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Design and Application of Task-based Ultra Learning Intelligent Platform (TULIP) Based on "4C+AeroRacing" Concepts

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Abstract: To improve the engineering practice competency of aviation personnel, the 4C education concept, that is, Competency, Cultivation, Conduction and Constructivism, is innovatively put forward, following the training concept of International Civil Aviation Organization (ICAO) based on the competency and combining with the concepts of the engineering education certification, classical education theory and modern teaching methods. Focusing on eliciting higher-order thinking and centering on trainees, the Aero-Racing learning mode is formed, which includes Attempt, Explore, Research, Operate, Rethink, Assessment, Challenge, Innovate and Generate. Based on the 4C concept and the Aero-Racing mode, the Task-based Ultra Learning Intelligent Platform (TULIP) is designed and developed by combining information technology with education and teaching and combining with the characteristics of "Digitalization + Intelligence". Taking the major of Civil Aviation Transportation as an example, the teaching practice and verification of TULIP are carried out. Through the comparative analysis of the learning data of two groups of trainees, such innovative intelligent learning mode can effectively improve the learning efficiency of trainees and has high reference and promotion values for the cultivation of professional and technologically innovative talents in the engineering education.

Keywords: Competency-based Training; Educational Innovation; Higher-order Thinking; Intelligent Learning; Learning Intelligent Platform

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1.0 Introduction

In the aviation transportation system, as a direct participant in aviation transportation activities, knowledge and working competency are of great significance to the safe, efficient and green operation of the system. With the increasing number of global aviation traffics, the aviation transportation system has higher and higher requirements for the comprehensive quality and competency of aviation personnel. However, the traditional educational concept and educational mode are limited by their own shortcomings, which are increasingly unsuitable for the needs of the competency training of aviation personnel nowadays. On the other hand, in today's highly developed information technology, intelligent education, as a high-end form of educational informationization, has attracted more and more attention around the world (Zhu and He, 2012, Gu and Du, 2019). How to innovate the educational concept and educational mode, deeply integrate information technology, intelligent learning and aviation education and teaching, and promote the further development of aviation education informationization has become an inevitable choice for aviation colleges and training institutions to innovate the educational mode for aviation talents (Song et al., 2020, Zhang et al., 2022, Gong et al., 2022).

Therefore, this paper first aims at improving the competency of aviation personnel and explores an innovative "4C" concept and Aero-Racing mode that is consistent with the requirements of competency training and the development of modern educational

concept, is learner-centered and conforms to the law of learning cognition. Secondly, based on the "4C" Concept and Aero-Racing mode, a learning intelligent platform which can be used for trainees' autonomous learning is designed and developed by using the information technology, and a major change from "Teacher Teaching" to "Student Learning" is realized.

2.0 "4C" Concept and "Aero-Racing" Mode

2.1 The Problems of Lecture-based Teaching

Lecture-based teaching is a widely adopted teaching method among university teachers, where teachers deliver a high-density output of knowledge information. However, from the students' perspective, the effectiveness of learning is questionable. Therefore, we should objectively view the role of classroom teaching in contemporary university education. The effectiveness of teaching depends on the teaching methods employed by the teachers. If traditional lecture-based teaching is used, its effectiveness will be significantly reduced for the following reasons:

(1) Lecture-based Teaching Fails to Stimulate High-level Thinking

In lecture-based teaching, teachers deliver lectures at a fixed pace and maintain logical relationships between statements, which is a one-way output. For students, this is a passive reception, and it is primarily sensory, involving the eyes and ears. But has the brain, which should process, store, and integrate new knowledge, truly received it? Or how much has it received? The core issue is that a normal lecture pace does not provide students with time to think. Even teachers who emphasize heuristic, inquiry-based, or problem-solving teaching methods can only give students a very limited time to think after posing a question. In the context of extensive lectures, teachers who ask questions often reveal the answers within a few seconds. It is difficult for students to activate all their neural networks to connect new knowledge with existing knowledge, form comparisons, analyze, and reflect within a limited time frame. Moreover, frequent use of heuristic, inquiry-based, or problem-solving teaching methods can negatively impact the teacher's inherent rhythm. Given the reality of large class sizes and tight schedules in many Chinese universities, many teachers are reluctant to extensively employ these teaching methods. As a result, lecture-based classroom teaching tends to produce sensory or low-level thinking, and the acquisition of knowledge information remains superficial.

(2) The Presentation of Knowledge is not Conducive to High-level Thinking

In contemporary classroom teaching, knowledge is often presented through PowerPoint slides, which have become the absolute mainstream due to their convenience, flexibility, richness, intuitiveness, and efficiency, gradually replacing traditional blackboard teaching. However, a common problem arises in the use of PowerPoint for lectures: knowledge is presented too early and too much to students. Before a concept is even discussed, the content is already displayed, and the information on a slide is revealed without any animation, leaving nothing to the imagination. This approach can lead to a "preconceived notion" of knowledge, where the content or questions the teacher is about to discuss are prematurely revealed to students, hindering their ability to engage in independent and in-depth thinking. Higher-level thinking such as association, criticism, and innovation is also stifled.

Furthermore, traditional blackboard teaching has gradually been replaced by PowerPoint, and teachers rarely write beautiful blackboards anymore, which seem incompatible with the era of information and digitalization. However, from the essence of learning, knowledge mastery must be based on a structured and networked system, as isolated knowledge lacks vitality. Although PowerPoint has many advantages, it has an inherent "defect" in that it cannot present knowledge in a structured and systematic manner. Its method of presenting information is instantaneous, showing only the content of the current slide, making it difficult for students to learn within a related system. In contrast, blackboards can display knowledge structures more enduringly, and writing on them can adjust the lecture pace, allowing more time for students to think. The act of writing on the blackboard can also create an "empathy mirror" in students' minds, as they guess what the teacher is writing, which is more in line with the mechanism of high-level thinking.

2.2 Theoretical Basis of the "4C" Concept

The training of aviation personnel belongs to the category of engineering education. In the quality assurance system of higher education, engineering education certification is an internationally accepted quality assurance system for the engineering education, and its core is to confirm that engineering graduates meet the established quality standards recognized by the industry (Ye et al., 2018). Improving the educational concept and educational mode of aviation personnel from the perspective of the engineering education certification can not only cultivate trainees' practical competency, but also further cultivate trainees' competency to analyze and solve problems.

