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Original Paper

Teaching Practice Research of Scaffolding Instruction in Secondary Vocational Mechanical Courses

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Abstract

Against the backdrop of vocational education reform and manufacturing industry upgrading, which have heightened talent requirements, this study addresses challenges in secondary vocational mechanical courses, including students' weak logical coherence, insufficient self-directed learning abilities, and poor initiative in seeking help. Grounded in Constructivism and the Zone of Proximal Development (ZPD) theory, scaffolding instruction is introduced into the teaching practice of these courses. Considering the pedagogical characteristics of secondary vocational mechanical curricula, a systematic framework is designed focusing on three dimensions: principles for scaffold construction, scaffold types, and scaffold adjustment strategies. Building upon the fundamental elements of scaffolding instruction and implementing adaptive modifications, a tailored scaffolding teaching process for secondary vocational mechanical courses is developed. Empirical implementation demonstrates that scaffolding instruction effectively enhances students' abilities in autonomous knowledge construction, collaborative learning, and problem-solving, thereby providing a referential pathway for the reform of mechanical engineering curricula in secondary vocational education.

Keywords

Scaffolding Instruction, Teaching Model, Secondary Vocational Curriculum, Mechanical Courses

1. Introduction

Against the backdrop of China advancing vocational education reform and manufacturing industry transformation and upgrading, secondary vocational mechanical engineering programs face new challenges in talent development. (Huang, 2024) National policies are continually introduced to vigorously promote vocational education reform, aimed at fostering its high-quality development and cultivating more skilled technical personnel to meet the needs of economic and social development. Concurrently, the intelligent transformation of the machinery industry imposes higher demands on students, requiring them not only to possess mechanical expertise but also abilities in innovation, teamwork, and problem-solving. However, the current quality of vocational education in China varies considerably, and mechanical vocational education cannot fully meet talent demand. (Yang, 2021) Through in-depth research, this study identified significant problems in current mechanical engineering instruction at the secondary vocational level: ① Students commonly exhibit weak foundational knowledge and low motivation, underdeveloped logical thinking skills, a lack of independent inquiry ability, and poor initiative in seeking help; ② Concurrently, teaching practices are characterized by ineffective implementation of innovative teaching methods, the dominance of traditional instructional models leading to ineffective classroom interactions, and insufficiently detailed, stage-based assessment of student learning progress resulting in inadequate guidance. These problems adversely impact teaching quality and the effectiveness of talent cultivation, highlighting the urgency and necessity of exploring new pedagogical models.

Instructional scaffolding, grounded in Vygotsky's Zone of Proximal Development (ZPD) theory and constructivism learning theory (Wang, 2024), provides dynamic and personalized support to help students bridge the gap between their current developmental level and their potential level. Teachers, based on ongoing assessment of student learning progress, erect tailored scaffolds and dynamically adjust them. As students' abilities increase, these scaffolds are gradually faded, ultimately empowering students to construct knowledge independently. This approach offers a promising avenue to address the aforementioned challenges in secondary vocational mechanical education.

2. Connotations of Scaffolded Instruction

Scaffolding Instruction lacks a universally standardized definition due to varying scholarly interpretations. The dominant conceptualization derives from the European Community's Distance Education and Training Programme (DGXXII), defining it as a teacher-mediated process where educators provide learners with a conceptual framework for knowledge construction based on current competency levels. This framework enables learners to systematically deconstruct complex tasks, progressively advancing cognitive development and subject mastery (He, 1997). The term "conceptual framework" signifies methodological systems for interpreting information (Cheng, 2006), positioning Scaffolding Instruction as both a teaching model and pedagogical approach. Its essential characteristics include student-centered design, systematic implementation of developmentally appropriate methods, and strategic teacher support to facilitate active knowledge construction and skill advancement toward higher competence levels (Jia, 2018). While some scholars characterize it as a teaching strategy or theoretical concept, all definitions converge on the central tenet of erecting scaffolds through structured teacher guidance to optimize learning processes.

Since its introduction to China, Scaffolding Instruction has stimulated extensive academic engagement. Professor He Kekang proposed a five-phase framework comprising scaffold erection, contextual immersion, independent exploration, collaborative learning, and outcome evaluation, which gained broad recognition among Chinese scholars (He, 1997). Adapting this to mechanical vocational education, we define Scaffolding Instruction as an instructional model anchored in constructivism and Vygotsky's Zone of Proximal Development theory. Centered on learning objectives and students' current competency levels, it utilizes scaffolds from teachers or peers to facilitate knowledge construction through standardized procedures. Within learners' proximal development zones, teachers progressively erect scaffolds to guide task completion (Cheng, 2006). Subsequent dynamic fading of scaffolds upon goal attainment enables students' transition from supported dependence to autonomous practice.

