to express their ideas and explore solutions using diverse methods. Teachers observe students' performance, listen to their thoughts, and provide targeted guidance to groups requiring assistance. This step helps students articulate their preconceptions and lays the foundation for the development of new concepts.

Step 3: Explain. Students conduct a comprehensive review of the methods and skills utilized during the exploration phase. Teachers encourage students to articulate their understanding of concepts and any challenges they encountered in their own words. Students present their findings using precise symbolic language and rigorous reasoning processes. Peer groups may question each other regarding unclear knowledge points. Finally, teachers introduce new terms and definitions using standardized mathematical language and symbols, building upon students' prior experiences and correcting misconceptions as needed.

Step 4: Elaborate (Migrate). After acquiring new concepts, students apply them to solve related mathematical problems, thereby reinforcing their mastery and practical application of these concepts.

Step 5: Evaluate. A diversified evaluation system, incorporating multiple dimensions and varied evaluators, comprehensively assesses students' overall abilities. This enables students to develop an accurate self-assessment and encourages continuous reflection, fostering a sense of learning satisfaction and success.

2. Growth Mindset Measurement Scale

The Growth Mindset Scale employed in this research was originally developed by Dweck (2013) and has been appropriately adapted to reflect the pedagogical characteristics of mathematics instruction in higher vocational colleges. The revised version of the scale consists of 24 items, each with four response options. The scoring system is structured as follows: Strongly Agree corresponds to 4 points, Agree to 3 points, Disagree to 2 points, and Strongly Disagree to 1 point.

To ensure content validity, input from three subject matter experts was solicited. The Item Objective Consistency (IOC) index was utilized as a quantitative measure of validity, and only items with IOC values between 0.67 -1.00 were retained. The revised version of the scale demonstrated high internal consistency, with a Cronbach's alpha coefficient of 0.921. These results suggest that the adapted Growth Mindset Scale possesses adequate psychometric properties and is suitable for use within the context of this study.

Table 1 Reliability Detection

	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted	Alpha
A1	0.306	0.922	0.921
A2	0.387	0.921	
A3	0.483	0.919	
A4	0.449	0.920	
A5	0.421	0.920	
A6	0.359	0.921	
A7	0.447	0.920	
A8	0.610	0.917	
A9	0.617	0.917	
A10	0.484	0.920	
A11	0.683	0.916	
A12	0.721	0.915	
A13	0.495	0.919	
A14	0.684	0.916	
A15	0.573	0.917	
A16	0.726	0.915	
A17	0.584	0.917	
A18	0.334	0.922	
A19	0.742	0.915	

Table 1 (continued)

	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted	Alpha
A20	0.654	0.916	
A21	0.699	0.915	
A22	0.582	0.917	
A23	0.693	0.916	
A24	0.708	0.915	

As shown in Table 3-1, the reliability coefficients of the scale items are consistently high, ranging from 0.915 to 0.922. Furthermore, the correlations for each item exceed 0.2. When any particular item is removed, the reliability coefficient does not show a substantial increase. Therefore, it can be inferred that the survey data exhibit a high degree of reliability, and the questionnaire items are justified for retention.

3.4 Research Procedures

This study adopts the experimental research method, which is divided into three stages: pre-test, Inquiry-based learning intervention and post-test. The specific process is as follows:

Step 1: Pretest

All participating students were assessed prior to the commencement of the experiment to determine their baseline levels of growth mindset. Each student completed a standardized questionnaire, evaluating each item on a 4-point Likert scale based on their personal circumstances. A higher cumulative score reflects a more pronounced growth mindset orientation. Subsequently, forty participants whose scores ranged from 30 to 60 were randomly and evenly assigned to two experimental groups, each consisting of twenty individuals, to proceed with the subsequent phase of learning and evaluation.

Step 2:. Intervention based on inquiry-based learning

At this stage, the experimental group received inquiry-based learning, whereas the control group did not, in order to investigate the impact of inquiry-based learning on the development of a growth mindset. This study utilizes the teaching content of higher vocational mathematics as the experiment tool for implementing inquiry-based learning. The specific implementation process is structured into five stages: engage, explore, explain, elaborate, and evaluate, with the aim of guiding participants to actively engage in the learning process and enhance their growth mindset. The inquiry-based learning experiment spans four weeks, conducted three times per week, with each session lasting two hours.

Step 3: Post-test

Following the completion of the inquiry-based learning program, a post-test was administered to all participating students to evaluate potential shifts in their growth mindset. The same validated growth mindset scale used in the pre-test was employed for the post-test assessment.

3.5 Data Collection

The experimental and data collection procedures were as follows:

First, the growth mindset questionnaire was used to understand the current score of first-year students' growth mindset.

Secondly, after participating in inquiry-based learning, students will again take the growth mindset questionnaire to understand the growth mindset after the test.

3.6 Data Analysis

Data analysis was conducted using SPSS statistical software. Descriptive statistical analysis and t-test were utilized to examine and compare the growth mindset scores of the experimental and control groups. Prior to the experiment, an independent samples t-test was performed on the pretest data to assess baseline equivalence, yielding mean values and corresponding t-values. Following the experiment, both groups completed a posttest, and a subsequent t-test was conducted to evaluate post-experiment performance. A comparative analysis of pretest and posttest scores indicated that the experimental group not only outperformed the control group in the posttest but also demonstrated a notable improvement from its own pretest scores.

Further analysis using paired samples t-tests revealed statistically significant differences in the experimental group's scores before and after the experiment. Moreover, a statistically significant difference was observed between the posttest scores of the experimental and control groups, suggesting the experiment had a measurable effect on fostering a growth mindset.

CHAPTER 4
RESEARCH RESULTS

4.1 Descriptive Statistics

The study collected data from 40 first-year college students who were randomly assigned to an experimental or control group. Two sets of descriptive statistics are calculated as follows:

4.1.1 Pre-experimental Analysis of Growth Mindset Differences Between the Experimental and Control Groups

This study collected data from 358 first-year college students. Among them, 40 students with scores ranging from 30 to 60 were selected and randomly assigned to either the experimental group or the control group. Two sets of descriptive statistics were calculated as follows:

Table 2 Analysis of differences of in Growth Mindset between the experimental group and the control group before the experiment

Data description: pre-test results						
Variable	Group	N	Mean	Standard Deviation	T	P
Growth mindset	control	20	1.958	0.702	- 0.707	0.484
	experiment	20	1.831	0.393		

The data indicates that the pre-experiment average scores for Growth mindset were 1.831 in the experimental group and 1.958 in the control group. A statistical significance test comparing these scores yielded a p-value of 0.484, which exceeds the conventional alpha level of 0.05. This outcome demonstrates that there was no statistically significant difference in Growth mindset between the two groups prior to the implementation of the inquiry-based learning experiment. Consequently, it is methodologically sound to proceed with administering the inquiry-based learning program to the experimental group.

4.1.2 Analysis of the Differences in Growth Mindset Before and After the Experiment in the Experimental Group

Table 3 Analysis of the Differences in Growth Mindset of the Experimental Group Before and After the Experiment

	The results of the experimental group before and after the experiment					
Variable	Group	N	Mean	Standard Deviation	T	P
Growth mindset	Pretest	20	1.831	0.393	13.948***	0.000
	Posttest	20	3.185	0.499		

*** $p < .001$

The data indicate that, following the implementation of inquiry-based learning in the experimental group, there was a notable increase in the average Growth Mindset score, rising from 1.831 to 3.185, which reflects a meaningful improvement compared to pre-experiment levels. Statistical analysis revealed a significant difference in Growth Mindset scores before and after the experiment, with a p-value of less than 0.001. These findings provide strong evidence that inquiry-based learning had a significant effect on the development of Growth Mindset among students in the experimental group.

4.1.3 Analysis of the Differences in Growth Mindset between the Experimental Group and the Control Group Post-Experiment

Table 4 Analysis of the differences in Growth Mindset between the experimental group and the control group after the experiment

Data description: post-test results						
Variable	Group	N	Mean	Standard Deviation	T	P
Growth mindset	Control	20	2.423	0.482	4.916^{***}	0.000
	Experimental	20	3.185	0.499		

*** p < .001

Data indicate that following the implementation of the inquiry-based learning program, a statistically significant difference emerged in growth mindset development between the experimental group and the control group ($p < 0.001$). These findings reveal that students in the experimental group demonstrated considerably higher post-experiment growth mindset scores compared to those in the control group.

CHAPTER 5
CONCLUSION AND DISCUSSION

5.1 Research Objectives

The objectives of this study are as follows:

5.1.1 To compare the differences in growth mindset scores of the experimental group before and after participating in inquiry-based learning.

5.1.2 To compare the differences in growth mindset scores between the control group and the experimental group after inquiry-based learning.

5.2 Research Hypotheses

5.2.1 After participating in the experimental project, the experimental group exhibited a higher average growth mindset score compared to their pre-project scores.

5.2.2 After participating in the experimental project, the experimental group demonstrated a higher average growth mindset score compared to the control group.

5.3 Research Method

This study utilizes a quasi-experimental research design to investigate the effect of inquiry-based learning on the cultivation of a growth mindset among college students. The independent variable is the instructional method, specifically comparing inquiry-based learning with traditional teaching, while the dependent variable is the development of a growth mindset. Prior to the intervention, a pre-test was administered, and based on the results, a sample of 40 participants scoring between 30 and 60 was randomly assigned to either the experimental group or the control group. The experimental group engaged in inquiry-based learning activities, whereas the control group received instruction through conventional teaching methods. Following the intervention, a post-test was administered, and the outcomes were analyzed to evaluate the efficacy of inquiry-based learning in fostering a growth mindset.

This study takes students' growth mindset as the research object and compares the total average scores of the pre-test and post-test.

5.4 Conclusion

This study utilized a quasi-experimental research design to examine the effect of inquiry-based learning on the cultivation of a growth mindset among first-year college students. Building on the empirical findings detailed in Chapter Four and in accordance with the two defined research objectives and their associated hypotheses, the following conclusions can be drawn:

1. To examine changes in growth mindset scores among participants in the experimental group before and after engaging in inquiry-based learning.

Research Objective 1 is designed to investigate changes in growth mindset scores among participants in the experimental group before and after engaging in inquiry-based learning. According to the research findings presented in Table 4-2, the average growth mindset score in the experimental group increased markedly from 1.831 to 3.185. The results of the statistical analysis ($p < 0.001$) demonstrate that this increase is statistically highly significant. These outcomes provide robust support for Research Hypothesis 1, which asserts that the growth mindset score of the experimental group post-intervention was significantly higher than the pre-intervention baseline. Collectively, these findings offer compelling evidence that inquiry-based learning effectively promotes the development of students' growth mindset.

2. To compare the differences in growth mindset scores between the control group and the experimental group after inquiry-based learning.

Research Objective 2: To compare the differences in growth mindset scores between the experimental group and the control group following participation in an inquiry-based learning program. The research findings (Table 4-3) demonstrate that the experimental group achieved a significantly higher average post-test score ($M = 3.185$) than the control group ($M = 2.423$). Statistical analysis revealed a statistically significant difference between the two groups ($p < 0.001$), thereby providing support for Research Hypothesis 2. These results indicate that, after engaging in the inquiry-based learning intervention, the experimental group exhibited a more pronounced development of a growth mindset compared to the control group. This finding further highlights the superior efficacy of inquiry-based learning over traditional instructional methods in promoting a growth mindset.

5.5 Discussion

This study aims to investigate the impact of inquiry-based learning in mathematics on the development of a growth mindset among first-year students in Chinese higher vocational colleges. The research findings provide robust empirical support for both research hypotheses.