In the existing educational theories, the relevant mechanism and constructivism process of trainees' knowledge learning and competency formation have been fundamentally explained by classical educational theories such as the Bloom's teaching objective classification theory (Zhang, 2016), the constructivism theory (Wen and Jia, 2002) and the education theory of learning in practice (Duan, 2021). With the continuous innovation of educational concepts, educational experts have further explored the ways to realize knowledge constructivism and competency formation of trainees through some teaching methods such as the task-based teaching (Yang, 2006), the research-based teaching (Yan, 2021) and the flipping classroom teaching (Guo, 2021).

Therefore, following the concepts of Competency Based Training (CBT) (ICAO, 2020) and Competency Based Education (CBE) (Robert J, 2017) in the field of education of International Civil Aviation Organization (ICAO), and referring to the three concepts of the engineering education certification including the learner-centered, the objective-oriented and the continuous improvement, based on the classical educational theories such as the Bloom's teaching objective classification theory, the constructivism theory and the education theory of learning in practice, the advantages of modern teaching methods such as the task-based teaching, the research-based teaching and the flipping classroom teaching are used, and a theoretical system of "4C" teaching concept is constructed, as shown in Figure 1.

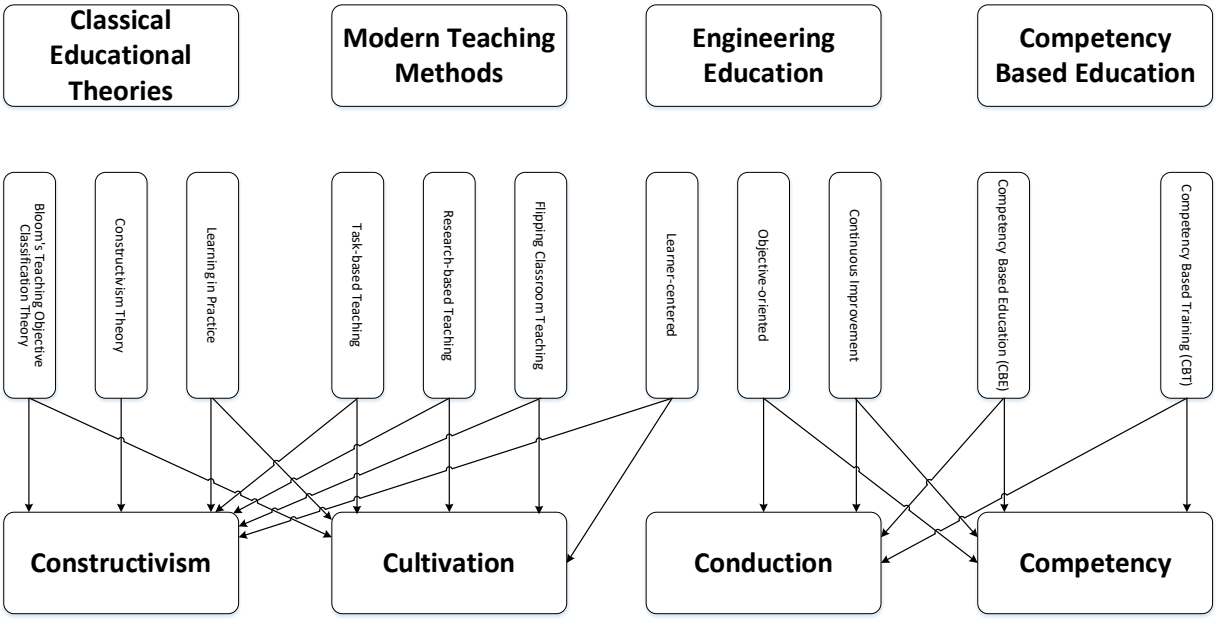

Figure 1. Theoretical Basis of the "4C" Concept

2.3 Definition and Composition of the "4C" Concept.

In 2011, the International Civil Aviation Organization (ICAO) introduced the concept of competency-based training and evaluation into the training of aviation personnel in the Regulations of Air Navigation Service Procedures-Training (PANS-TRG, Doc.9868). According to the relevant definitions in Doc.9868 (ICAO, 2020), Doc.10056 (ICAO, 2017) and Doc.10057 (ICAO, 2017), competency is a combination of skills, knowledge and attitudes required to perform a task to the prescribed standard. Compared with the traditional training mode, the competency-based training and evaluation is aimed at mastering the working competency, focusing on the trainees, and conducting targeted training for the aviation post competency requirements through flexible and diverse training methods, so that aviation personnel can effectively have the competency to be competent for a certain post.

Therefore, according to the concept of the competency-based training, for professional trainees in aviation colleges, the core of the education is "Competency" first, so that they can have the knowledge and skills required to be competent for future posts and achieve excellent results. To achieve such objective, first, teachers need to provide trainees with corresponding learning resources and learning paths, so that trainees can actively find the learning resources needed to solve problems through self-search, exploration and identification, and carry out autonomous learning, which is called "Cultivation". Secondly, for cultivating trainees' "Competency", it is not enough to learn knowledge only, but also to apply knowledge in practice, that is, it is necessary for trainees to concretize the acquired abstract knowledge and apply it in practice to solve practical problems, and then feedback and mobilize the consciousness and enthusiasm of

autonomous learning in the next stage through the experience of the meaning and function of knowledge, which is also called “Conduction”. “Conduction” and "Cultivation" interact and complement each other, and jointly support the core objectives of “Competency” training for trainees. At the same time, to complete the process of "Cultivation" and “Conduction” without outside help for trainees, it is necessary to create a “learner-centered” “Constructivism” learning environment for trainees in advance based on studying the relationship between knowledge learning and competency formation. Through the support of the environment, trainees can learn independently driven by their interests, which truly presents the profound connotation of “Independent Learning, Independent Practice and Independent Acquisition Competency of Trainees”, and then realizes the complete transformation from “Knowledge is taught by teachers” to “Knowledge is constructed by trainees themselves”.