3. Application Design of Scaffolded Instruction

Scaffolded Instruction is fundamentally characterized by dynamic and personalized support, with scaffold erection serving as its critical foundation. The efficacy of this process directly determines instructional coherence and student competency development. Consequently, preparing tailored scaffolds constitutes the core implementation strategy, as their strategic deployment within learners' Zone of Proximal Development significantly enhances learning outcomes (Du, 2005). This study systematizes scaffold erection through establishing guiding principles, categorizing scaffold types, and formulating adjustment protocols. The resulting structured framework elevates instructional quality in secondary vocational mechanical classrooms by bridging theoretical constructs with practical application.

3.1 Principles of Scaffold Erection

(1) Principle of student body

Scaffolding teaching is based on constructivist theory, which emphasizes that students are the main body who take the initiative to explore, integrate and create the meaning of knowledge based on their own experience and cognitive structure. Therefore, the implementation of scaffolding teaching must be student-centered, fully respecting the main position of secondary students in the construction of mechanical knowledge.

On the one hand, teachers need to change their roles from the dominant player in the classroom to the guide of learning. For secondary students' weak foundation, ability difference, teachers grasp the learning situation is not specific enough, analyze the students' situation, accurately grasp the cognitive characteristics of secondary students, knowledge base and learning needs, determine the starting point of teaching, tailored to the material, targeted to provide support, give support, guidance and help.

On the other hand, the teaching content needs to be close to the actual life of students and vocational (job) ability needs, not only to emphasize the theoretical learning of textbooks, but also to emphasize the practical ability to improve. Through the creation of mechanical troubleshooting, equipment disassembly and commissioning and other real task situations, to stimulate students' desire to explore, to achieve common progress in theory and ability.

(2) Principle of Zone of Proximal Development

Scaffolded Instruction operates within Vygotsky's Zone of Proximal Development which refers to the optimal learning space between students' current abilities and their potential capabilities. This zone represents where teacher guidance can most effectively promote learning progress (Wang,2025). Teachers need to carefully adjust task difficulty to match this developmental range and provide properly designed scaffolds to ensure substantial learning advancement.

As students' zones of proximal development continuously expand with increasing knowledge and skills the scaffolds must be correspondingly adjusted to maintain suitable challenge levels. Teachers should therefore establish flexible support systems that are personalized varied and adaptable to progressively enhance students' mechanical expertise.

(3) Principles of appropriateness and dynamics

The appropriateness principle governs scaffold design through three dimensions: timeliness, suitability, and moderation. Timeliness requires intervention precisely when students encounter cognitive barriers near their competence boundaries, preventing premature constraints or delayed assistance. Suitability demands alignment between scaffold difficulty/content and learners' current developmental levels. Moderation regulates scaffold quantity to balance autonomy and support.

The dynamicity principle necessitates flexible adjustments to scaffold parameters based on real-time teaching progress and student feedback. Crucially, scaffolds must follow a fading protocol - progressively withdrawn as competence grows - to ultimately foster independent knowledge construction.

(4) Principle of collaboration and interaction

This principle activates knowledge construction through structured teacher-student and peer interactions. Teachers must dynamically monitor learning states, provide just-in-time guidance, and cultivate egalitarian dialogue environments to optimize instructional efficacy.

Peer interactions form mutual scaffolding systems where students challenge cognitive boundaries through collaborative problem-solving, simultaneously enhancing knowledge integration and teamwork competencies.

(5) Principle of combining engineering and learning

For mechanical vocational education, scaffold design must bridge classroom and workshop. Industry-aligned scenarios embed theoretical knowledge into authentic tasks like equipment troubleshooting, implementing "learning through practice" pedagogy to develop actionable problem-solving skills.

3.2 Types of Scaffolding

Building scaffolding is the foundation and core of scaffolding teaching, and scaffolding in the teaching process mainly plays a guiding role, and teachers should provide students with different types of scaffolding to guide learning and inspire thinking. (Xiao, 2024) In the division of teaching scaffolding types, the domestic and foreign academic circles have not yet achieved a consistent opinion, and scholars from various countries have put forward diversified categorization. Through systematic study of related literature, combined with the teaching characteristics of secondary mechanical courses, this paper divides learning scaffolds into two categories: general-purpose scaffolds and specialized scaffolds. Among them, universal scaffolding has wide applicability and can be universally applied in the teaching of various disciplines; comparatively speaking, specialized scaffolding is more suitable for the teaching of secondary mechanical courses, and can also be applied in the teaching of other disciplines.

Table 1. Classification of Scaffolds

Scaffold Category	Specific Scaffold Types
Generic scaffolding	Question Scaffolding, Suggestion Scaffolding, Chart Scaffolding, Tool Scaffolding, Emotion Scaffolding, Evaluation Scaffolding
Specialized scaffolds	Contextual scaffolds, terminology scaffolds, operational scaffolds

(1) Generalized scaffolding

According to the different teaching contents of each subject, the commonly used types of scaffolding are focused on the following:

① Problem scaffolding: it is a chain of problems or a collection of associated problems with gradient. The design of questions should follow the logic from easy to difficult, from shallow to deep, and guide students to think deeply and inspire their thinking in a gradual manner.