First, with respect to the first research objective, this study examines potential differences in growth mindset scores among students in the experimental group before and after their engagement in inquiry-based learning. The hypothesis posits that the average growth mindset score of the experimental group will demonstrate a statistically significant increase following participation in the experiment. The results indicate that the growth mindset scores of students in the experimental group increased significantly after completing the inquiry-based learning program, with the difference reaching statistical significance ($p < 0.001$). These findings substantiate Hypothesis 1, suggesting that inquiry-based learning effectively contributes to the enhancement of students' growth mindset.

From a theoretical standpoint, the research findings exhibit a robust congruence with Dweck's (2006) theory of growth mindset. This framework highlights several essential features: a constructive orientation toward challenges, the capacity to extract meaningful insights from errors, and the prioritization of effort and procedural development over immediate outcomes. Notably, inquiry-based learning—characterized by students' active engagement in problem identification, collaborative communication, and iterative reflective improvement—directly reflects these foundational attributes of a growth mindset.

The systematic implementation of inquiry-based learning in this study has demonstrated a pivotal contribution to the development of a growth mindset throughout all stages of the learning process:

The first stage is Engage. In this phase, teachers are expected to create meaningful problem contexts by linking mathematical concepts with real-life situations. This strategy aims to capture students' attention, stimulate interest in the learning task, foster curiosity, and establish clear objectives for exploration. Through skillful verbal guidance and the integration of growth mindset-oriented encouragement, students develop confidence in their ability to explore new knowledge actively. By overcoming pre-existing fixed mindsets such as resistance or fear of challenges, students can more readily adapt to the inquiry-based learning environment, thereby promoting the development of a growth mindset.

The second stage is Explore. Here, students assume a central role in the learning process. They are encouraged to accept challenges, express their ideas collaboratively within groups, and engage in diverse methods of exploration to collectively complete tasks. Within the collaborative framework, students experience intellectual exchange, draw inspiration from peers' successes, and cultivate the disposition to engage in discussions and strive for leadership roles. Furthermore, through group cooperation, students maintain motivation and confidence when facing challenges, reducing self-doubt that may arise during independent exploration. This stage reinforces the continuous development of growth thinking.

The third stage is Explain. It involves a comprehensive review of the strategies and techniques employed during the exploration phase. Students articulate their understanding, interpretations, and encountered difficulties using their own words. They then present their findings using precise symbolic language and logical reasoning. Peer questioning among groups is encouraged to deepen conceptual understanding. Subsequently, the teacher provides explanations of new terms and definitions using standardized mathematical language and symbols, drawing upon students' prior experiences. Any misconceptions formed during self-exploration are promptly corrected. When students encounter partial misunderstandings or incorrect solutions, it is essential to guide them out of negative emotional states associated with being "wrong," preventing regression into fixed thinking patterns. Through reflection and guided clarification, students enhance their sense of self-efficacy and begin to internalize an independent growth mindset.

The fourth stage is Elaborate. At this point, students apply newly acquired concepts to solve related mathematical problems, thereby deepening their comprehension and practical application of the material. When presented with varied types of assignments, students demonstrate eagerness to learn, recognizing the value of effort. This stage further nurtures the development of a growth mindset, enhances students' confidence in mathematics, and helps them move beyond limiting fixed thinking patterns.

The fifth stage is Evaluate. A comprehensive assessment is conducted through multiple evaluation methods, multidimensional criteria, and diverse evaluators. This allows students to gain accurate self-awareness, engage in reflective practices, and ultimately experience the satisfaction and joy of academic progress. Reflections across various levels—such as knowledge acquisition, thinking strategies, and mathematical literacy—contribute to the enrichment of students' cognitive frameworks. As students embrace a growth mindset that supports personal development, they come to believe that intelligence can be cultivated through effort and that abilities can be enhanced through social influence. Consequently, they become more resilient and motivated to face challenges with determination.

Research has shown that inquiry-based learning supports self-regulation, agency, and resilience among students. For instance, Steurer (2018) emphasized that allowing students to learn from mistakes and reflect on their learning processes in inquiry-rich environments promotes deeper mindset transformation. Similarly, Blackwell, Trzesniewski, and Dweck (2007) found that junior high school students who received growth mindset experiments showed improved academic motivation and achievement over time.

In the specific context of vocational education, this finding holds added significance. Students in vocational colleges often struggle with self-perception issues, believing their academic abilities—especially in subjects like mathematics—are fixed and limited (Boaler, 2009; He, 2023). Inquiry-based learning, by emphasizing effort, process, and collaborative problem-solving, helps dismantle these limiting beliefs. The learning process becomes a positive feedback loop where effort leads to success, which in turn reinforces a growth-oriented belief system (Paunesku et al., 2015; Yeager et al., 2019).

Moreover, the model used in this study provided multiple opportunities for students to explore problems independently and in groups, make mistakes safely, and receive scaffolded support from teachers. These conditions have been identified as critical in fostering intellectual risk-taking and long-term academic resilience (Goodnough & Cashion, 2006; Kuhlthau & Maniotes, 2010).

In conclusion, the findings of this study provide strong evidence that inquiry-based learning constitutes a highly effective pedagogical strategy for cultivating a growth mindset among students in higher vocational institutions. This approach not only significantly enhances students' motivation to learn and their cognitive flexibility, but also presents a practical and sustainable alternative to the conventional, lecture-dominated instructional model. Future efforts should focus on further aligning inquiry-based pedagogy with the theoretical foundations of growth mindset, which can in turn facilitate deeper curricular reform in higher vocational mathematics and support the attainment of core literacy objectives.

Second, regarding the second research objective, this study compares the growth mindset scores between the experimental group and the control group after the implementation of inquiry-based learning. The hypothesis assumes that the experimental group will exhibit significantly higher average growth mindset scores than the control group post-experiment. The findings confirm this assumption, as the data reveal that the experimental group's scores on the growth mindset scale were markedly higher than those of the control group ($p < 0.001$). This outcome provides evidence that inquiry-based learning is more effective than traditional teaching methods in promoting the development of a growth mindset among vocational college students.

Inquiry-based learning promotes an active, student-centered classroom environment where learners are encouraged to explore problems, engage in collaboration, and reflect on their learning processes. This contrasts sharply with conventional instruction, which tends to emphasize passive knowledge acquisition and memorization (Hmelo-Silver, Duncan, & Chinn, 2007). The student-centered design of inquiry-based pedagogy supports the psychological development of learners by encouraging intellectual risk-taking, learning from failure, and persistence in solving complex problems (Zimmerman, 2002; Kuhlthau, Maniotes, & Caspari, 2015).

The specific advantages of inquiry-based learning are as follows: Firstly, problem-based scenarios foster curiosity and enhance learners' intrinsic motivation to explore and acquire new knowledge. Secondly, students proactively embrace challenges and engage in collaborative discussions throughout the inquiry process, thereby deepening their understanding of the "value of effort." Thirdly, participants build self-confidence during explanation sessions and actively seek constructive feedback to support continuous improvement. Fourthly, this approach promotes the development of enduring learning habits and facilitates the ongoing updating of knowledge through the application and transfer of acquired concepts. Finally, reflective practices and assessments enhance self-awareness and reinforce the belief that "abilities can be developed through persistent effort.

The superiority of inquiry-based learning observed in this study is also supported by prior research. For example, Boaler and Dweck (2015) argue that engaging students in challenging, open-ended tasks within a supportive environment enhances their belief in their own potential and fosters cogniti ve flexibility. In addition, students in the experimental group were more likely to experience a sense of autonomy and competence—key components in the development of a growth mindset, as highlighted by Deci and Ryan’s (2000) self-determination theory.

The findings are particularly meaningful in the vocational education context, where many students internalize negative beliefs about their academic abilities, especially in subjects such as mathematics (Boaler, 2009; He, 2023). Traditional instruction may reinforce fixed mindset beliefs by focusing heavily on correct answers and penalizing mistakes, whereas inquiry-based learning allows students to engage in authentic learning experiences that emphasize the value of effort, revision, and resilience (Yeager & Dweck, 2012).

Moreover, the inquiry-based learning framework utilized in this research affords students extensive opportunities to exercise initiative, navigate uncertainties, and benefit from formative feedback. These learning experiences served not only to build content knowledge, but also to reshape students' beliefs about learning, failure, and self-efficacy (Bandura, 1997; (HARLEN, 2013).

In conclusion, the comparative analysis between the experimental and control groups further reinforces the argument that inquiry-based mathematics instruction is a powerful tool for cultivating growth mindset among vocational students. Beyond improving academic outcomes, it contributes to the development of essential psychological competencies, including persistence, optimism, and adaptive learning behavior.

5.6 Implications for practice

The findings of this study offer substantial practical implications for educators, curriculum developers, and academic administrators within the domain of higher vocational education. Research evidence indicates that inquiry-based learning can significantly promote the development of students' growth mindset, thereby substantiating the efficacy of targeted instructional strategies in cultivating positive academic beliefs, fostering constructive learning behaviors, and enhancing psychological well-being. Drawing upon these research outcomes, the following practical recommendations are presented:

1) Establish a regular implementation mechanism for inquiry-based learning

It is recommended that mathematics teachers in higher vocational colleges systematically integrate inquiry-based learning into the curriculum, positioning it as a core component of routine instructional practices. The implementation of inquiry-based learning can be guided by a well-defined five-step model: Engage, Explore, Explain, Elaborate, and Evaluate. This model provides a balanced framework that combines structure with adaptability, effectively supporting both classroom design and pedagogical planning. Throughout the teaching process, instructors are encouraged to construct authentic problem contexts and facilitate students' engagement in meaningful cognitive activities, including problem-solving, logical reasoning, reflective thinking, and conceptual synthesis. These learning experiences not only enhance students' self-efficacy through active participation but also foster the progressive development of a growth mindset—defined as the belief that intellectual abilities can be cultivated through persistent effort. Given that this pedagogical strategy aligns closely with the logical rigor and practical applicability inherent in mathematics, it serves to challenge fixed mindsets while promoting continuous cognitive growth and reinforcing the conviction that competence is expandable through deliberate practice.

2) Create a Supportive Growth Mindset Classroom Ecosystem

Teachers should strive to establish a classroom environment centered on the values of "effort - strategy - process", and cultivate students' psychological resilience through systematic instructional design. The specific implementation strategies include: First, reshaping inaccurate perceptions by viewing learning mistakes as valuable opportunities for cognitive restructuring, and guiding students in reflective analysis rather than merely correcting errors; Second, optimizing the feedback mechanism by providing constructive feedback that emphasizes learning strategies and progress, thereby reducing overreliance on outcome-based evaluations. Thirdly, implementing explicit instruction on mindset. Through theoretical explanations and case analyses, teachers can systematically introduce students to the core concepts of a growth mindset—such as the malleability of ability and the importance of effort—and help them develop a scientifically grounded model of learning attribution. This type of classroom ecosystem is particularly beneficial for vocational college students with low self-efficacy. By consistently emphasizing process-oriented assessment and delivering positive psychological reinforcement, it can effectively enhance their engagement in learning and strengthen their resilience when facing academic challenges.

The teaching strategies identified in this study offer empirical support for curriculum reform in higher vocational mathematics education. It is recommended that educators integrate the development of inquiry-based learning and a growth mindset within their instructional practices. Establishing a three-dimensional educational framework encompassing "cognitive shaping - behavioral guidance - environmental support" will lay a solid foundation for cultivating lifelong learning skills among vocational college students.

5.7 Recommendations for future research

While this study has provided valuable insights into the effect of inquiry-based learning on vocational college students' growth mindset, several areas warrant further investigation. The following recommendations are proposed for future research to build upon the current study's findings and address its limitations.

1) Conduct Longitudinal Studies

Given that growth mindset is a psychological trait that develops over time, longitudinal research designs are recommended. Tracking students over several semesters or academic years would allow researchers to examine the sustained effects of inquiry-based learning on mindset development, academic performance, and personal growth. Long-term studies could also explore whether mindset improvements translate into career readiness or job performance after graduation.