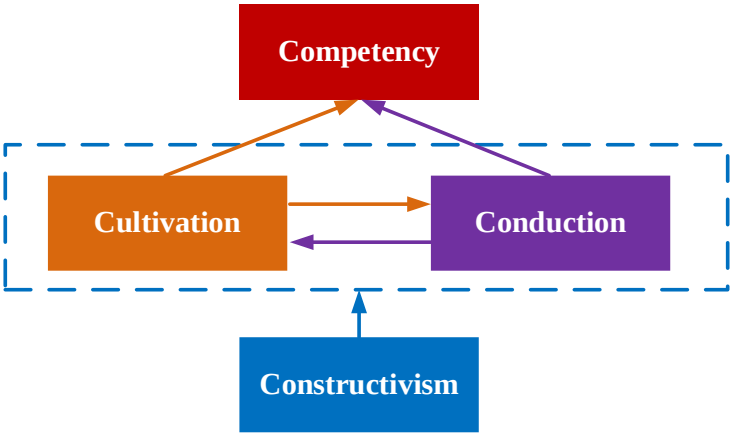

Figure 2. Composition of the “4C” Concept.

As shown in Figure 2, the meaning of the “4C” educational concept refers to: around the Competency index, under the learning environment of Constructivism, task-based learning stimulates trainees' learning motivation, cultivates learning resources by designing learning paths (Cultivation), and applies the learned knowledge in practice (Conduction), and finally achieves the organic integration of trainees' character, skills and innovation competency.

2.4 Meaning and Composition of the “Aero-Racing” Mode

Under the “4C” concept, in order to realize knowledge constructivism and competency formation for trainees, it is also necessary for trainees to generate higher-order thinking in the learning process (Jiang, 2017), and the more categories and the longer the duration of higher-order thinking, the better the effect of knowledge constructivism and competency formation.

The development of trainees' higher-order thinking needs corresponding practice or activity support, so that trainees can devote themselves to learning activities applied the higher-order thinking (Wang, 2018). Therefore, under the guidance of the “4C” concept, and based on the learner-centered, it is constructed from a learning mode composed of a series of higher-order thinking processes such as “Attempt - Explore - Research - Operate - Rethink - Assessment - Challenge - Innovate - Generate”, that is the Aero-Racing mode, which is as shown in figure 3.

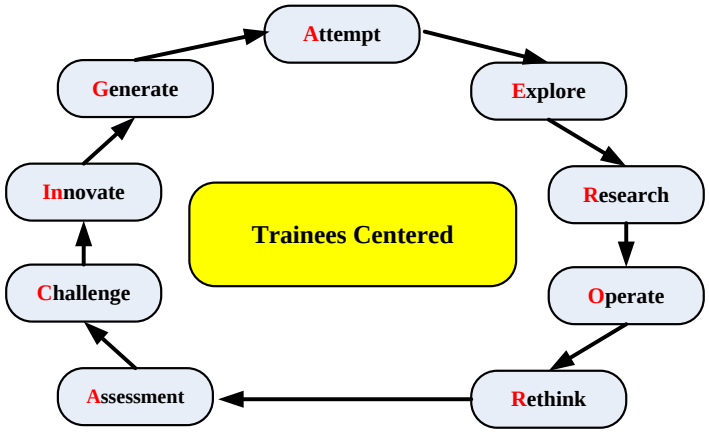

Figure 3. Composition of the Aero-Racing Mode.

3.0 Design of Task-based Ultra Learning Intelligent Platform (TULIP) based on "4C" Concept and "Aero-Racing" Mode

Under the guidance of the "4C" concept, this paper studies the objectives and overall structure of the courses, summarizes and analyzes the trainees' cognitive competency and application competency cultivated by the courses, studies the connection between the courses and the aviation personnel's post competency, and forms competency objectives of the courses. Applying the competency-based education to the contents of training courses, based on the "Aero-Racing" mode, this paper explores the mode and path to achieve the competency objectives of courses. Combining virtual simulation behavior analysis, learning behavior analysis, big data analysis, data visualization and other technologies with education and teaching, this paper designs and develops a tool which name is Task-based Ultra Learning Intelligent Platform (TULIP). The design concept of the platform is shown in Figure 4.

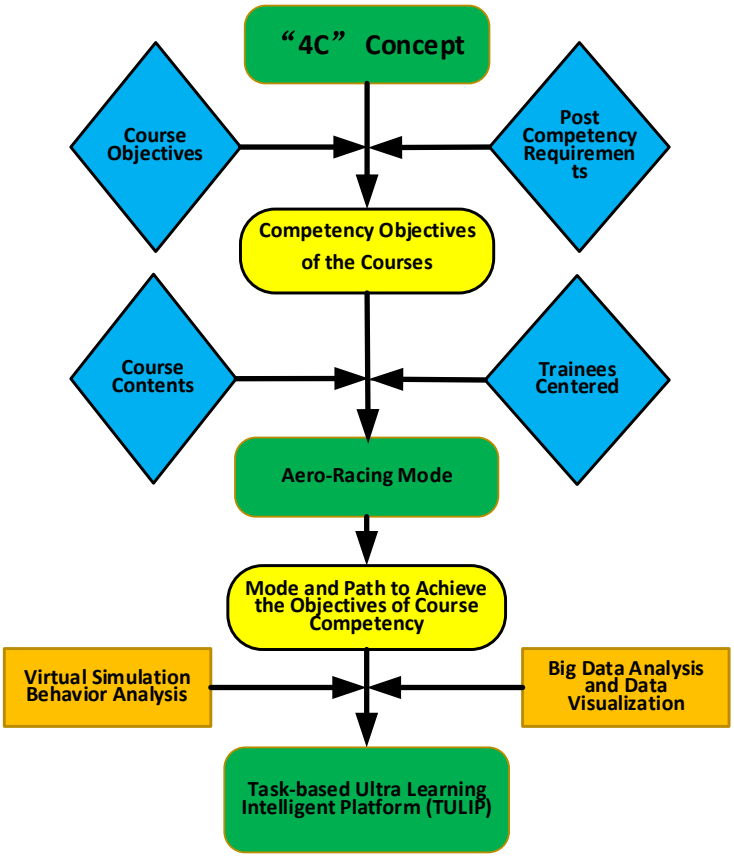

Figure 4. Design Concept of Task-based Ultra Learning Intelligent Platform (TULIP).

The "4C" concept and Aero-Racing mode provide theoretical support for knowledge constructivism and competency formation of trainees, while task-based ultra learning intelligent platform (TULIP) provides learning environment and implementation paths for knowledge constructivism and competency formation of trainees.