② Suggestion scaffolding: it refers to inspiring and guiding suggestions that provide perspectives on thinking and ways to solve problems, which can help students clarify the direction of learning, cross the difficulties, and gradually realize the learning objectives.

③ Chart Scaffolding: "Charts include a variety of tables and diagrams, which can visually express the connection between things and systematically grasp the pulse of complex issues. Describing information in a visual way is particularly suitable for supporting students' advanced thinking activities, such as interpretation, analysis, synthesis, and evaluation." (Gao,2012)

④ Tool scaffolding: provide tools or methods that can assist students in learning, such as teaching courseware, teaching aids, virtual models, online learning platforms, and AI intelligent assistants, AI exercise recommendation systems, etc., to help students complete knowledge construction.

⑤ Emotional scaffolding: establish a harmonious teacher-student relationship, give students personalized care and encouragement, pay attention to students' emotional needs and psychological state, mobilize their intrinsic learning motivation, and realize the common growth of knowledge and emotion.

⑥ Evaluation Scaffolding: With the help of quantitative assessment forms, classroom performance, homework completion, etc., students' learning effects are comprehensively evaluated from multiple dimensions, and the feedback of evaluation promotes the two-way improvement of teachers' teaching and students' learning.

(2) Specialized Scaffolding

Specialized scaffolding for intermediate mechanical courses include:

① Situational scaffolding: create vocational scenes or problematic situations with a certain degree of authenticity and inspiration, which are closely related to the actual work tasks, attracting students' interest and guiding them to explore and learn in specific scenes, so as to realize the integration of theory and practice.

② terminology bracket: simplification, analogy, comparison, associated scenes, etc., the abstract mechanical terminology into a familiar or easy to understand form of expression, reduce the learning difficulty.

③ Operation scaffolding: refers to the support tools and strategies designed to help students master practical operation skills or processes. For example, sorting out the operation process, decomposing the task steps or providing specific aids, etc., as a way to guide the operation and support students to gradually master the skills.

3.3 Scaffolding Adjustment Strategies

Students' learning of knowledge is a dynamic and gradual development process, and students are independent individuals with differences in cognitive level and knowledge construction level between individuals. (Shen, 2022) According to the principle of appropriateness and dynamics of building scaffolds, it is necessary to build appropriate scaffolds and adjust them dynamically in the students' nearest development area to help realize the crossing of Zone of Proximal Development (ZPD). In the teaching of secondary mechanical courses, corresponding adjustment strategies can be set according to the teaching.

3.3.1 Preparation before Class

Analyze the learning situation before class, accurately preset scaffolds, and integrate scaffold resource packages to lay the foundation for smooth teaching in class.

(1) Diagnose the learning situation and preset scaffolds

With the help of homework, questionnaires and pre-study tests, systematically assess the current level of students, accurately grasp their stage of learning and preset scaffolds with different contents and difficulties. The questionnaire is combined with the learning style test (e.g., visual, auditory, kinesthetic preferences) to gain a deeper understanding of students' learning characteristics and cognitive habits, and to preset diverse scaffolds.

For example, according to the stratification of learning styles, we prepare scaffolds such as illustrations of basic concepts and a list of key knowledge points for students with a weak foundation, and provide advanced scaffolds such as extended learning materials and introductions to cutting-edge theories for students with a better foundation, in order to satisfy the learning needs of students at different levels. At the same time, according to students' habits, we provide appropriate scaffolding forms for students with different styles, such as visual scaffolding for visual students, such as charts, images and AR models; and hands-on scaffolding for kinesthetic students, such as hands-on operation and virtual simulation.

(2) Design of scaffolding resource packages

The resources are categorized and organized into different scaffolding types, which makes it easy for teachers to quickly call up scaffolds based on students' feedback and teaching progress in classroom teaching.

Table 2 Categorization of Scaffolding Resources

Scaffolding types		Typical examples of resources
Generic scaffolding	Question Scaffolding	Gradient question chain, contextualized quiz list, etc.
	Suggestion Scaffolding	Analogical migration suggestions, etc.
	Diagram Scaffolding	Schematic diagrams of parts structure, data comparison tables, etc.
	Tool Scaffolding	Videos, animations and other multimedia resources, teaching aids, virtual models, etc.
	Emotion Scaffolding	Personalized encouragement cards, milestone achievement reward cards, etc.
	Evaluation Scaffolding	Evaluation scales, testing exercises, etc.
Specialized scaffolds	Situational Scaffolding	Troubleshooting cases, work scenarios videos, etc.
	Operational Scaffolding	Operating manuals, virtual simulation software, etc.
	Terminology Scaffolding	Analogical mnemonic mnemonics, specialized vocabulary illustrations, terminology Thinking maps, etc.

3.3.2 In-class Adjustment

Relying on the scaffolds and resource packages preset before class, collect learning feedback in multiple dimensions and use multiple strategies to adjust the scaffolds in order to optimize the teaching effect.