2) Compare Different Pedagogical Models

While this study focused on the 5E model of inquiry-based instruction, other models—such as problem-based learning, project-based learning, or flipped classroom approaches—may also contribute to mindset development. Future research could compare the relative effectiveness of these approaches in fostering growth-oriented beliefs and determine which instructional methods work best for specific student populations.

3) Incorporate Mixed-Methods Approaches

Quantitative data alone may not fully capture students' internal cognitive or emotional transformations. Therefore, future research could adopt a mixed-methods approach, incorporating interviews, reflective journals, classroom observations, or focus groups to gain richer insights into how students experience inquiry-based learning and how their mindset evolves throughout the process.

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APPENDIX

APPENDIX 1

Growth Mindset Scale

Dear students, welcome to participate in filling out this scale! This scale is designed to investigate the personal characteristics of thinking patterns. This scale is only for academic research. The questions and options in the scale are not good or bad. At the same time, Your personal information and answers will be kept strictly confidential, please do not have any concerns.

There are some questions below. Please select the extent to which you agree or disagree with these situations. Please fill in the information truthfully according to your true situation. Your valuable opinions are very important to us. Thank you for your cooperation!

Class: (year class) Name: Gender:

Growth mindset	Strongly disagree	Not agree and quit	Agree	Couldn't agree more
1. You think you have a certain level of intelligence that is almost impossible to change.*				
2. You think that no matter your intelligence level, you can always change a little bit more.				
3. You can make a big difference in your level of intelligence.				
4.You think you can learn new things, but you can't change your level of intelligence.				
5. You can learn math well by studying it.				
6. You think that only a few people are really good at math.*				
7. Math is easier to learn if you're a boy or				

Growth mindset	Strongly disagree	Not agree and quit	Agree	Couldn't agree more
come from a family that values math.*				
8. You think all people with no brain damage or physical defects have the same ability to learn.				
9. The harder you work at something, the better you'll be at it.				
10. You think brilliant people don't have to work hard.				
11. You believe that you can achieve anything you want through persistent effort.				
12. You think that working hard to accomplish something, you prefer to be considered talented.				
13. You think trying new things is stressful, so you avoid trying new things.*				
14. You think learning is about exploring new things..				
15. You think you tend to give up when you fail to solve a complex problem several times.				
16. You believe you will actively explore, find solutions, and enjoy yourself despite repeated failures or challenging problems.				
17. You will thank your parents and teachers when they give me feedback on my performance.				

Growth mindset	Strongly disagree	Not agree and quit	Agree	Couldn't agree more
18. You think you get angry when others judge your behaviour.*				
19. You think that parents and teachers praise your grades, will have a lot of encouragement for you, and your future grades will be bette				
20. You think that being rewarded for your efforts in learning makes you feel happier and more motivated to perform.				
21. You think you care more about acquiring new knowledge or skills during learning.				
22. You believe that learning is about getting better grades and making progress.				
23. You think that although you didn't get good grades, you will enjoy learning new skills during the study process.				
24. You think that when choosing between multiple tasks, you are more likely to select the task that will get you a high score.				
Note: Among them, questions 1, 6, 7, 13 and 18 are reverse scoring questions.				

APPENDIX 2

Inquiry-based learning program

Definition

Inquiry-based learning program is an inquiry process in which students discover problems, collect information, solve problems and demonstrate and explain issues under the guidance of teachers in teaching activities. In the learning process, students can independently construct knowledge, acquire knowledge, and apply knowledge, and they can improve their inquiry thinking, practical ability, and scientific literacy. Inquiry learning consists of the following five steps:

Step 1: Engage. To stimulate students' interest in learning tasks, teachers must create reasonable problem situations and connect mathematical knowledge with real-life examples and physical models to attract students' attention. Teachers should fully understand the pre-concepts that students have mastered for the task to be learned, analyze the differences between the original concepts and the scientific concepts and the reasons for the differences, and then create a problem situation that produces a cognitive conflict with the students' known pre-concepts so that students can have the willingness to explore.

This initial step is utilized to foster students' curiosity, encouraging them to maintain an inquisitive mindset towards the unknown and be open to trying new things and acquiring new knowledge. Subsequently, it involves establishing clear goals for students and devising feasible plans to attain these objectives. Breaking down the goals into smaller milestones allows for gradual progress towards cultivating a growth mindset among students.

The second step: Explore. Teachers should be able to choose exploration materials reasonably according to the actual situation and guide students to explore. In the process of inquiry, students should be in the main position, fully express their ideas through group cooperation and communication, and try to explore various ways to complete the inquiry task jointly. In the whole process, teachers listen to students' ideas, observe students' performance, give correct guidance to groups needing help, let students fully expose the pre-concepts they have mastered, and lay the foundation for forming subsequent new concepts.

In this stage, students are initially encouraged to embrace challenges. Throughout the exploration process, students proactively seek and embrace challenges, viewing them as opportunities for growth and learning. Subsequently, within this phase, students acquire the skill of collaboration in order to work with others in problem-solving and goal achievement. They learn to attentively listen to and respect others' perspectives while collectively learning and growing. Lastly, they cultivate a positive mindset as they are guided to maintain positivity and believe in their own abilities and potential. They perceive failure as an opportunity for learning and growth without easily giving up.

The third step: Explain, students in the process of inquiry used in an all-round review of the skills of the method. The teacher encourages students to use their language to explain their knowledge and understanding of the concept and the problems they encounter, to present the inquiry results with accurate symbolic language and rigorous reasoning process, and to question each other on doubtful knowledge points. Finally, the teacher uses standardized mathematical language and symbols to explain new terms and definitions based on students' experiences. Correct the deviations formed in the minds of students in time.

Through this process, students demonstrate perseverance and a belief in the efficacy of effort and persistence. They fearlessly confront challenges and setbacks, persistently striving to find solutions, actively seeking feedback and suggestions from others, and willingly accepting criticism and opinions in order to identify their weaknesses and work towards improvement.

The fourth step: Elaborate. Strengthening link, but also extension link. After students acquire new concepts, they use them to solve relevant mathematical problems and improve their mastery and application of new ideas.

Through this step, students should first keep learning, maintain the attitude and habit of learning, constantly improve their knowledge and skills, and constantly update their knowledge reserve. Second, keep focusing on the process, the process of accomplishing a task or reaching a goal, not just the outcome.

The fifth step Evaluate . The reflection phase is also a summary and conclusion phase. The evaluation standard is not only limited to the degree of knowledge mastery but also to the students' comprehensive ability. In terms of evaluation, from the diversified evaluation methods, multi-dimensional evaluation content, and diversified evaluation subjects, students' comprehensive ability is comprehensively examined so that they can correctly understand themselves and constantly reflect on themselves to obtain the joy of learning and success.

Through this step, students first learn to reflect, students reflect on their actions and decisions, and find out the reasons for success and failure. Learn from them and improve your methods and strategies. Secondly, develop self-confidence, so that students believe in their own abilities and potential, and believe that they can continue to grow and improve. Cultivate your self-confidence and face challenges bravely.

In this study, inquiry-based learning is aimed at creating a more positive learning environment for students, enabling them to learn how to confidently face unfamiliar opportunities, learn how to learn from others and learn with others; take risks, explore ideas, reflect on their learning process, question assumptions and ideas that are taken for granted, thereby cultivating students' growth mindset.

The present study will utilize a self-designed inquiry learning program as an experimental tool for inquiry-based learning. The program comprises three components: classroom learning objectives, teaching focuses and challenges, and teaching steps (5E teaching model).

Structure of inquiry-based learning programs

Activity theme	Procedure	Quest	Design intention
Activity 1: Introduction	Present the curriculum and administer the growth mindset assessment questionnaire.	Comprehend the course material and fulfill the pre-test questionnaire.	
Activity 2—11	Step1 Engage	Teachers create a reasonable problem situation and connect mathematical knowledge with real-life examples and real models to attract students' attention. Teachers should fully understand the pre-concepts that students have mastered	This step is first used to cultivate students' curiosity so that students remain curious about unknown things and are willing to try new things and learn new knowledge. Secondly, clear goals

Activity theme	Procedure	Quest	Design intention
		for the task to be learned, analyze the differences between the original concepts and the scientific concepts and the reasons for the differences, and then create a problem situation that produces a cognitive conflict with the students' known pre-concepts so that students can have the willingness to explore.	should be set for students, and feasible plans should be made to achieve these goals. Break your goals down into small milestones and work towards them. To cultivate students' growth mindset.
	Step2 Explore	Teachers should be able to reasonably choose inquiry materials according to the actual situation and guide students to explore. In the	In this step, students are first asked to accept challenges. In exploring, students take the initiative to

Activity theme	Procedure	Quest	Design intention
		process of inquiry, students should be in the main position, fully express their ideas through group cooperation and communication, and try to explore various ways to complete the inquiry task jointly. In the whole process, teachers listen to students' ideas, observe students' performance, give correct guidance to groups needing help, let students fully expose the pre-concepts they have mastered, and lay the foundation for forming subsequent new concepts.	seek and receive challenges and regard challenges as opportunities for growth and learning. Secondly, in this step, students learn to cooperate so that students can collaborate with others to solve problems and achieve goals together. Learn to listen to and respect the views of others and learn and grow together. Finally, develop a positive

Activity theme	Procedure	Quest	Design intention
			mindset, guide students to maintain a positive attitude, and believe in their abilities and potential. See failure as an opportunity to learn and grow, and don't give up easily.
	Step3 Explain	Students comprehensively comb out the methods and skills used in the inquiry process. The teacher encourages students to use their language to explain their knowledge and understanding of the concept	Through this step, students persist and believe in the power of effort and persistence. They should not be afraid of difficulties and setbacks, continue to work hard and find

Activity theme	Procedure	Quest	Design intention
		and the problems they encounter, to present the inquiry results with accurate symbolic language and rigorous reasoning process, and to question each other on doubtful knowledge points. Finally, the teacher uses standardized mathematical language and symbols to explain new terms and definitions based on students' experiences. Correct the deviations formed in the minds of students in time.	ways to solve problems, cultivate self-confidence in the process of explanation, let students believe in their ability and potential, and think they can continue to grow and progress. Cultivate their self-confidence, bravely face challenges, and finally, seek feedback in the explanation process; students take the initiative to seek input and suggestions from others and accept

Activity theme	Procedure	Quest	Design intention
			criticism and opinions. Learn your weaknesses and try to improve.
	Step4 Elaborate	After students acquire new concepts, they use them to solve relevant mathematical problems and improve their mastery and application of new ideas.	Through this step, students should keep learning, maintain the attitude and habit of learning, constantly improve their knowledge and skills, and continuously update their knowledge reserve. Second, keep focusing on the process of accomplishing a task

Activity theme	Procedure	Quest	Design intention
			or reaching a goal, not just the outcome.
	Step5 Evaluate	Students summarize today's inquiry learning, sum up their experience, and conduct self-evaluation and mutual evaluation between teachers and students. The standard of assessment is not only limited to the degree of knowledge mastery but also to students' comprehensive ability. In terms of evaluation, from the diversified evaluation methods, multi-dimensional evaluation content, and diversified evaluation	Through this step, students learn to reflect on their actions and decisions and determine the reasons for success and failure. Learn from them and improve your methods and strategies. Secondly, develop self-confidence so that students believe in their abilities and potential and believe that they can continue

Activity theme	Procedure	Quest	Design intention
		subjects, students' comprehensive ability is comprehensively examined so that they can correctly understand themselves and constantly reflect on themselves to obtain the joy of learning and success.	to grow and improve. Cultivate your self-confidence and face challenges bravely.
Activity 12: Summary	Send the questionnaire again.	Students complete the post-test questionnaire	