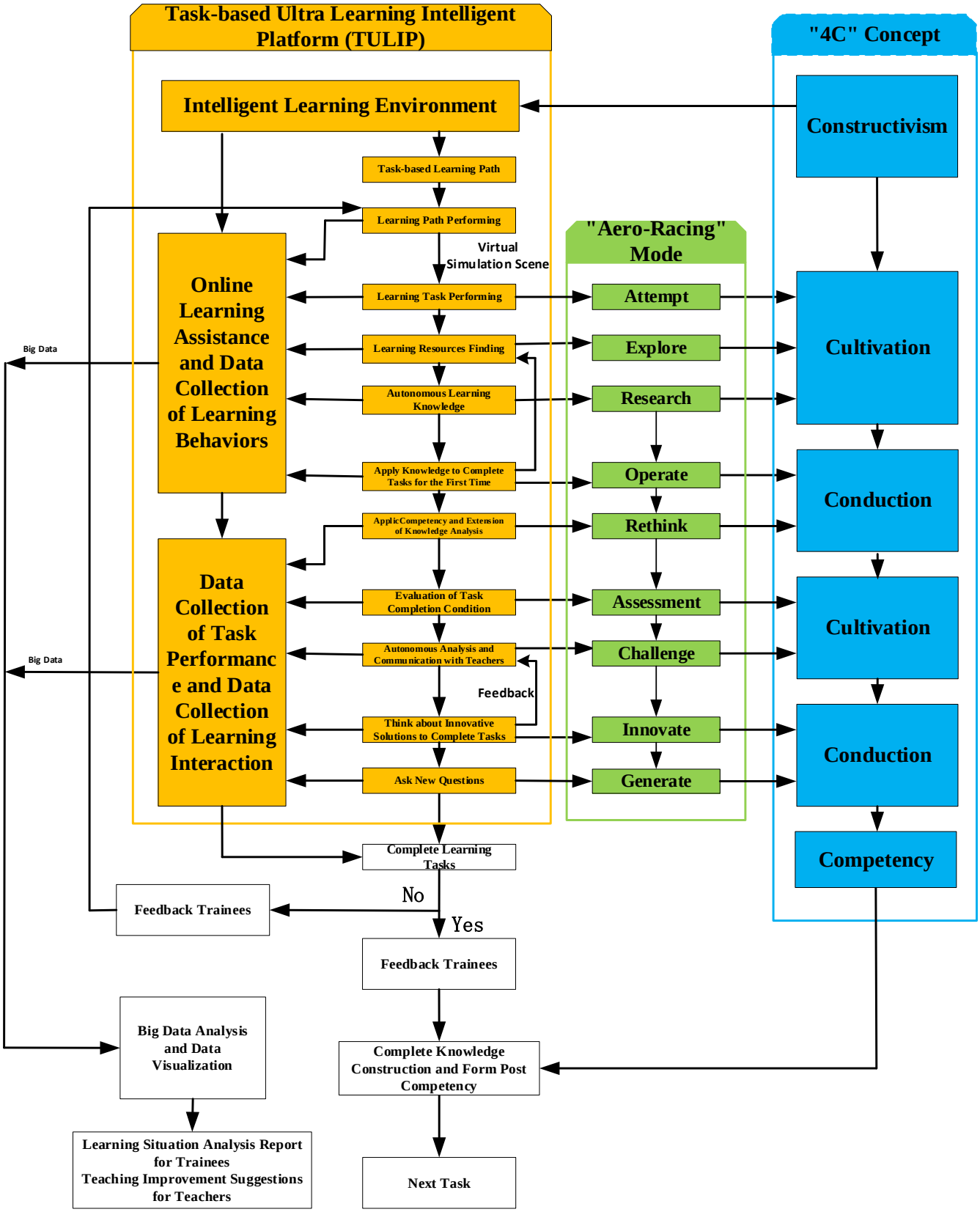

Figure 5. Implementation Paths of the “4C” Concept and "Aero-Racing" Mode.

As shown in Figure 5, an intelligent learning environment is formed through the “Constructivism” of task-based ultra learning intelligent platform (TULIP). With the support of the intelligent learning environment, “Task + Trial and Error” are used as the inducing condition, and the learning motivation of trainees is stimulated by the task-based

learning path, and the learning behavior of trainees is triggered by the "Aero-Racing" mode. Trainees find learning resources and complete their learning tasks in the autonomous learning mode with "Inducing Research". Through the continuous reciprocating and dynamic cycle of "Cultivation" and "Conduction", they complete knowledge constructivism and competency formation, and finally achieve the objectives of “Competency”. Taking the "Wake Interval" learning task in air traffic management course as an example, this paper explains the learning processes and learning behaviors for trainees.

Before the task begins, trainees need to read the learning guidance carefully to understand the requirements and objectives of the task, which is as shown in Figure 6.