(1) Classroom Observation and Instant Feedback

Observation of Learning Status: During classroom teaching, teachers should closely observe students' listening status, participation and response, pay attention to non-verbal signals such as students' eyes, facial expressions, and motivation in answering questions, and determine students' understanding of knowledge and points of confusion, so as to provide scaffolding in time.

Online Instant Quiz: Use various ways to collect students' learning feedback. Instant quizzes are conducted using real-time classroom question-answering tools to quickly understand students' mastery of knowledge points. For common problems, teachers immediately focus on explaining and invoking scaffolding to strengthen instructions; for individual problems, individual guidance and personalized learning suggestions and supplementary materials.

(2) Stage knowledge assessment and scaffolding adjustment

Classroom teaching content is divided into a number of sub-tasks, and after the end of each sub-task, a quick knowledge assessment is carried out. For example, after explaining the theoretical knowledge of "gear transmission", a 10-minute mini-test is conducted through the online testing platform to assess students' mastery of gear parameters, transmission ratio principle and other content. The scaffolding is adjusted based on the assessment results after the assessment:

A high correct rate (>85%) indicates that students have a high level of mastery of knowledge, and the adjustment strategy is to remove the basic scaffolding and provide scaffolding for higher-level learning or challenging extension tasks and resources.

For moderate correct rates (60%-85%), the adjustment strategy is to maintain the existing scaffolding and provide reinforcement for the points where students' errors are concentrated, and scaffolding can be added to help students consolidate their learning.

For low correct rate (<60%), it is necessary to enhance the support of scaffolding, further disassemble the complex knowledge content, and adopt a more detailed and intuitive way of explanation.

(3) Differentiated scaffolding supply

In the middle of the lesson, tiered teaching support and personalized teaching guidance are still needed. According to students' learning bases and receptive abilities, students are divided into different levels, and scaffolds of corresponding difficulty are provided. For students with different learning styles and characteristics, provide personalized scaffolding.

3.3.3 Post-lesson Reflection

After classroom teaching, analyze the effectiveness of the scaffolds used and the teaching effect, organize and analyze the learning data, improve the design of the scaffolds and improve and update the scaffold resources.

(1) Effectiveness analysis and improvement

Collect students' feedback through homework, post-class evaluation, etc., evaluate the effectiveness of the scaffolding and the overall teaching effect against the teaching objectives, and summarize the teaching experience and shortcomings. Optimize and improve the scaffold according to the analysis results. For the knowledge points that students do not have a solid grasp of, we will redesign or adjust the presentation, content difficulty and timing of the scaffolding used in this part; for the knowledge points that students have a better grasp of, we will further improve the relevant scaffolding so that it can better serve the teaching and learning. At the same time, according to the students' learning needs and developmental changes, constantly update and supplement the scaffolding resources to ensure the scientific and effective scaffolding adjustment strategy, and continuously improve the quality of teaching.

(2) Learning data organization

collects and organizes classroom assessment data, students' homework completion, learning feedback information, etc., and establishes students' dynamic learning files. Integrate students' learning data into the form of line graphs, radar charts and other charts for in-depth analysis to find out students' prevailing knowledge weaknesses and learning difficulties, and provide a basis for subsequent teaching and scaffolding adjustments. Through interviews and other means, we investigate students' preference and evaluation of the use of different scaffolding resources, and analyze the interview data by organizing them into the form of pie charts, bar charts, word cloud charts, etc., so as to understand the effect of the use of each type of scaffolding and students' acceptance, and to make clear the effective scaffolding and scaffolding that needs to be improved. Based on the results of the analysis, the scaffold design is adjusted and improved, and the adaptive resources are updated to ensure that the teaching support is highly compatible with students' learning needs.

In summary, the principle of scaffolding provides a theoretical basis and standardized guidelines for teachers to build scaffolds, so that the scaffolds are in line with the needs of students and guarantee the scientificity and effectiveness of scaffolding teaching; summarizing and organizing the types of scaffolds can help teachers to quickly match the scaffolds with the target of calling them during the different teaching sessions and enhance the relevance of teaching; the scaffolds are not static and fixed but need to be dynamically adjusted according to the development of students' abilities and learning needs. Dynamic adjustment, inappropriate timing, the difficulty of the content may hinder the learning process, so the design of scaffolding adjustment strategy to realize the scaffolding of the scientific predetermination, flexible adaptation and timely withdrawal, to ensure the efficiency of classroom teaching. The three are interrelated and work together to make the core action of “building scaffolds” scientifically implemented in the teaching process, ensure that the scaffolds are adapted to the actual needs of students, and effectively enhance the effectiveness of the scaffolds.

4. The Construction of Teaching Process

reference to Professor He Kexiang put forward the basic links of stent teaching, combined with the teaching characteristics of the secondary mechanical courses, the original teaching links for adaptive transformation, to build the content of the secondary mechanical courses in line with the teaching process, as shown in Figure 1. Among them, “building a scaffold” as the basic activity of scaffolding teaching, running through the “presetting scaffolding, entering the situation, independent exploration, collaborative learning, evaluation of the effect" of the teaching process, is to promote the core support for the construction of students' knowledge. Teachers study the learning situation before class, locate the existing development level of students, preset diversified scaffolds, build scaffolds for students layer by layer in each teaching session, and flexibly adjust them according to students' real-time feedback to form a progressive learning path.