Inquiry-based learning program 1

Course	Higher vocational mathematics		
Course content	Function concept	**Teaching time**	100 minutes
Textbook	Higher vocational applied mathematics		
1. Learning goals			
(1) Students are proficient in finding function domains, value ranges, and analytical expressions. (2) Correctly select the representation of the function (3) Let students feel that mathematics comes from life, mobilize students' learning enthusiasm, enhance their learning confidence, let students experience the process of acquiring knowledge, and cultivate students' growth mindset.			
2. Teaching key points and difficulties			
Function concept			
3. Teaching process			

Teaching procedure	Teacher and student behavior
Step1 Engage	The teacher first asked the students to answer the definition of the function concept in junior high school and the types of functions they had learned. After the students describe the definition, the teacher asks them to judge according to the previous definition and the types of functions they have learned: Is y=1 a function? Is y=x the same function as y=x^2/x? And ask why. Based on previous knowledge, students will judge that y=1 is not a function because it has only one variable, which does not conform to the definition; y=x and y=x^2/x are the same functions because their expressions are the same. Then, the teacher pointed out the correct

	answer:y=1 is a function, and y=x and y=x^2/x are not the same function. At this time, students will have doubts. The change from the "variable theory" of defining functions in junior high school to the current "correspondence theory" has caused cognitive conflicts in students' knowledge, attracted students' interest, aroused students' enthusiasm for learning, and made a good start for students' learning in this class.
Step2 Explore	To explore the concept of function, the teacher gives the following three examples for students to think carefully and answer the questions: Example 1: Using the geometric drawing board, it is dynamically shown that the ball is in free fall from a place 1000 meters away from the ground. If the height of the ball and the ground at time t is h, then the law between h and t is h=-1/2 gt^2+1000. Is (g is the acceleration of gravity) a function? Given any t in the t range, is there a specific h corresponding to it, and who determines this particular h? Is there also a range of variation in h? Example 2: Using multimedia to show the students the electrocardiogram, explain the transverse representation of the measured time, the t representation, the longitudinal representation of the measured cardiac index value, and the v representation, and ask: Is t a function of v? How to express this function in mathematical notation? If any t is given within the t range, is there a unique v corresponding to it in a given ECG? Example 3: Using multimedia to show the table of China's gross National income from 2013-2020, enlighten students: If y is expressed as the annual value and i is expressed as China's gross national income, is I a function of y? How do we express this function in mathematical notation? After the teacher inspires and guides the students to complete the above three problem situations, the students are required to discuss and analyze the problems in the above examples in a group, summarize their common

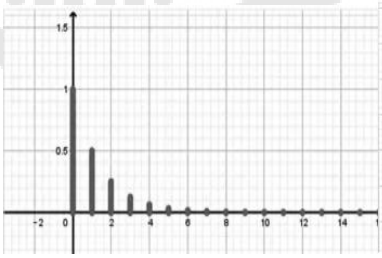
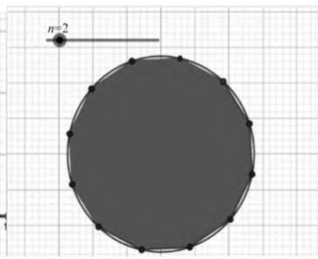
	characteristics, and think about how to explore the concept of function by using the relationship between the set and the corresponding variable (function relationship). In this link, according to the characteristics of the function, three examples are given according to the three ways of expression. Problems are put forward conducive to students exploring and concluding the concept of function according to the examples and existing knowledge and experience. Students must analyze and discuss in the group to understand the essence of the new idea of function.
Step3 Explain	Each student will try to state the concept in words in the group and choose one student from each group to share the answer with the whole class. This part adopts the form of group discussion, which abstracts concepts within students and preliminarily explores the verbal expression of ideas. After the group discussion, each group selects a student representative to make a speech, which not only exercises students' generalization ability but also exercises their language expression ability and provides opportunities for mutual evaluation among students. Meanwhile, teachers should properly inspect students during the discussion. Even if the students' wrong thinking direction is corrected, it is also ensured that all students can join in the debate. Finally, the teacher gives a standard answer so students can identify their shortcomings.
Step4 Elaborate	Students understand the essence of function through exploration and know how to describe the concept of function with set and correspondence. However, students still need clarification about how to apply this concept and what kind of knowledge expansion this

	concept has. Next, teachers will raise a series of questions to help students. This part sets a series of questions to deepen the concept. Question 1 helps students understand the unique correspondence in function through the image function image. Question 2 solves the cognitive conflict caused by the attraction link, question 3 and question 4 pave the way for question 5, and question 6 concretifies question 5. Restoring the general function concept to the concrete function, allowing students to experience the abstract idea in the concrete function, will reduce the degree of abstraction, and using the geometric drawing board to express the function dynamically will further deepen the image of the function, but also allow students to understand the importance of "number form association" in learning the function. Such interlinked problems can deepen the concept comprehensively and help students understand the importance of "number form association" in learning the function. To eliminate the misunderstanding of students' concept understanding, and in line with the inertia of thinking, conducive to students' memory.
Step5 Evaluate	The teacher asked the students to find the similarities and differences between the concept of function in junior high school and the concept of function in the mind. What did you learn in this lesson? The students raised their hands to answer the teacher's questions. Such open questions raised in this section allow teachers to understand students' learning situation, summarize the lesson's main content according to the student's answers, and fully allow students to examine their specific gains and shortcomings in this lesson.

Inquiry-based learning program 2

Course	Higher vocational mathematics		
Course content	The limit of the sequence	**Teaching time**	100 minutes
Textbook	Higher vocational applied mathematics		
1. Learning goals			
(1) Master the definition of series limits; (2) Cultivate students' ability to independently discover and solve problems and the spirit of daring to challenge, encourage students to dare to ask and answer questions and explore boldly in math class, exercise students' mathematical and logical thinking, and cultivate students' ability to dare to challenge and scientific inquiry.			
2. Teaching key points and difficulties			
Definition of series limits			
3. Teaching process			

Teaching procedure	Teacher and student behavior
Step1 Engage	Teachers create situations: Situation 1: In 263 AD, Liu Hui mentioned the "Circle cutting technique" put forward as a note for China's ancient mathematical work "Nine Chapters Arithmetic": "When the cut is fine, the loss is less, and when the cut is cut again so that it cannot be cut, it will be combined with the circumference and lose nothing." Do you know what this passage means? Situation 2: The philosopher Zhuang Zhou of the Warring States Period, in his book Zhuangzi • Tianxia, quoted a saying: "The hammer of one foot,

	the day takes half of it, will never be exhausted." Suppose the length of the original hammer is 1. (1) Try to write the first five items in the list; (2) With the infinite increase of n, what is the changing trend of the series? Teachers design problem situations from the perspective of mathematical culture. On the one hand, they let students understand the brilliant achievements made by China in mathematical research, stimulate students' patriotic enthusiasm, introduce mathematicians' rigorous and realistic mathematical spirit and professional quality of excellence, help students understand the growth process of mathematicians, perceive mathematical thoughts and mathematical methods, and carry out ideological and political education for students. On the other hand, through multimedia-assisted teaching, students can feel the idea of limits and then construct A mathematical model according to the problem situation and analyze the characteristics of the model by using the concept of the number of numbers that have been learned. When the number of terms n increases infinitely, the general term of an infinite number series approaches the characteristics of a constant, reaching the dual realm of being able to see and think.  
Step2 Explore	Students draw pictures in small groups to observe and discuss the trends in the following series of numbers:

	(1) $\frac{1}{10}, \frac{1}{10^2}, \frac{1}{10^3}, \cdots, \frac{1}{10^n}, \cdots$ (2) $\frac{1}{2}, \frac{2}{3}, \frac{3}{4}, \cdots, \frac{n}{n+1}, \cdots$ (3) $-1, \frac{1}{2}, -\frac{1}{3}, \cdots, \frac{(-1)^n}{n}, \cdots$ Through analyzing three concrete infinite series, students have a preliminary feeling of the limit of the series in their minds and understand that the limit is a changing process. In this process, the thought of an "infinite approach" has been accompanied by, although it cannot reach the truth step by step, it can approach the truth step by step, and this thought of an "infinite approach" can be summarized as "limit spirit."
Step3 Explain	Students report the cooperation of their group, explain and analyze the research results, and use their language to explain the results ts. The teacher comments on and explains the students' explanations of the conceptual conjectures about the limits of the series derived from the inquiry. Also, ask: 1. Does every sequence have a limit? 2. Look at the following sequence. Do they have limits? If so, name the limit. （1） 1,1,1， ……1； （2） $a_n = \begin{cases} \frac{1}{n}, n \text{ is odd number} \\ \frac{n-1}{n}, n \text{ is even number} \end{cases}$ Students' understanding of new concepts usually needs to be divided into three steps - "understand - comprehend - opinion ." The in-depth process is of great help for students to grasp the method of concept formation and then distinguish and appreciate concepts on this basis. Finally, students will put forward their own opinions. Through the above two questions, students can determine the concept of series limit based on understanding the concept and cultivate the ability to raise questions, analyze, and solve problems. A clear understanding of the

	key elements of a descriptive definition of sequence limits is very helpful in strengthening the basic concept.
Step4 Elaborate	Students use the concept of function limit just learned to solve the problem of applying function limit in real life, learn to abstract the concept of function limit from practical issues, and then extend the idea of function limit to real life. **Question**: Look at the following sequence of numbers. Do they have limits? If so, name the limit. (1) $a_n=\frac{2021^{2021}}{n}$; (2) $a_n=5-(\frac{1}{3})^n$; (3) $a_n=\begin{cases}-4(1\leqslant n\leqslant 1001)\\4(n\geqslant 1001)\end{cases}$; (4) $a_n=\begin{cases}1-\frac{1}{n}, n \text{为奇数}\\1, n \text{为偶数}\end{cases}$.
Step5 Evaluate	Students first review what they have learned in this class and then exchange their own experiences and gains with each other among the group members. Second, they self-evaluate what they have learned and their thought methods in class and mutually evaluate with the group members. Second, they reflect on their shortcomings and learn relevant learning experiences from others. The teacher summarized the lesson.

Inquiry-based learning program 3

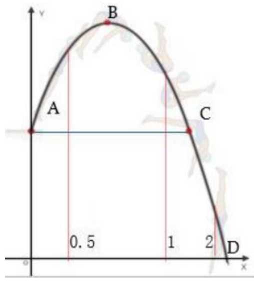
<table>
<tr><td>Course</td><td colspan="3">Higher vocational mathematics</td></tr>
<tr><td>Course content</td><td>Derivative concept</td><td>**Teaching time**</td><td>100 minutes</td></tr>
<tr><td>Textbook</td><td colspan="3">Higher vocational applied mathematics</td></tr>
<tr><td colspan="4">1. Learning goals</td></tr>
<tr><td colspan="4">(1) Master the concept and geometric significance of derivatives..