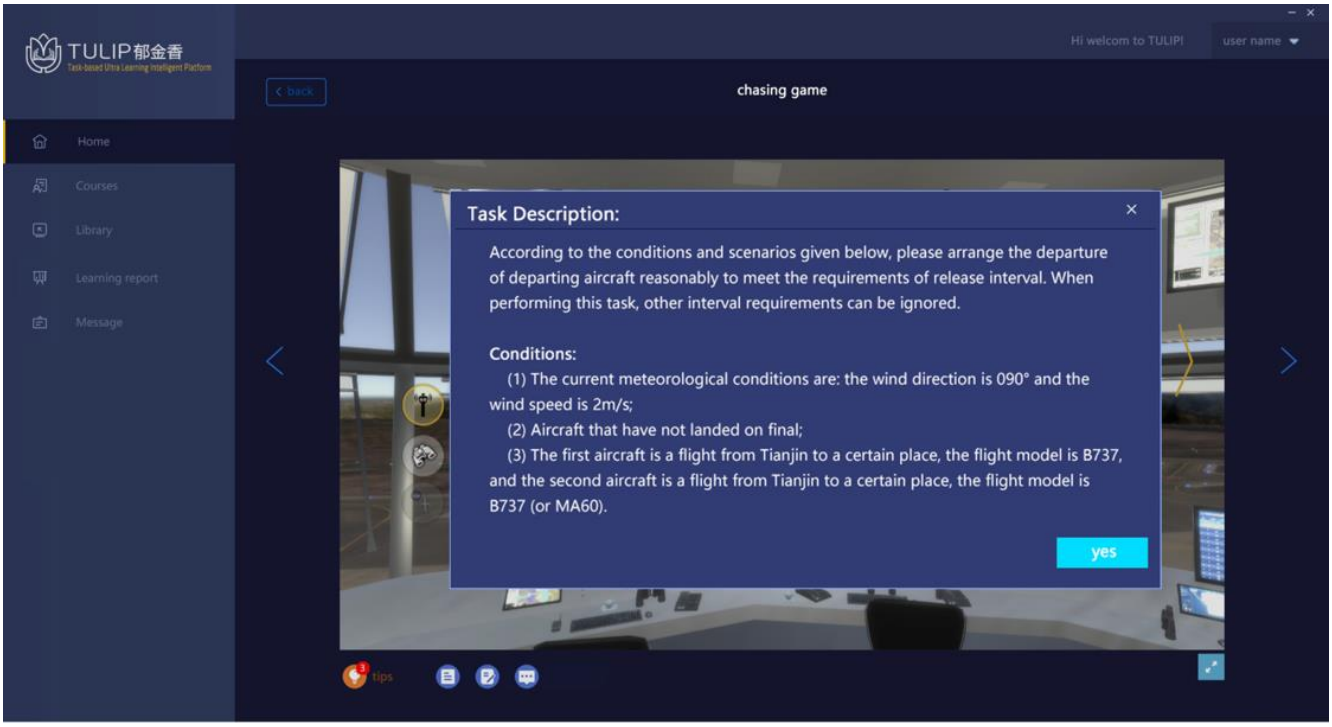

Figure 6. "Wake Interval" Learning Task.

After performing the task for the first time, the learning platform provides trainees with a trial opportunity, during which no help is provided, and no grades are recorded. Trainees need to complete the task in a limited time, with the objective of making them feel the task and make preliminary thinking and design without any reference materials. Finally, trainees might probably end up in failure, but it would cause trainees to think further and activate their learning motivation.

From the second performing the task, trainees can see new tips, and the learning platform gives three tips containing tips, as shown in Figure 7. Tips do not provide specific answers to complete tasks but tell trainees where the key to complete tasks may be, and guide trainees to find answers in the learning resource library through clues, and the number of tips used also affect trainees' scores in cognitive competency indicators. All kinds of learning materials in the learning resource library contain the knowledge points needed to complete this task, but trainees need to find, explore, analyze and learn by themselves. As shown in Figure 8, the numerical value of wake interval in the learning materials found by trainees is the key to complete this learning task.

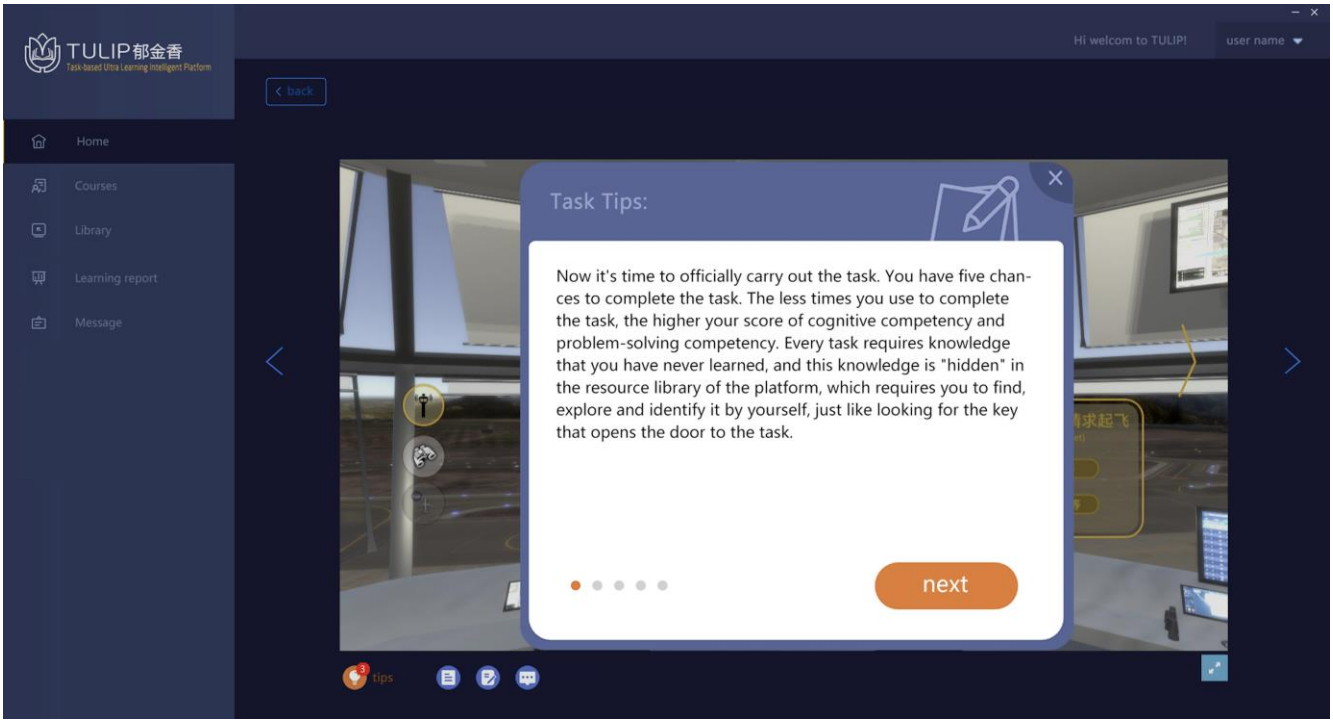

Figure 7. Task Tips.