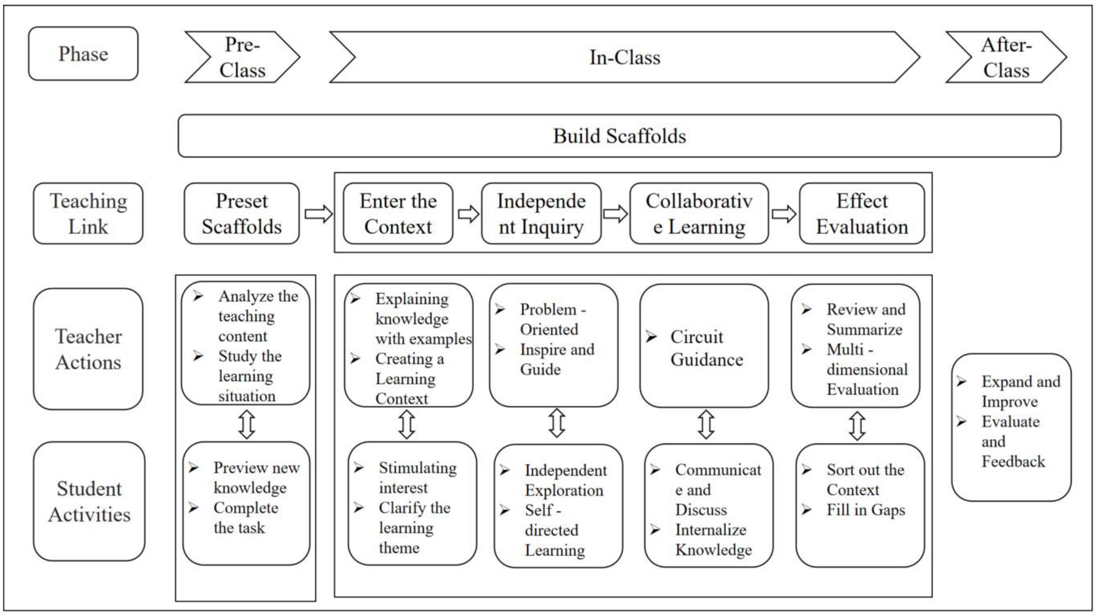

Figure 1. Flowchart of Teaching and Learning

4.1 Pre-class stage

Section ①: Preset Scaffolds

Generally, scaffolds are preset in the pre-class stage of scaffolding teaching. First, teachers systematically analyze the teaching content, clarify the teaching objectives and key and difficult points. Then, through means such as distributing questionnaires and assigning previewing tasks, they understand students' current knowledge level, learning habits, etc., to accurately identify students' "zone of proximal development". Subsequently, teachers preset learning scaffolds based on the teaching content and students' conditions. Common types of scaffolds include visual scaffolds such as micro-video explanations, tool scaffolds like AI learning assistants, guiding question scaffolds that inspire thinking, and situational scaffolds related to mechanical industry job positions, with the difficulty of the scaffolds controlled within students' zone of proximal development. Students complete previewing tasks, initially perceive the learning content, and establish a preliminary connection between existing knowledge and new knowledge, laying a foundation for in-depth learning with the aid of scaffolds during the class.

4.2 In-class Stage

As shown in Figure 1, the in-class stage consists of four sections: entering the situation, independent exploration, collaborative learning, and effect evaluation.

Section ② : Get into the situation

Teachers should start from the teaching objectives and content, take into account the needs and characteristics of students, and use various means to create vivid situations related to the learning theme, allowing students to explore learning in specific situations and stimulate their interest in learning. In this stage, the creation of scenarios can help students clearly define the learning theme and tasks, make abstract knowledge concrete, form an initial perception of the learned content, lay a solid foundation for subsequent teaching links such as independent exploration and collaborative learning, and build a bridge from the known to the unknown.

In the teaching of mechanical courses, the main ways for teachers to create scenarios are as follows:

(1) Build situations related to life or real working scenarios

Integrate teaching content closely with daily life examples or working scenarios in the mechanical industry, allowing students to directly experience the practicality of mechanical knowledge, evoke their resonance, stimulate their desire to explore, and enhance their application awareness.

For instance, when explaining "chain drive", relate it to the normal operation scenarios of bicycle chains in daily life; When explaining "belt drive", relate it to the working scenarios of factory conveyor belts or the fault analysis of the "belt drive" part of factory mechanical equipment.

(2) Use multimedia means to present abstract knowledge

By leveraging multimedia technologies such as images, animations, videos, and virtual AR models, mechanical structures, working principles, or motion processes are presented, breaking through the limitations of time and space and transforming abstract knowledge into intuitive presentations.