(2) Let students feel the commonality between solving math problems; both methods and knowledge points can be extended and transferred. From shallow to deep, it can encourage students to master methods to think deeply and solve problems flexibly, realize the growth of their knowledge and ability, improve their willingness to learn independently, enhance learning resistance, and cultivate their growth mindset.</td></tr>
<tr><td colspan="4">2. Teaching key points and difficulties</td></tr>
<tr><td colspan="4">Derivative concept</td></tr>
<tr><td colspan="4">3. Teaching process</td></tr>
<tr><td>Teaching procedure</td><td colspan="3">Teacher and student behavior</td></tr>
<tr><td>Step1

Engage</td><td colspan="3">The teacher first leads the students to review the average rate of change. Then give the following three life situations: Situation 1: In life, when we blow up a balloon, as the balloon continues to expand, it will become more and more difficult to blow up; what is going on? How do we explain this phenomenon mathematically? Scenario 2: Appreciate the towering Mount Qomolangma, show two different pictures of the steep
</td></tr>
</table>

	state of climbing Mount Qomolangma team, guide students to think when appreciating these two pictures: when the steepness of Mount Qomolangma is different, the degree of feeling of mountaineers is completely different, how to use the knowledge in mathematics to describe the steepness of the mountain, to provide some useful reference for mountaineers? Scenario 3: The teacher shows a video of diving at the 2021 Tokyo Olympics. Ask students to review the average rate of change in the last lesson and answer: At the beginning of this class, the teacher guides students to review old knowledge, aiming to help them find the connection between new and old knowledge to facilitate students to construct new knowledge based on existing knowledge. The teacher also lists three practical situations in life, aiming to make students fully feel that mathematics comes from life and is closely related to mathematics to transfer students' attention to the class quickly. Let the students participate smoothly because the examples listed are lively and closely follow the facts. This can arouse the enthusiasm and enthusiasm of students to learn so that the desire and interest of students to know can be further released.
Step2 Explore	For scenario 3, the teacher introduced the video content to the students and gave them learning tasks: It was found that the beautiful arc formed by the athletes in the process of high diving just met the relationship.$h(t) = -4.9t^2 + 6.5t + 10$ The athlete's height relative to the water's surface is recorded as h(in meters), and the time after the jump is recorded as t(in seconds). Students work in small groups to explore the following questions:

(1) What is the type of motion trajectory?



(2) Where the player is when t=0; This function reflects the movement of several meters;

(3) When h=10, how many positions does the player have, and why?

(4) What is the average speed of the athlete from point A to point C

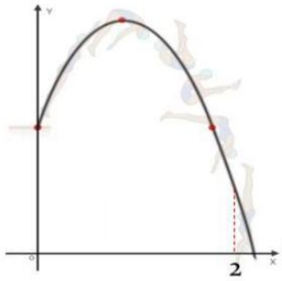
(5) Calculate the average speed of athletes in the following two time periods: (a)[0,0.5](b)[1,2]

After the discussion, the teacher asked the student representatives to answer the first three questions and asked them to write the solution process for the last two questions on the blackboard, and the teacher made a corresponding evaluation. When solving the fourth question, the teacher asked: Since the average speed of the athletes at this time is 0, how can the athlete's state be? Is it still? For example, what is the athlete's state of motion at points A, B, C, and D? If the average velocity doesn't tell us anything about the state of motion, what should we do? This leads to instantaneous velocity.

Students discuss related questions according to the teacher's prompts. For the first three questions, students only need to look at the picture and answer them.

For questions 4 and 5, students will practice and communicate with group members to get results and then answer relevant questions after a series of questions from the teacher.

In this part, students first feel the change of athlete state requirements, that is, the change of average speed to instantaneous

	speed, to lay a foundation for students to understand the process and connotation of derivative generation.  Teacher question: (1) How to characterize the period around t=2? (a) In literal terms; (b) How to represent values near t=2; (c) Representation of periods. Based on the above question, continue to ask: Why this expression? (2) Find the instantaneous velocity at t=2. Organize students to work together in A group to complete the following form, and ask the group representative to complete the form and ask: When A approaches 0, how does the average speed change? How can the average speed better represent the instantaneous speed? Do you think the result (constant) from the experiment is the instantaneous velocity? Is this data accurate or approximate? (3) Guide students to find from the simplified expression that when $\Delta t \to 0, \ -4.9\Delta t - 13.1 \to 13.1$ Guide students to conclude: when $\Delta t \to 0$, the average speed approaches a constant infinitely, an exact value rather than an approximation, and has nothing to do with the change but only with the specific moment. Student activities :(1) Observe the parabola, answer the questions raised by the teacher, and understand the method of characterizing the period near t=2.

	(2) Students work in groups to complete the calculation of Δt and $\bar{v}$, complete the above table, summarize the rules, and draw corresponding conclusions. (3) Students derive their conjecture and explain it based on simplifying the forms and expressions.
Step3 Explain	Students explain the conjectures obtained in the inquiry process to explain their understanding and gain of knowledge in the inquiry process. The teacher comments on and explains the student's interpretation of the conjectures obtained in the inquiry session. This link not only exercises students' ability to integrate and summarize knowledge, but also improves students' language organization ability and improves their thinking level when they summarize knowledge.
Step4 Elaborate	The teacher first asked the students to talk about the steps of finding the derivative of the function $y = f(x)$ at $x = x_0$ according to the derivation of the derivative concept, and then made appropriate comments based on what the students said, and finally led the students to summarize the steps together. Crude oil can be refined into various products, such as gasoline, diesel, and plastics. The refining process mainly involves cooling and heating the crude oil. If at $x(h)$, the temperature of the crude oil (unit: ℃) is: $f(x) = x^2 - 7x + 15 (0 \leq x \leq 8)$ Can you calculate the instantaneous rate of oil temperature change at 2(h) and 6(h) and explain what they mean? Students discuss and answer the steps to find the derivative of a function $y = f(x)$ at $x = x_0$ on this basis to solve the problem of the application of derivatives in real life, learn to abstract the concept

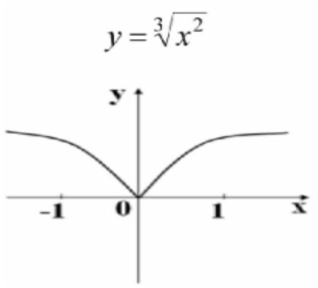
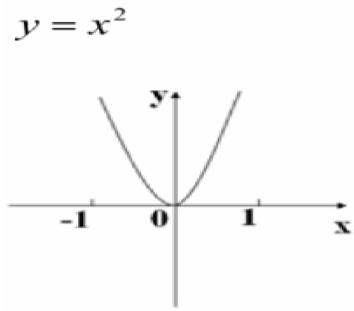
	of derivatives from practical issues, and then extend the idea of derivatives to real life.
Step5 Evaluate	First, the students review what they have learned in this lesson, and the group members exchange their own experiences and gains with each other and reflect. Learn from others about their shortcomings and answer teachers' questions. Finally, the teacher summarizes the content of this lesson. Through the students' summary and review, they can further understand the meaning of derivative and the idea of limit, and exercise their generalization ability at the same time. Finally, complete the homework assigned by the teacher and consolidate the learned content.

Inquiry-based learning program 4

Course	Higher vocational mathematics		
Course content	Monotonicity of a function	**Teaching time**	100 minutes
Textbook	Higher vocational applied mathematics		
1. Learning goals			
(1) Master the method of determining the monotonicity of functions (2) Let students feel the commonality between solving math problems; both methods and knowledge points can be extended and transferred. From shallow to deep, it can encourage students to master methods to think deeply and solve problems flexibly, realize the growth of their knowledge and ability, improve their willingness to learn independently, enhance learning resistance, and cultivate their growth mindset.			
2. Teaching key points and difficulties			
Theorem of monotonicity of function			
3. Teaching process			

Teaching procedure	Teacher and student behavior
Step1 Engage	Teachers introduce new lessons through effective questioning: Question 1: What is the definition of function monotonicity? (Guide students to answer as a group) Question 2: What are the ways to judge the monotonicity of a function? (Students answered "Definition method" and "image method") Question 3: Ask students to determine the monotone interval of function f(x)=x^2 (Guide students to use the definition method and the image method, respectively)

	Question 4: Can you determine the monotonicity of the function f(x) =sinx-x(0,π)? Let the students try to complete it in a short time. The result found that it is difficult to judge the positive and negative of the final symbol after using the "definition method" (or as a quotient), and the image is not easy to draw with the "image method." The goal is to make students realize that the definition and image methods have limitations. This raises the question: "Is there a new way to judge the monotonicity of a function?" This leads to the theme of this lesson and also makes a good beginning for inquiry teaching.
Step2 Explore	The teacher guides the students to observe, explore, and summarize the conclusion. First, with a general function y=f(x) as the carrier, look at the graph and think: Question 1: What is the relationship between the monotonicity of the function and the sign of the derivative? During the explanation, the teacher uses the geometric drawing board to dynamically draw the tangent lines at each point on the image. Through dynamic demonstration, focusing on students' observation, the teacher guides students to explain the phenomena using the geometric meaning of derivatives and then makes necessary explanations. It can be seen from the graph that the first derivative of the function is more significant than zero when the function is monotonically increasing; When the function monotonically decreases, the first derivative is less than zero. Question 2: Instead, can we use the sign of the first derivative to determine the monotonicity of the function?

	  To break through the difficulties of this lesson, students are guided to guess, and then teachers and students jointly analyze: then the teacher puts forward the opposite proposition. Similar to the above analysis, let the students work it out themselves. Thus, the theorem of determining the monotonicity of the function by using the derivative is obtained. Guide students to think that sometimes a function does not monotonically increase or decrease over its entire domain but rather over a part of its interval, such as giving a graph of two functions. Question 3: What other information can you get from the graph? The teacher guides students through observation, allowing students to experience the process from the special to the general; the idea of the research problem is the same, only to obtain a more general formal representation
Step3 Explain	Teacher question: According to the above discussion process, can you summarize the general steps of using the derivative to judge the monotonicity of the function? Let the students discuss in groups and give them a chance to think thoroughly. After two minutes, select several group representatives to talk about the discussion results, and the teacher will gradually revise the conclusion. Through thinking and discussion, students can cultivate an active learning attitude, experience the formation process of knowledge,

	and experience the penetration of the combination of number and form. At the same time, my oral expression ability has also been perfect practice.
Step4 Elaborate	Based on students' understanding of the conclusion, teachers organize students to use the monotony of the symbolic judgment function of the derivative in time so that students can consolidate and deepen the theory in application. First, we give example 1 to find the monotone interval of the function. Teachers and students use the general steps of determining the monotonicity of derivative functions to complete together. Teachers should emphasize the writing methods of multiple monotonicity intervals when explaining. With this method, we can look back at the problem that has not been solved at the beginning, that is, the monotony of the judgment function. In the beginning, we found that it was more troublesome to use the definition method and the image method through judgment, so we guided students to use the derivative method and found that the derivative method is relatively simple so that students can fully understand the advantages of the derivative method. The teacher asked: What other problems can the theorem solve? The teacher makes a detailed analysis to guide students to think about Example 2. During the study, the teacher should fully improve the students' awareness of participation and the ability to transform mathematical methods. Then, the students should try to write out the proof process. Finally, teachers and students jointly write the solution process, emphasizing the steps of solving problems. Then, based on the analysis and proof of Example 2, teachers and students jointly summarize the primary method of proving inequalities by using the monotonicity of functions. After explaining the example, the students try to practice for the first time and act out, and the teachers guide them. Focus on helping students

	memorize the steps. Practice to further check students' mastery of the content of this section
Step5 Evaluate	First of all, students review what they have learned in this lesson. Group members exchange their own experiences and gains with each other, reflect on their shortcomings, learn relevant learning experiences from others, and answer the teacher's questions. Finally, students should be organized to summarize the above teaching content to reflect on the learning process and understand the steps of solving the problem. Through summary and joint comments, students can form a sense of value judgment, improve their understanding of mathematical knowledge, and gradually develop good learning habits and thinking habits.