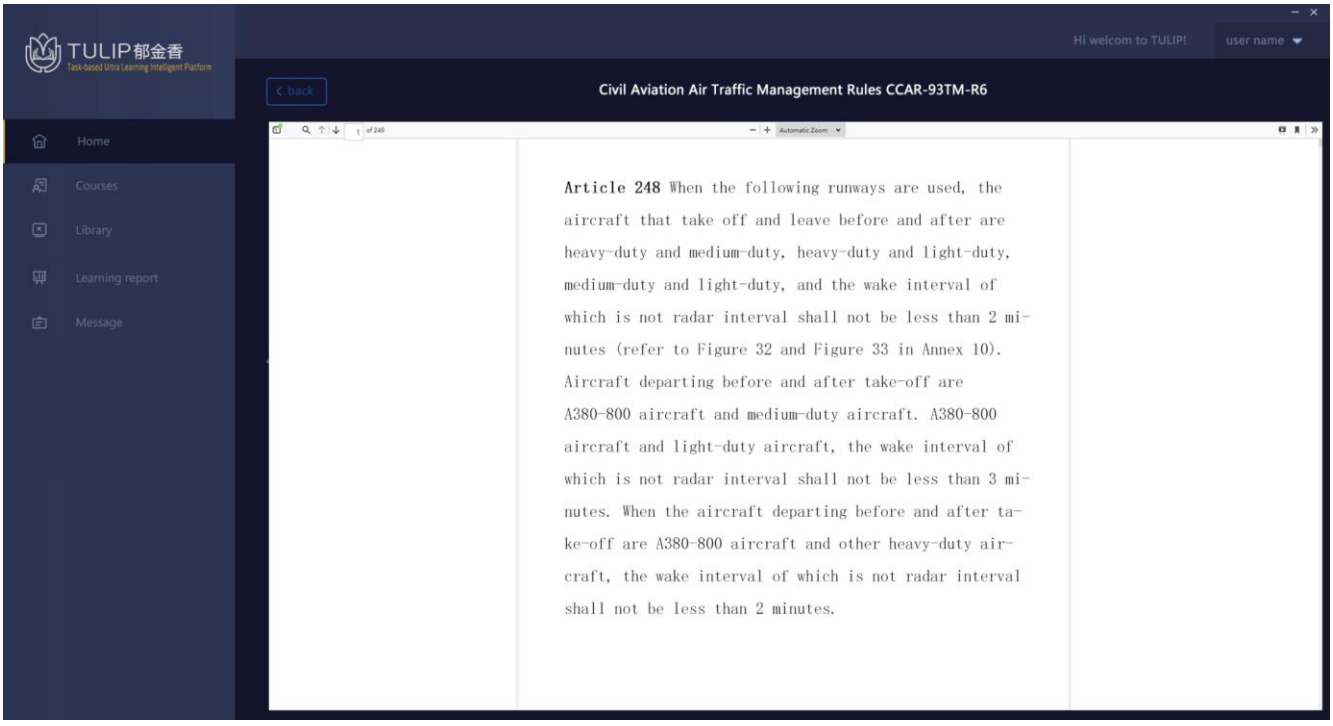

Figure 8. Learning Materials in the Learning Resource Library.

During the whole learning period, trainees are allowed to keep trying tasks continuously, but the number of customs clearances can affect the score of problem-solving competency index of trainees.

After the task is finished, trainees need to answer after-school tests and metacognitive competency surveys, and complete four questions in their learning notes, which trigger the cultivation of reflecting competency and consciousness of critical innovation for trainees.

In addition, from the time trainees enter the platform to perform tasks, their learning behaviors on the platform, including mouse operation, document search, learning materials, task performance, communication and interaction, are recorded. These data are an important basis for analyzing learning styles, learning habits, learning attitudes, learning effects of trainees and providing academic reports.

4.0 Analysis of Learning Behaviors Based on Data of Task-based Ultra Learning Intelligent Platform (TULIP)

In the process of knowledge learning and task operation of trainees, through the data collection and analysis function of Task-based Ultra Learning Intelligent Platform (TULIP), learning behaviors of trainees are tracked and recorded, and combined with big data and artificial intelligence algorithms, intelligent learning assistance and learning behavior analysis are provided for trainees in the whole process of learning.

(1) Online Learning Assistance

The intelligent tutor "Xiaobei" carries out intelligent reminding and learning assistance in the process of learning and task operation of trainees, assists autonomous learning online of trainees, analyzes and evaluates learning styles and habits of trainees, gives follow-up learning suggestions, corrects bad learning habits and cultivates lifelong learning competency. The details about the intelligent tutor "Xiaobei" are as shown in Figure 9.

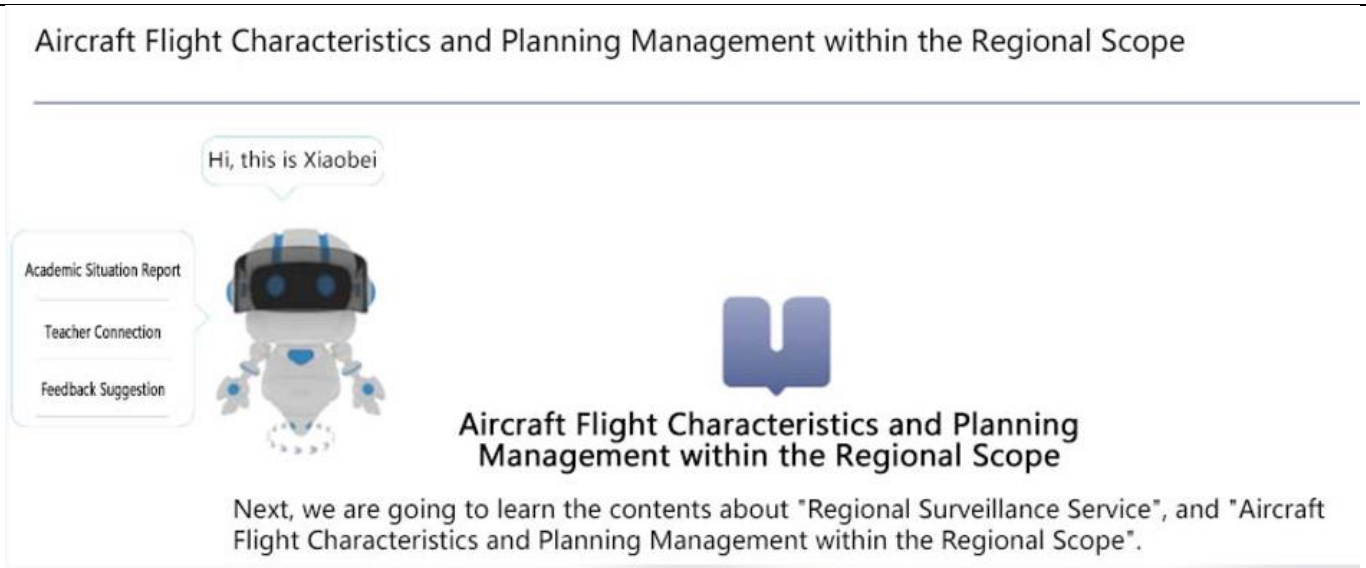

Figure 9. Intelligent Tutor "Xiaobei" in Task-based Ultra Learning Intelligent Platform (TULIP).