For instance, in the learning of "Gear Transmission", an AR virtual model is used to demonstrate the meshing process of spur cylindrical gears, and a maintenance scenario of "abnormal noise from the gearbox caused by abnormal gear meshing clearance" is created, allowing students to intuitively understand the transmission principle in the process of fault diagnosis and analysis.

(3) Create problem-oriented inquiry scenarios

Centering on the teaching content, design problems or tasks closely related to the mechanical professional scenarios. By posing questions, guide students to apply knowledge to analyze, explore and solve problems, and cultivate engineering thinking.

For instance, in the "Threaded connection" teaching, a problem-oriented approach is adopted: "The screws on a bicycle tend to loosen after long-term riding. How can we prevent the screws from loosening?" Encourage students to actively think about the anti-loosening methods of threaded connections and seek solutions to promote the learning process.

Section ③: Independent Inquiry

Teachers break down learning tasks into several sub-tasks and gradually assign tasks or provide problem scaffolds to students. With the help of situational scaffolds and problem scaffolds, students carry out independent analysis and exploration through independent thinking, data consulting and other methods.

The ability of independent exploration is the core teaching objective of the scaffolding teaching mode. Teachers should play the role of guides, providing students with sufficient space and time for independent exploration and minimizing unnecessary intervention and constraints (Sun,2020). At the same time, they should dynamically observe students' states, promptly identify problems that students cannot solve independently, offer support, and enable students to receive appropriate guidance within their "zone of proximal development", thus achieving advanced thinking.

As students' mastery of knowledge improves, teachers gradually reduce the number of supports and increase the difficulty of the supports to help students cross the zone of proximal development and gradually cultivate their ability of independent exploration.

For instance, when explaining "Common Types of Gear Transmission", first, the teacher breaks down the learning task into two sub-tasks: "Appearance" and "characteristics", designs a hole-out exercise about the appearance, characteristics and other knowledge of different types of gears, and requires students to fill in the blanks according to the content of the textbook and learn independently. Secondly, teachers build question scaffolds, guiding students to establish connections between knowledge points. Students independently explore the relationship between appearance and characteristics. Teachers dynamically provide scaffolds based on students' performance to assist in learning. Finally, the teacher removed the brackets, demonstrated the applications of different types of gear transmission, and asked the students to identify the types and state the corresponding characteristics. From "filling in the blanks with reference books" to "making judgments independently without referring to books", simple tasks and application examples are used to enable students to learn to analyze the types and characteristics of gear transmission by themselves.

Section ④ : Collaborative Learning

Following the independent inquiry stage, it is an important period for students to further deepen their understanding of knowledge and enhance their comprehensive abilities. Teachers usually group students reasonably before class based on multiple factors such as their knowledge reserves, learning abilities, and personality traits, striving to achieve complementary advantages among group members, heterogeneity within the group, and homogeneity between groups.

Students work in groups and actively share their gains and insights during the independent exploration stage. For knowledge points that are controversial or difficult to understand, they jointly consult materials, analyze and reason, have intellectual collisions, break through the boundaries of thinking, and finally achieve a more comprehensive and in-depth understanding of knowledge through cooperative communication, realizing the internalization and absorption of knowledge. During this process, students build up "peer supports", enhance their teamwork and knowledge application abilities, and promote the progress of knowledge construction. Teachers, on the other hand, play an organizing and guiding role, making rounds to observe and promptly capture various issues that arise during discussions, providing timely guidance and inspiration. At the same time, they encourage mutual exchanges among groups, share viewpoints, and promote diverse collisions of thinking.

For instance, when discussing the "working process of CAM mechanisms", if there are differences within the group regarding the "lifting" process, the teacher can provide suggested brackets and advise students to compare and analyze the four processes of "lifting, stopping, lowering, and stopping", guiding students to clearly distinguish the essential characteristics of "lifting" as an independent motion stage.

Section ⑤: Effect Evaluation

After the previous study, students have mastered the basic knowledge, but this knowledge may be rather scattered and not systematic enough. At this point, teachers help students build a complete knowledge system and consolidate their understanding by comprehensively reviewing the teaching content and connecting scattered knowledge points. Students can also share the achievements of group collaboration or their personal experiences of exploration and cooperation, promoting collective communication and common progress. Conducting diverse process evaluations can involve the diversification of evaluation subjects and dimensions, enabling students and teachers to have a clear understanding of their own learning and teaching.

For instance, teachers evaluate the performance of each group, select the group with the best performance for praise, thereby achieving the effect of setting an example and encouraging progress. Meanwhile, the teacher provided emotional support to the non-winning group, encouraging them to keep up the good work.

4.3 After-school Stage

In terms of expansion and improvement, stratified homework of basic and extended types is assigned. All students are required to complete the basic homework, and those who have spare capacity for study should complete the extended homework. Teachers release extended materials on the online learning platform for students to consult and study independently.

In terms of evaluation feedback, evaluation scales can be developed based on scientific methods such as the CIPP evaluation model to comprehensively assess students' learning situations from multiple dimensions and subjects, making the evaluation results visible, achieving full-process evaluation, ensuring consistency among goals, processes, and evaluations, clarifying the direction for improvement in the next step, and laying the foundation for the scaffolding teaching in the next class.