Inquiry-based learning program 5

Course	Higher vocational mathematics		
Course content	The extreme value of a function	**Teaching time**	100 minutes
Textbook	Higher vocational applied mathematics		
1. Learning goals			
(1) Understand the concept of the extreme value of the function through the image, use the derivative to find the maximum and minimum value of the function, and develop mathematical operation literacy (2) Students improve their independent learning ability, enhance their awareness of information collection, gain a sense of achievement, strengthen their concept of effort, and promote the formation of a growth mindset.			
2. Teaching key points and difficulties			
To understand the concepts of maximum value and minimum value and the steps to find the extreme value of differentiable function			
3. Teaching process			
Teaching procedure	**Teacher and student behavior**		
Step1 Engage	Then, the teacher highlighted the outline of the Guilin mountain peak, and a continuous curve appeared. At this time, the teacher explained to the students that the peak was the maximum value and the valley was the minimum value, which naturally led to the learning content of this lesson -- the extreme value of the function. Guide students to protect and cherish natural resources and establish ecological awareness; Enable students to master the idea of transforming from concrete to abstract		

Step2 Explore	Looking at Figure 1, what is the relationship between the value of the analysis function at the point and the value on both sides near it? Students express their views after observation and analysis, and teachers summarize and improve the definition of the maximum value of the blackboard function. The teacher encourages students to copy the definition of the maximum value to write the definition of the minimum value and emphasizes to the students in the definition, the point that obtains the extreme value is called the extreme point; the extreme point is the value of the independent variable, and the extreme value refers to the value of the function. The teacher guided the students to observe Picture 2. Answer the following questions: (1) Find the poles in the graph and state which points are maximum and minimum. Is the extreme point unique? (2) Is the maximum necessarily more significant than the minimum? (3) Is the endpoint of the interval extreme? The teacher emphasizes that: (1) Extremum points may not be unique, and monotone functions have no extremum: (2) Extreme values are local and exist inside the interval rather than at the endpoints; (3) No size relationship exists between maximum and minimum values. Thirdly, the teacher compared this curve with multiple extreme values to a tortuous life, pointing out that the maximum value is the peak of life, the

<table>
<tr>
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minimum value is the trough of life, ups and downs are the only way, is the process of growth,

Observe and understand again: Observe Figure 3 and Figure 4, the research method of the monotonicity of the analog function and the derivative relationship, and see the relationship between the extreme value and the derivative.

For group discussion, complete the following table:

In this link, (1) students understand and master the thought method of combining number and form; (2) In the process of exploration, the definition of minimum value is given according to the maximum value to cultivate students' induction ability; (3) Using the perspective of connection to look at the problem, through analogy method to let students experience the connection between knowledge, help students to construct the overall knowledge :(4) Using the maximum value of the function is not necessarily more significant than the minimum value, can cultivate students' dialectical materialism view, make students understand that there is no absolute good and evil; (5) Solve problems through group cooperation to improve students' teamwork ability.

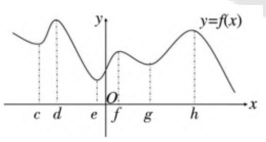


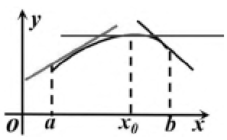
图 2


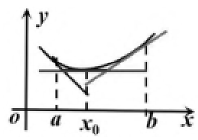
图 3


图 4
</td>
</tr>
<tr>
<td>Step3

Explain</td>
<td>
The debriefers of each group report on the cooperation of their group, interpret and analyze the inquiry's findings, and use their language to explain the findings.

Teachers and students jointly summarize the concept of the extreme value of the function
</td>
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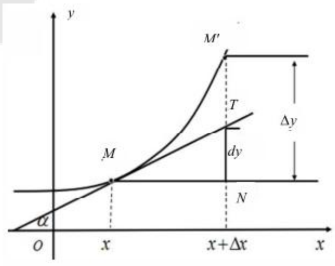
</table>

Step4 Elaborate	Teachers tell stories about the use of extreme value theory to save lives. After the February 1953 sea flood disaster in the Netherlands, which killed 1,800 people and destroyed 47,000 homes, the Dutch government urgently needed to build new sea defences that would protect the country for hundreds of years. Because more than half of the Netherlands lies below sea level, the government must build seawalls to protect it. Scientists analyzed the country's data on such extreme events, designed according to the mathematical principles of extreme value theory. They devised a standard of five meters of new levees to deal with the worst challenges that nature can throw at it. In this way,16 million Dutch residents are protected by the extreme value theory, which is also a central element of the new maritime safety recommendations. Concrete examples let students feel the critical position of mathematics in developing science and economic life. At the same time, listing examples from life can improve students' interest and enthusiasm for learning. Students complete relevant exercises independently, and teachers inspect and comment on them in time. Students summarize the steps of solving the extreme value of the function through examples and exercises, and the teacher adds them. The multimedia presents the complete steps: Teachers guide students in analyzing and solving problems independently and strengthening their knowledge. This helps students maintain their enthusiasm and confidence in learning and develop a solid, strict, practical scientific attitude.

Step5 Evaluate	Students first review what they have learned in this class and then exchange their own experiences and gains with each other among the group members. Second, they self-evaluate what they have learned and their thought methods in class and mutually evaluate with the group members. Second, they reflect on their shortcomings and learn relevant learning experiences from others. Finally, the teacher summarizes this lesson.

Inquiry-based learning program 6

<table>
<tr><td>Course</td><td colspan="3">Higher vocational mathematics</td></tr>
<tr><td>Course content</td><td>Differential of a function</td><td>Teaching time</td><td>100 minutes</td></tr>
<tr><td>Textbook</td><td colspan="3">Higher vocational applied mathematics</td></tr>
<tr><td colspan="4">1. Learning goals</td></tr>
<tr><td colspan="4">(1) Master the definition of differentiation
(2) Master how to use the definition of differential to calculate the differential of function
(3) Let students apply the knowledge in the existing knowledge framework and the experience and ability of daily life to solve problems, stimulate different degrees of curiosity and exploration, improve learning interest and motivation, and improve thinking ability and thinking level.</td></tr>
<tr><td colspan="4">2. Teaching key points and difficulties</td></tr>
<tr><td colspan="4">How to differentiate</td></tr>
<tr><td colspan="4">3. Teaching process</td></tr>
<tr><td colspan="2">Teaching procedure</td><td colspan="2">Teacher and student behavior</td></tr>
<tr><td>Step1
Engage</td><td colspan="3">To pave the way, the teacher first gives two fascinating practical cases and separates several critical points in the concept of differentiation.
Question 1 (1) Placing a red flag with a length of 10cm outside a unit circle (along the radius) will give a larger circle, and ask how much the circumference of the larger circle will increase compared to the unit circle.
(2) If a red flag 10cm long is also placed on the earth's equatorial line, how much will the circumference of the resulting significant circle change</td></tr>
</table>

	compared with the circumference of the equatorial line, which will change the circumference of the more important? Question 2: If the radius of the ball changes by 10cm, how much does the volume change
Step2 Explore	Students discuss and analyze in groups: Question 3: Based on historical data, estimate the number of WeChat active accounts in the next stage. First, the statistics on the monthly active accounts on WeChat and WeChat were found online. Students were asked to estimate the rate of change in the number of active accounts in a recent quarter using the known data and then the number of active accounts in the following quarter. The teacher leads the students to analyze the following questions: 1. Use the average rate of change to estimate the instantaneous rate of change; 2. Use the formula to estimate the end function value at a certain point, that is, to estimate the change of the function value. 3. When can this approximation be applied? In this process, teachers guide students to understand intuitively from a geometric perspective.  图1 微分的几何意义
Step3 Explain	Students report the cooperation of their group, explain and analyze the research results, and use their language to explain the results ts. The teacher comments on and explains the students' explanations of the conceptually related conjectures about the differentiation of functions obtained in the inquiry session. Guide students in using mathematical

	language to explain their findings so that they can have a deeper understanding of functional differentiation. Finally, the teacher will explain and display if the students still need to solve the problem.
Step4 Elaborate	The teacher puts forward the relevant problems of applying the concept of functional differentiation. The students use the concept of functional differentiation just learned to solve the issues in applying functional differentiation in real life, learn to abstract the concept of functional differentiation from practical problems, and then expand the idea of functional differentiation to real life. Question: (1) Suppose there is a spherical watermelon with a radius of 10 cm and a layer of plastic wrap around it. How much will the volume or mass change? (2) If a layer of plastic wrap is wrapped around the surface of the earth, the volume or mass will probably change how much Applying these abstract mathematical concepts to everyday life can be very interesting. If you choose watermelon, why should you choose thin skin? If the thick skin of the watermelon is large enough, the quality is basically on the watermelon skin (because the density of the skin is also much more significant). Girls buy cosmetics, glass bottles are at least two layers, and some have to be dug into the bottom of a minor hemisphere, and the packaging box should be aerial. Differential knowledge can quickly calculate that the radius increased by one time, the volume increased by at least three times, and it looks enormous, but the real essence is minimal. But it gives us an excellent intuitive feeling. Business savvy is evident; although businesses need to understand differential, they have been able to use the basic idea of differential to make money.

Step5 Evaluate	Students first review what they have learned in this class and then exchange their own experiences and gains with each other among the group members. Second, they self-evaluate what they have learned and their thought methods in class and mutually evaluate with the group members. Second, they reflect on their shortcomings and learn relevant learning experiences from others. Then the teacher summarized this lesson: 1. Definition of differentiable and differential functions of one variable; 2. The equivalent relation between differentiability and differentiability of a function of one variable; 3. The geometric meaning of the differential function of one variable; (4) The method of using differential as the approximate calculation is preliminarily explained, which implies an essential idea in higher mathematics, that is, the idea of substituting Qu with direct, which will be seen many times in later higher mathematics courses. Finally, to improve the students' self-learning ability, they can assign after-class thinking problems: because the calculation of differential has its limitations, then the curve fitting, approximate calculation, and What are some other effective ways to predict function values? Interested students can find information after class.

Inquiry-based learning program 7

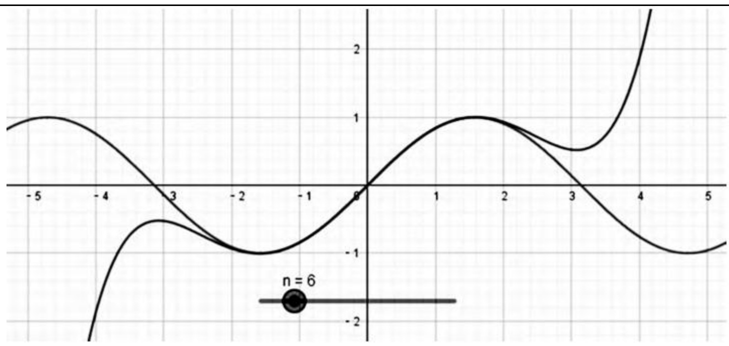
Course	Higher vocational mathematics		
Course content	Taylor formula	**Teaching time**	100 minutes
Textbook	Higher vocational applied mathematics		

1. Learning goals
(1) Master Taylor's formula (2) Students improve their independent learning ability, enhance their awareness of information collection, gain a sense of achievement, strengthen their concept of effort, and promote the formation of a growth mindset.
2. Teaching key points and difficulties
Taylor formula
3. Teaching process

Teaching procedure	Teacher and student behavior
Step1 Engage	Teachers teach the history of Taylor's formula - its connection to ancient Chinese mathematics - and foster national pride. Taylor's formula is the pinnacle of unitary differential calculus, and many of the problems related to differential calculus can be solved. When teaching this formula, the verse is quoted, "You will be towering over the top, and you will see all the small mountains, " reflecting the commanding feeling of using it to solve problems. In the history of mathematics, Taylor's formula originated from Newton's finite difference method of interpolation, and the high-precision interpolation method can be traced to the ancient mathematics of China's Sui and Tang dynasties; in fact, China's ancient astronomers created the pioneer of finite difference calculation, the Chinese people's research

	work is a thousand years earlier than Newton and Taylor. Still, in the book "Ancient Mathematical Thoughts, " Klein did not mention anything about it.
Step2 Explore	Teachers guide students in exploring the meaning of Taylor's formula by asking the following questions: How can we approximate a function curve in the neighbourhood of a particular point? Question 1. Why approximate the function? Is it reasonable to calculate indirectly? In practical problems, one often needs to calculate the value of the function; if the direct calculation is laborious and one can not calculate the result, such as the calculation of sin 40°, the student said that you can use a calculator or look up the table, then the calculator is how to calculate it, the data in the table is how to get? The principle needs to be clarified here. It is pointed out that the significance of Taylor's formula lies in the approximation of a function by the polynomial. Question 2: Why is the function approximated by polynomials and not other functions? Students compare and discuss the conclusion: The term expression is the simplest form of a class of elementary functions. It only involves addition, subtraction, and multiplication operations and is easy to run on the computer. Its undeniable advantage is that its form will become more straightforward with the higher order of derivation. Question 3. How do we approximate a function by polynomials? The principle of polynomial approximation function can be vividly compared to the process of "imitation show."