(2) Learning Behavior Analysis

The platform accurately correlates and deeply analyzes the collected learning behavior data, task performance data and learning interaction data with the evaluation index system, and analyzes and evaluates trainees' learning competency, communication habits and learning attitude (Nick Cercone and Kanlaya Naruedomkul, 2013, Daniel D and Jason Mazanov, 2016, Durksen, 2016). On the one hand, the platform generates personalized learning situation analysis report for trainees, including competency portrait, attitude analysis, improvement suggestions and so on, to realize personalized and customized learning plan (Kenneth Strang, 2016). On the other hand, it can automatically generate teaching improvement suggestions for teachers, and scientifically predict the trend of future learning results for trainees (Yeonjeong Park and Ji Hyun Yu, 2015).

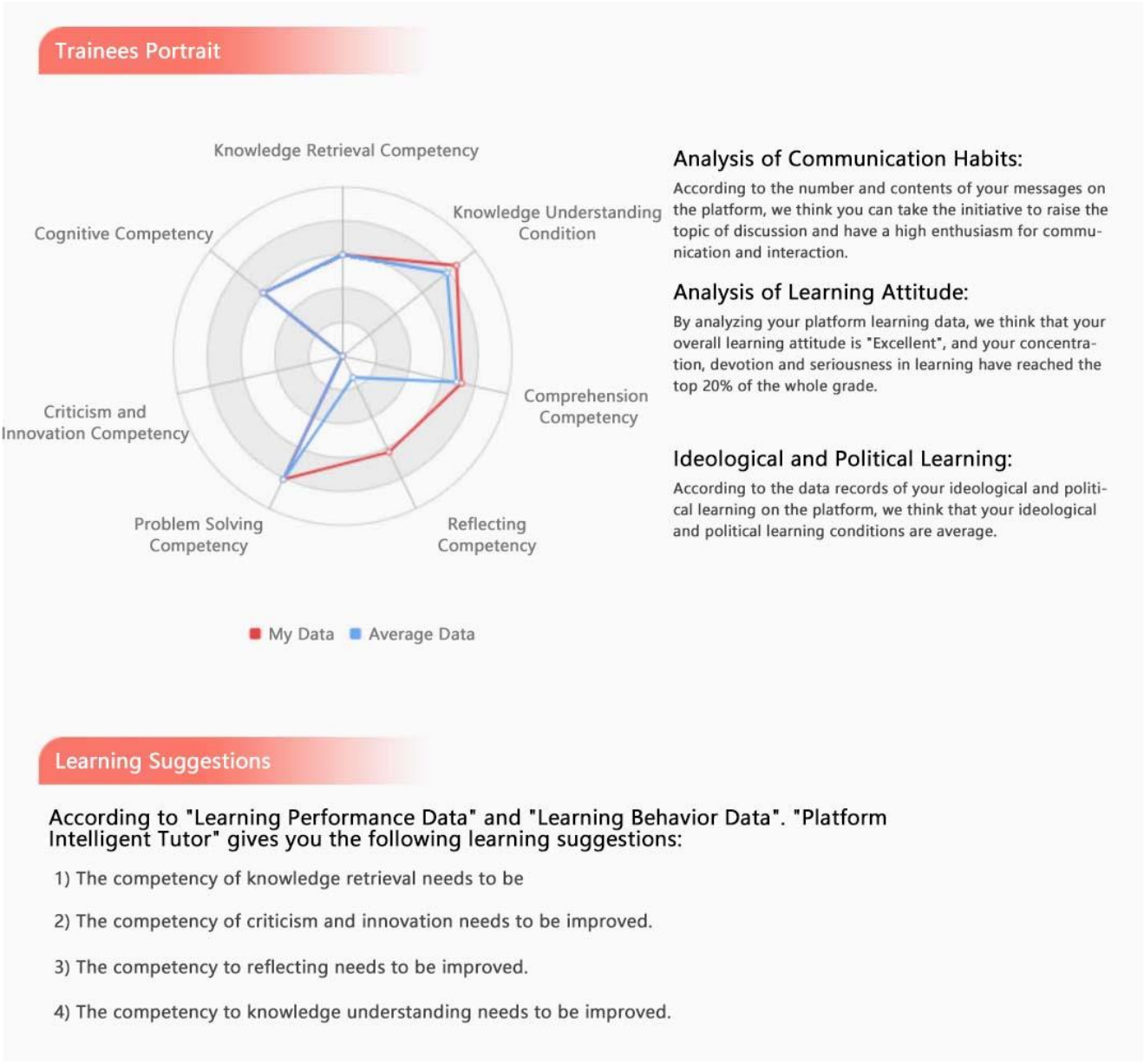

Figure 10. Learning Report of Trainees in Task-based Ultra Learning Intelligent Platform (TULIP).

5.0 Application Effect Analysis

Up to now, the cumulative number of users of Task-based Ultra Learning Intelligent Platform (TULIP) has exceeded 7,000, and the satisfaction of teachers and trainees has reached 96.25%. Taking the radar control course of the majors of Civil Aviation Transportation as an example, trainees are divided into two groups. For some learning tasks, trainees use their spare time to learn by themselves online, and teachers do not need to explain more. For the rest of the learning tasks, the traditional classroom teaching mode is still adopted to explain the trainees in class. In the teaching process, we set up a test to understand the mastery of knowledge in class and compare and analyze the learning effect of autonomous learning on the platform and traditional teaching.

Figure 11 shows the results of the in-class test of the courses. From the comparative results of the in-class test results of all eight learning tasks, the correct answer rate of autonomous learning in six tasks is higher than that of the traditional learning method, which verifies the effectiveness of the teaching concept and method based on the Task-based Ultra Learning Intelligent Platform (TULIP).