5. Cases of Teaching Design

Based on the principles of bracket construction, diverse bracket types and bracket adjustment strategies, taking the teaching content of "Installation and Tensioning of V-Belt Drive" in the secondary vocational school "Mechanical Fundamentals" as an example, the theoretical framework is transformed into a specific teaching process, forming a teaching example that combines theoretical guidance and practical operability (Ni,2016), providing a reference for the application of bracket teaching in secondary vocational school mechanical courses.

(1) Pre-class stage

Step ① : Preset the bracket

Activity A: Preview new knowledge and grasp the learning situation

Study the curriculum standards and sort out the connection between knowledge points and job skills in combination with the content of the teaching materials. By analyzing the homework of the previous class, distributing student situation questionnaires and classroom observations, etc., the students' mastery of prior knowledge, existing foundation and learning habits are analyzed. Teaching goals are scientifically set, learning scaffolds are preset, and the support resources are classified and organized.

Based on the teaching analysis results and the constructed teaching process, the teaching approach is determined, as shown in Figure 2. Break down the knowledge points into two sub-tasks: "Composition and Main Parameters" and "Installation and tensioning Methods", and match the corresponding learning brackets for each task.

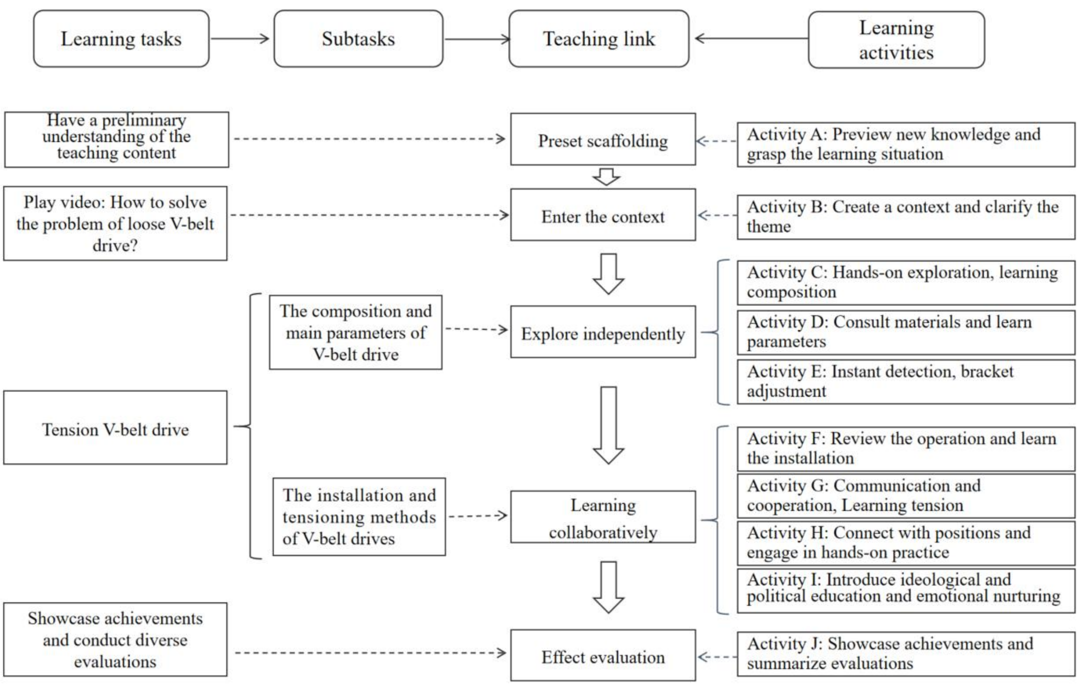

Figure 2. Teaching Approach

(2) In-class stage

Section ② : Get into the situation

Activity B: Create a context and clarify the theme

Set up the problem bracket and raise the question: "The V-belt of the car generator makes abnormal noises due to loosening. What should I do?" .

Set up a scenario stand, play a video, and create a working scenario to help maintenance worker Master Li solve the problem of loose generator belt to introduce the new lesson. Students watch videos, combine their existing knowledge and think about problems.

Section ③ : Independent Exploration

Activity C: Hands-on exploration, learning composition

Provide tool stands, distribute V-belt drive teaching AIDS, let students install V-belts independently, and think about how to solve the problem of loose V-belt drive through hands-on practice. Guide students to come up with the answer of "tensioning the V-belt".

Build a problem framework, guide students to independently explore the composition of V-belt drive, and raise the question "How is tensioning carried out?" .

At this point, students might answer "Reduce the length of the V-belt" or "increase the distance between the two pulleys".

If the student cannot get the second answer at this point, provide a suggested support. Use the example of "tensioning a rope with a skipping rope" to compare "tensioning a V-belt", and guide the student to come up with "increasing the distance between the two pulleys".

Activity D: Consult materials and learn parameters

When setting up the problem bracket, "What parameters are related to tensioning the V-belt?" .