	Question 4: No matter how close the "clone" curve is to the "original" curve, there must still be a difference between them, so what is the difference? Thus, Taylor's formula with the remainder of the Peano type is obtained Question 5. The Peano remainder term is only a qualitative analysis of the error, which cannot be used to calculate the error accurately. Then, what is the form of the quantitative analysis of the error? Thus, Taylor's formula with Lagrangian-type remainder is obtained Question 6: How do you understand the difference between the two residual term forms? Question 7: Taylor's formula is always too abstract to understand. How do we know the effect of using it to approximate a function? In small groups, students discuss the Maclaurin formula of order n for f(x)=sinx $\sin x \approx x - \frac{x^3}{3!} + \frac{x^5}{5!} - \cdots + (-1)^{n-1}\frac{x^{2n-1}}{(2n-1)!}$.
Step3 Explain	Students report the cooperation of their group, explain and analyze the research results, and use their own language to explain the research results. The teacher directly calls the Taylor formula command in the dynamic geometry drawing board GeoGebra, and the animation program generated with the increase of order n can intuitively demonstrate the approximation process of polynomial functions.

	 图 1 六次多项式逼近正弦函数示意图
Step4 Elaborate	Question 8. How should Taylor's formula be used to solve specific problems? Application of Application 1 to approximate computations using Lagrangian Lagrangian-type residual terms Example 1 Uses the approximate formula to calculate the approximate cost value so that it is accurate to 0.005 and tries to determine the application range of x. Application 2 Using Taylor's formula to find the limit - using Peano-type terms Example 2: Find the limit.
Step5 Evaluate	Students first review what they have learned in this class and then exchange their own experiences and gains with each other among the group members. Second, they self-evaluate what they have learned and their thought methods in class and mutually evaluate with the group members. Second, they reflect on their shortcomings and learn relevant learning experiences from others. The teacher summarized the lesson.

Inquiry-based learning program 8

<table>
<tr><td>Course</td><td colspan="3">Higher vocational mathematics</td></tr>
<tr><td>Course content</td><td>The concept of a definite integral</td><td>Teaching time</td><td>100 minutes</td></tr>
<tr><td>Textbook</td><td colspan="3">Higher vocational applied mathematics</td></tr>
<tr><td colspan="4">1. Learning goals</td></tr>
<tr><td colspan="4">(1) The area of the shadow part of a given figure can be obtained according to the geometric meaning of the definite integral;
(2) Can use the property of definite integral to compare the size of the integral value;
(3) Let students apply the knowledge in the existing knowledge framework and the experience and ability of daily life to solve problems, stimulate different degrees of curiosity and exploration, improve learning interest and motivation, and improve thinking ability and thinking level.</td></tr>
<tr><td colspan="4">2. Teaching key points and difficulties</td></tr>
<tr><td colspan="4">Properties of definite integrals</td></tr>
<tr><td colspan="4">3. Teaching process</td></tr>
<tr><td colspan="2">Teaching procedure</td><td colspan="2">Teacher and student behavior</td></tr>
<tr><td>Step1
Engage</td><td colspan="3">The teacher showed a picture of the large irregular lawn in front of the school building and asked the students to calculate its area. The large lawn in front of this teaching building is familiar to every student. To calculate its area, the students are very interested, and at the same time, they find that the application of mathematical knowledge is everywhere. Based on this scenario, question 1: Do you know how the formula for the area of a circle is derived? Question 2: Do you know Liu Hui's "circle cutting technique"? This paper introduces Liu Hui, an outstanding mathematician in ancient China, and his "circle cutting</td></tr>
</table>

	technique". Question 3: What is the thinking method of "circle cutting"? Based on solving these three problems, students have the basic idea of "substituting song with direct" and "substituting change with invariance", as well as the understanding of using "the idea of limit method" to find the exact value. It makes a good beginning for the inquiry teaching of definite integral concepts.
Step2 Explore	The teacher gave two cases and asked the students to discuss them in groups Case 1: How to find the area of the trapezoid with a curved edge Because of the previous "circle cutting" to find the area of the circle "by straight" method of thinking, organize students to discuss and ask questions; the general students think of (1) first find the approximate value of the trapezoid of the curved edge, what graphics can be used to approximate the area of the curved edge trapezoid? Triangle, rectangle, trapezoid? (2) If the rectangle is used to approximate, then how many rectangles are used to approximate will be closer? Two and three? (3) How do you find its exact value? Let the students think boldly about what can be done to make the error smaller and smaller until it is zero. Combined with the students' discussion, the more detailed the segmentation is, the closer it is so that the students can have a more intuitive understanding. On this basis, guide the students in summarizing the method of finding the trapezoid of a curved edge. The process of "segmentation, approximation, summation, limit taking" is demonstrated. Case 2: Find the distance of variable speed linear motion This case mainly adopts the method of students' independent learning, through the analogy of example 1, to carry out active

	exploration, experience the beauty of the mathematics process, summarize the method and get the specific expression. Students first try to analyze the case according to the existing knowledge, speculate and assume the direction of inquiry and possible results. Then, have a group class discussion to determine the solution to the problem. Finally, give students a few minutes to describe their research results briefly. In this stage, the teacher is liberated from the mere transfer of knowledge and becomes the guide of students' learning.
Step3 Explain	Teachers and students jointly analyze and summarize all the processes and conclusions, guide students to put aside the practical significance of the problems, find their commonalities from the perspective of mathematics, find the laws hidden behind the phenomena, and extract and summarize the knowledge to form definitions. This step is the consolidation of the inquiry process and the examination of the inquiry results. Through two examples and discussion, the students found that the methods of solving problems in the two cases are the same; both involve "integral" to "zero", "straight" to "qu", "unchanged" to "change"; The steps are the same, divided into "division, approximation, summation, limit" four steps; The conclusion is to find a particular form of "sum limit". Based on summarizing the law, the concept and notation of definite integral are derived. After acquiring the idea, let the students immediately analyze the difference between indefinite integral and definite integral. After comparing the two concepts, the definite integral is the limit value of a particular sum, while the indefinite integral is to find all the original functions: on this basis, ask (1) Is the value of the definite product related to the division of intervals and the method of

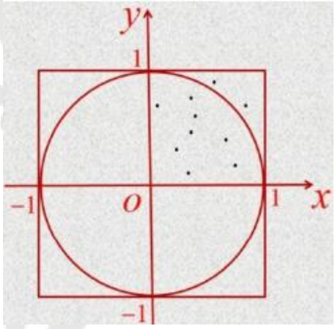
	taking variables in each interval? (2) What does the value of a definite integral relate to? Finally, solving the two problems means that the integral f(x)dx equals the integral f(t)dt.
Step4 Elaborate	Based on students' understanding of the concept, the geometric meaning is explained intuitively with the help of multimedia. Organize the practice of applying geometric meaning to obtain an area in time so that students can consolidate and deepen the concept in the application. After mastering the concept of the definite integral, students were asked to solve the two examples before class, and they found that both the area of the trapezoid with a curved edge and the distance of the variable speed line could be solved by a definite integral. Every definite integral expression, no matter its actual meaning, can be explained geometrically, and the geometric definition of the definite integral can be visually demonstrated. Show example problem: Find the parabola y=x? The area of a plane figure enclosed by a line x=1,y=0. Teachers explain this so that students can further understand the method's division and arbitrary nature. In the consolidation exercise using the definition of definite integral to find the area of a plane figure, students practice teacher comments. During the training, deepen your understanding of the concepts.
Step5 Evaluate	Organize students to summarize the above teaching links so that students can reflect on the learning process and understand the essence of solving problems. Through induction, students can master the key points, find out the key to solving problems, comprehend the thought and method contained in mathematical knowledge, and, more importantly, master the scientific method of researching issues, thus developing and improving students' thinking and learning. At the same

	time, guide the students to put forward relevant questions to study this lesson and explore further. Teachers should expand the time and space limited to the classroom to the classroom, create online courses, QQ groups and other communication platforms, and guide students to explore with questions combined with social life after class. Based on exchange and discussion, students are invited to make a summary, and teachers and students comment according to the situation of the students' summary. At the same time, the students are guided to ask questions based on this lesson. During the practice, the students find that calculating the definite integral with the defined value is complicated and difficult. Is there another way to estimate the value of the definite integral? What if I approximate the area of a trapezoid with a curved edge? What's the connection between definite integrals and indefinite integrals? According to the questions put forward by students, let students discuss in groups after class to stimulate students' desire for further exploration.

Inquiry-based learning program 9

Course	Higher vocational mathematics		
Course content	Probability of random events	**Teaching time**	100 minutes
Textbook	Higher vocational applied mathematics		
1. Learning goals			
(1) Let students understand random events, the frequency stability and the probability definition. Competency literacy goals: (2) Cultivate students' core qualities of mathematics in three aspects: intuitive imagination, mathematical abstraction and data analysis, and cultivate students' development core of learning, courage to explore and apply information technology;			
2. Teaching key points and difficulties			
The law of randomized trials, the difference and connection between frequency and probability			
3. Teaching process			

Teaching procedure	Teacher and student behavior
Step1 Engage	Teachers use pictures of basketball games to create situations and let students analyze whether a shot can score. Question: Look at the picture. Do you know the athletes in the photo? Do you think this player's shot will go in? How do you think his shot went? What's your reason?

Step2 Explore	In order to explore the concept of random events, the teacher gives the following two examples to let students think carefully and answer questions: Question 1: in the match between China and Slovenia in the 2016 men's basketball world championship, we were still two points behind the opponent in the last 5.6 seconds. As a result, Wang Shipeng was given the last chance to shoot. Please explore and discuss the reasons? Students first think about the reasons by themselves, and then discuss each other's views in groups. Question 2: draw a circle with a radius of 1 and a square with a side length of 2 with Excel. The circle is inscribed on the square. You can sprinkle sesame seeds into the square at random. What is the probability of sesame seeds falling into the garden? Can you figure out? The students in the first group will do 10 experiments, the second group will do 20 experiments, the third group will do 50 experiments, the fourth group will do 100 experiments, and the fifth group will do 500 experiments. After that, the groups will discuss the results.  Teachers guide students to analyze and think about practical problems in life from the perspective of mathematics, and associate the hit rate in basketball with the probability in mathematics, so as to realize the purpose of explaining practical problems through mathematics. Students cooperate in the experiment, and each group carries out the experiment according to the required number of times through the pull-down function of Excel. Students draw a line chart based on the experimental results. Discuss the reasons for data discrepancy between groups.

<table>
<tr>
<td>Step3

Explain</td>
<td>According to the life situation of wangshipeng's winning shot, all students in the group think and summarize the reasons for wangshipeng's winning shot, and give their own understanding and understanding of random events and probability. Students who have experienced the random experiment process can better understand the randomness of the experiment, experience the regularity after a large number of repeated experiments, and deepen the understanding and mastery of the concept. Then discuss in groups and choose one student in each group to share the answers with the whole class. This can not only exercise students' generalization ability, but also improve their language expression ability, and provide opportunities for mutual evaluation among students. At the same time, teachers should properly patrol during students' discussion, and ensure that all students can participate in the discussion even if students' wrong thinking direction is corrected. Finally, teachers guide students to summarize the mathematical definition of probability, correct the mistakes, and let students identify the shortcomings.