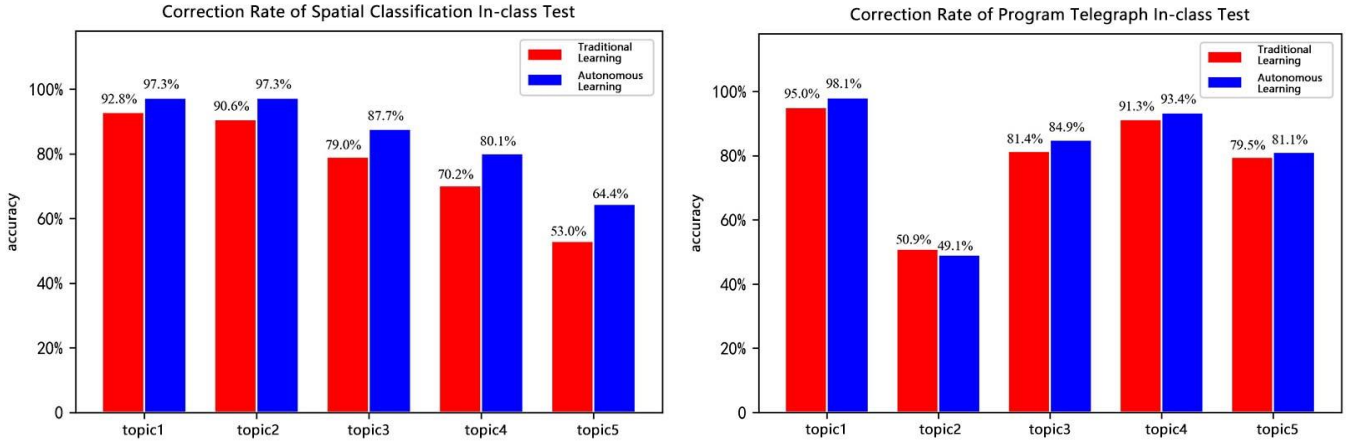

Figure 11. Comparison between Autonomous Learning and Traditional Learning.

As shown in Figure 12, to compare the learning feelings of autonomous learning and traditional learning methods for the same knowledge content, it can be seen that trainees generally think that autonomous learning has stronger learning motivation, higher learning challenges, greater learning performances and better learning experience.

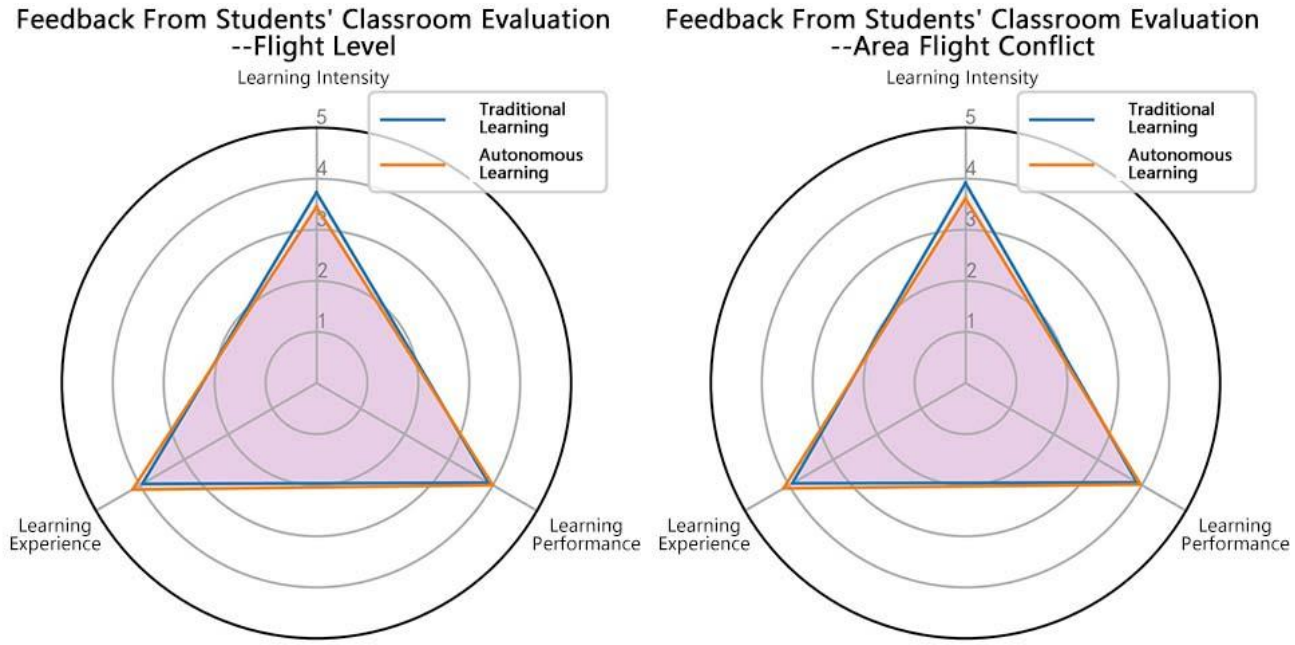

Figure 12. Comparison between Autonomous Learning and Traditional Learning.

6.0 Conclusions

Facing the education and training of aviation professional talents, the traditional teaching mode has been boldly reformed and innovated. In order to improve the competency of aviation personnel, a brand-new “4C” concept and "Aero-Racing" mode are constructed by analyzing and studying the learner-centered, the classical education theory, the modern teaching methods, the engineering education certification concepts and the competency-based education theory. Task-based Ultra Learning Intelligent Platform (TULIP) is designed and developed by using the information technology. The virtual simulation scene and learning tasks constructed by the platform fundamentally solve the two problems including learning environment and learning motivation and provide a solution for cultivating the engineering practice competency of trainees.

Through the practice and application in the courses of the major of Civil Aviation Transportation, Task-based Ultra Learning Intelligent Platform (TULIP) effectively stimulates trainees' interest in learning and desire for exploration, realizes the constructivism of knowledge and competency, meets the requirements of educational innovation and

development in the new era, conforms to learning methods and habits of trainees in the information age, and provides important and beneficial attempts and references for talent training in aviation and other engineering education fields.

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