Provide chart stands and examples of the main parameters of V-belt drives. Under guidance, students can independently consult materials to learn the main parameters of V-belt drives.

Activity E: Instant detection, bracket adjustment

Teachers release online real-time tests, and students complete the exercises.

For questions with a high error rate, teachers provide concentrated explanations. Individual guidance is provided for questions with a low error rate.

Teachers should not only provide students with sufficient space for independent exploration, but also dynamically observe their conditions, offer supports in a timely manner, answer their questions and solve their doubts. As students' mastery of knowledge improves, they should gradually remove the supports.

Section ④ : Collaborative Learning

Activity F: Review the operation and learn the installation

To help students transition between knowledge points, it is reminded that they should first learn how to install before learning how to tension.

The teacher reminded the students that the installation operation at the beginning of the class was not standardized and organized them to watch the V-belt installation video. In groups, let students reflect on their shortcomings and summarize the key points of operation. Teachers provide on-site guidance and targeted assistance.

Activity G: Communication and cooperation, Learning tension

Provide the problem bracket: How to adjust the relevant parameters for tensioning operation?

The teacher provides tool stands and shows animations and videos of various tensioning methods. Students build peer supports, study collaboratively in groups, communicate and exchange ideas, and summarize the tensioning methods of V-belt drives and their respective steps. Teachers provide on-site guidance and adjust the brackets in a timely manner.

Activity H: Connect with positions and engage in hands-on practice

When setting up a scenario support, "How can I check if the tension of the V-belt is appropriate when I enter the workplace in the future?" .

Students have group discussions. The teacher sets up the operation stand, explains the operation process and demonstrates it with teaching AIDS, and organizes students to complete the task work order.

During the process of student group collaboration and practical measurement, teachers dynamically provide support: (1) When students actively participate and have a high completion rate, emotional support is provided, praise is given, and group rewards are given; (2) Students actively participate, but when they make mistakes, suggestions for brackets, operation brackets, etc. are provided to guide and inspire the operation. (3) When students do not participate in the operation, join the student group to form a peer support, supplemented by operation supports, etc., explain the key points and work together.

Activity I: Introduce ideological and political education and emotional nurturing

Build an emotional framework for ideological and political education, remind students to operate with rigor and practicality, reduce the wear and tear of V-belts, on the one hand, bring out the significant meaning of the spirit of craftsmanship, and on the other hand, reduce energy consumption and establish the concept of green development.

Section ⑤ : Effect Evaluation

Activity J: Showcase achievements and summarize evaluations

After each group completed the task work order, they presented their operation "results", built evaluation scaffolds, and conducted mutual evaluations among groups and evaluations by teachers. Summarize the content of this class and make an overall comment based on the students' operational performance.

(3) After-class stage

In terms of expansion and improvement, assign corresponding stratified homework to consolidate what has been learned. In terms of evaluation feedback, an evaluation scale is designed based on the CIPP evaluation model and distributed to students. Teachers conduct a comprehensive evaluation of students through their classroom performance and the evaluation scale.

The results of teaching practice show that through building scaffolds, creating situations and collaborative learning mechanisms, scaffolds teaching can enrich the classroom teaching paradigm, help teachers accurately grasp the chemical situation at each stage, and provide effective support and assistance to students. Promote students to shift from passive acceptance to active exploration, significantly enhancing their logical connection ability and awareness of seeking help proactively. In the "independent exploration and collaborative learning" section, building a solid foundation framework for students with weak foundations can help them understand new knowledge, keep up with the classroom progress, and specifically improve the problem of students' weak foundations. At the same time, it can significantly enhance students' independent exploration ability and cooperative exploration level. The positive role of scaffolding teaching in cultivating students' comprehensive vocational abilities has thus been further highlighted, effectively achieving teaching objectives.

6. Conclusion

The scaffolding teaching mode is applied to the teaching of mechanical courses in secondary vocational schools. By establishing the principles of scaffolding construction such as the student-centered and the zone of proximal development, the types of scaffolding are summarized and integrated, and the scaffolding adjustment strategy throughout the process of "before class - during class - after class" is designed. Relying on the basic links of scaffolding teaching widely used in China and making modifications to them, A scaffolding teaching model for mechanical courses in secondary vocational schools has been formed, featuring "teachers dynamically building scaffolds and students independently constructing knowledge". Teachers systematically grasp students' learning situations and timely build personalized learning supports for them. Students complete knowledge construction with the help of different supports, gradually improving their abilities. This effectively alleviates the teaching pain points of students in mechanical education in secondary vocational schools, such as weak logical connection ability, poor awareness of actively seeking help, and single teaching methods.

In the future, the teaching design of secondary vocational mechanical courses based on scaffolding teaching will continue to be optimized. It can further integrate cutting-edge technologies such as intelligent manufacturing and AI-assisted tools to explore the integration of "intelligent scaffolding", enhance the application efficiency of scaffolding teaching in secondary vocational mechanical courses, and provide a more practical course reform path for cultivating compound technical and skilled talents.

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