The mathematical meaning of random events and probability is summarized through specific examples, so that students can learn to think with mathematical thinking.</td>
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<tr>
<td>Step4

Elaborate</td>
<td>Teachers show examples from life and let students solve them through the definition of probability.

<table>
<tr><td>抽取产品数</td><td>100</td><td>200</td><td>500</td><td>1000</td><td>2000</td><td>5000</td></tr>
<tr><td>残次品数</td><td>7</td><td>13</td><td>29</td><td>61</td><td>120</td><td>300</td></tr>
<tr><td>残次品频率</td><td>0.07</td><td>0.065</td><td>0.058</td><td>0.061</td><td>0.06</td><td>0.06</td></tr>
</table>

What is the probability of defective products being found when the number of products is large?

Which key is the longest on the keyboard? Why do designers design this way?</td>
</tr>
</table>

	Students solve the probability of defective products by the knowledge they have mastered. Discuss why keyboard Spaces are the longest and most convenient to use.Through the extension of common problems in life, students can use the knowledge to solve problems, enhance their sense of achievement, and let them truly understand the use of learning.
Step5 Evaluate	Students review and summarize the whole class, conduct self-evaluation and group mutual evaluation on the three aspects of what new knowledge they have learned in this class, their own exploration process and their own perception, speak boldly, state their own views on this class, and evaluate the teacher's teaching. It enables students to clarify the context of the knowledge in this section, have a comprehensive and systematic understanding of the knowledge, skills and thinking methods learned, cultivate students' ability of induction and language expression, and facilitate teachers to find advantages and disadvantages from students' evaluation, and pay attention to maintaining or improving in future teaching.

Inquiry-based learning program 10

<table>
<tr><td>Course</td><td colspan="3">Higher vocational mathematics</td></tr>
<tr><td>Course content</td><td>Classical scheme</td><td>Teaching time</td><td>100 minutes</td></tr>
<tr><td>Textbook</td><td colspan="3">Higher vocational applied mathematics</td></tr>
<tr><td colspan="4">1. Learning goals</td></tr>
<tr><td colspan="4">(1) Understand the "finiteness" and "equal possibility" characteristics of classical schemes;
(2) Master the probability calculation formula of random events under classical probability;
(3) Experience the probability knowledge contained in life, strengthen the consciousness of applying what you learn, stimulate the interest and enthusiasm of mathematics learning, and cultivate the spirit of seeking truth.</td></tr>
<tr><td colspan="4">2. Teaching key points and difficulties</td></tr>
<tr><td colspan="4">Understand the "finiteness" and "equal possibility" characteristics of classical schemes and master the calculation formula of the probability of random events under classical schemes.</td></tr>
<tr><td colspan="4">3. Teaching process</td></tr>
<tr><td colspan="2">Teaching procedure</td><td colspan="2">Teacher and student behavior</td></tr>
<tr><td>Step1
Engage</td><td colspan="3">In the Renaissance period, the Italian mathematician Cardan was keen on gambling games; the rules of the game were to throw two dice, and the sum of the points of each dice faced up as the gambling content. Given that the six sides of a die are marked with 1 to 6 points, which number is the most advantageous to place in a bet? After the students operate by themselves and summarize the class results, as shown in Figure 3, they</td></tr>
</table>

	find that the number of times of "point sum of 7" appears the most, so the possibility of "point sum of 7" is the greatest. Through the introduction of mathematicians' stories, students' desire to explore is stimulated, students' scientific literacy is improved, and students can understand the history of mathematics, feel the charm of mathematical culture, encourage students to explore, propose and solve problems, and cultivate students' good learning attitude.
Step2 Explore	Question 1: Try to write the sample space of the following experiment and consider whether the probability of occurrence is the same for each sample point. (1) Throw a die of uniform texture and the number of points upward when landing; (2) There are six groups in the class. The teacher randomly selects one group and finds a particular group; (3) From the three white balls and three black balls of uniform texture, touch two balls without putting back and touching the white ball. The teacher summarized the students' answers and put them into a table Students try to explore the standard features of the above three experiments from the two aspects of sample space and sample points. Question 2: With the results of the class summary of the gambling problem just now, explain mathematically why "the sum of points is 7" is most likely. Each group in the class has a discussion and summarizes the group discussion results. Through exploring group cooperation, students' cooperation consciousness and cooperation ability are cultivated so that students

<table>
<tr><td></td><td>realize that a team's success cannot be separated from everyone's efforts, and students' teamwork spirit is nurtured. At the same time, through the short story about the history of mathematics, students realize that the probability of gambling is calculated, and they should be grounded.</td></tr>
<tr><td>Step3

Explain</td><td>Each group elected representatives to report on the outcome of the discussion on question 2. According to the group discussion results, students can obtain the sample space of this question, as shown in the table below. Among them, 6 sample points can get a "point sum of 7", more than the sample points of other point sums, so "point sum of 7" is the most likely. The teacher fully affirmed the students' findings and guided the students in abstracting the definition of classical schemes from this problem.

<table>
<tr><th>Ⅰ号 / Ⅱ号</th><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th><th>6</th></tr>
<tr><td>1</td><td>(1,1)</td><td>(1,2)</td><td>(1,3)</td><td>(1,4)</td><td>(1,5)</td><td>(1,6)</td></tr>
<tr><td>2</td><td>(2,1)</td><td>(2,2)</td><td>(2,3)</td><td>(2,4)</td><td>(2,5)</td><td>(2,6)</td></tr>
<tr><td>3</td><td>(3,1)</td><td>(3,2)</td><td>(3,3)</td><td>(3,4)</td><td>(3,5)</td><td>(3,6)</td></tr>
<tr><td>4</td><td>(4,1)</td><td>(4,2)</td><td>(4,3)</td><td>(4,4)</td><td>(4,5)</td><td>(4,6)</td></tr>
<tr><td>5</td><td>(5,1)</td><td>(5,2)</td><td>(5,3)</td><td>(5,4)</td><td>(5,5)</td><td>(5,6)</td></tr>
<tr><td>6</td><td>(6,1)</td><td>(6,2)</td><td>(6,3)</td><td>(6,4)</td><td>(6,5)</td><td>(6,6)</td></tr>
</table>

The primary body status of students should be reflected in the explanation link.

The teacher should guide the students to focus on specific points of their participation and inquiry, allow them to express their views, and then explain after the students have finished speaking. It can exercise students' expression and logical thinking abilities.</td></tr>
<tr><td>Step4

Elaborate</td><td>Through the participation of students in the above three links, the teacher puts forward new questions based on the student's recent development area and asks the students to "draw a lesson from one example" according to the previous learning to get the answer to the new question.</td></tr>
</table>

	Based on question 3, the teacher makes a variation to get question 4, which promotes the further transfer of knowledge and achieves the purpose of applying what they have learned. Question 3: In daily standardized tests, multiple-choice questions are A common form of question. Usually, candidates must choose a correct answer from four options: A, B, C, and D. If you do not know how to answer a random answer on the test, what is the probability of getting it right? Question 4: There are multiple choice questions in standardized tests, including four choices: A, BC and D (at least two are correct). Which is more challenging to choose between single choice and multiple choice? Why is that? Through the teaching of Question 3 and Question 4, teachers teach students to have a correct view of learning, not only rational thinking but also a down-to-earth, pragmatic spirit.
Step5 Evaluate	To give students correct feedback and self-positioning in the evaluation process, the teacher pays attention to everyone's participation during the group discussion and allows other group members to comment or ask questions during the group report. Finally, teachers can organize students to carry out self-evaluation, intra-group evaluation, inter-group evaluation and final summative evaluation. Through diversified evaluation methods, students' self-confidence and class cohesion can be improved. Students' interest in learning can be better stimulated, and students' personality quality and growth thinking can be educated.

Inquiry-based learning program 11

<table>
<tr><td>Course</td><td colspan="3">Higher vocational mathematics</td></tr>
<tr><td>Course content</td><td>Discrete random variable</td><td>Teaching time</td><td>100 minutes</td></tr>
<tr><td>Textbook</td><td colspan="3">Higher vocational applied mathematics</td></tr>
<tr><td colspan="4">1. Learning goals</td></tr>
<tr><td colspan="4">(1) Understand the concepts of random variables and discrete random variables and be able to solve practical problems with discrete random variables;
(2) Cultivate students' ability to discover, propose, analyze and solve problems and produce self-confidence and curiosity in learning mathematics.</td></tr>
<tr><td colspan="4">2. Teaching key points and difficulties</td></tr>
<tr><td colspan="4">Understand the concept of discrete random variables.</td></tr>
<tr><td colspan="4">3. Teaching process</td></tr>
<tr><td colspan="2">Teaching procedure</td><td colspan="2">Teacher and student behavior</td></tr>
<tr><td>Step1

Engage</td><td colspan="3">This part sets up the question situation, arouses students' interest in learning and stimulates students' desire for active exploration.
The teacher created the situation: in the Tokyo Olympic Games, Yang Qian, a young general born in 2000, won the champion in the 10-meter air rifle final. In shooting sports, each shooting result of shooters is a very typical random event.
(1) How do you describe the level and characteristics of each player's shooting skills?
(2) How do we select good players to have a better chance of winning in international competitions such as the Olympic Games?</td></tr>
</table>

	In this section, just three minutes, without affecting the progress of the course, can make students feel at home, pay attention to current national affairs and international events, and have a spirit of dedication. Stimulate students' desire to solve problems, generate interest in learning the knowledge of this lesson, and help students to learn new concepts.
Step2 Explore	Group credit discussion Exploration Activity 1: Question 1: What number of rolls are possible when you roll a die? Question 2: If someone shoots once, the possible number of loops? Question 3: What is the result of flipping a coin? In a random experiment, each sample point can always correspond to an actual number, thus realizing the quantitative quantification of sample points. The occurrence of sample points in random experiments is random, so the value of variable x is also random Exploration Activity 2: Introducing the question: The previous question was the result of tossing a coin once, so what is the number of flips required to toss a coin until it comes up with heads? Three of the 100 electronic components (including at least three defectives) were randomly selected for testing, and variable X indicates the number of secondary elements in the three components. Layers of questioning let the students think from the special to the general in-depth thinking, and then put forward the example of dice coins, let the students understand that relying on gambling to become rich is impractical and do things to be down-to-earth. In group communication, cultivate students' participation consciousness and cooperative exploration ability. In solving layers of problems, students are trained to

	analyze problems, solve problems and summarize mathematical ideas to achieve the teaching goal of this lesson.
Step3 Explain	This part allows students to explain their understanding of the concept, or teachers can discuss concepts, methods, or techniques. In the process, students gain a deeper understanding of the knowledge. After students understand the common points of the two variables, the group summarizes the concept of random variables and discrete random variables. In this section, all students are involved in group discussion, which exercises their language expression ability. In this class, they learn essential and demanding information in a relaxed and pleasant atmosphere. The historical story of the scientist who proposed the concept of the random variable not only allows students to experience the wisdom of traditional culture and celebrities in the field of humanities in ancient and modern China and abroad. We can also feel the spirit of scientists to challenge difficulties and train students to discuss more, explore more, and persevere in the spirit of scientific research and the spirit of truth.
Step4 Elaborate	The teacher asks questions, and the students answer them Are the following random variables discrete random variables? (1) Daily sales of a supermarket in May: (2) the life of the bulb; (3) The number of tourists received by the Forbidden City in Beijing every day, In this link, students can be trained to analyze problems dialectically and actively explore the spirit

Step5 Evaluate	The teacher asked, What kind of learning process did you go through in this lesson? What are the difficulties? What did you learn? What type of gain? Students review and discuss the answers. Through the final open questions, teachers can not only understand what students have learned in this lesson, further adjust teaching and improve teaching ability, but also improve students' summarizing ability and cultivate students' cooperation, communication and discovery ability.