



Analysis of the effect of content presentation of multimedia interactive technology in youth science education classroom

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SUMMARY: *In order to clarify the application effect of virtual reality technology in the youth science education classroom, this paper improves the Flanders Interaction Analysis System (iFIAS), and uses it as the main analytical tool, supplemented by the S-T analysis method, the time-series analysis method, and the analogical analysis method, to develop an experimental program from the five dimensions of the teaching concept, the form of the teaching structure, the teaching activities, the teaching media, and the interaction of the teaching behavior. Then based on the virtual reality education ecology, a multimedia interactive youth science education model based on VR is constructed to help workers in science education improve their ability to design and develop science education resources using virtual reality technology. The results show that the interaction between teachers and students in the virtual reality science education model classroom is diversified, its interaction frequency is frequent, and the interaction structure is complete. The degree of multimedia interactive technology's presentation of teaching content in the classroom is influenced by the teacher, and the overall performance is a teacher-led and student-led teaching structure. The learning effect of teenagers in science education classroom is affected by different multimedia interactive technology, such as science education classroom, students prefer to use the teaching video with dynamic background.*

KEYWORDS: *virtual reality technology; multimedia interactive technology; popular science education; iFIAS; S-T analysis method*

1 Introduction

With the rapid development of knowledge-based economy and the continuous advancement of economic globalization, the economy and society are increasingly calling for the great development of science and technology, the great development of education, and even more so for the great development of talents [1, 2]. Economic competition, scientific and technological competition, in the final analysis is the competition of talent [3]. And young people are the reserve force of talent, is the development of the booster star, but also the hope of social progress, their mastery of science and technology often determines the degree of innovation of a region, a society's development and a country's competitiveness [4, 5]. For this reason, in the face of the opportunities and challenges of the new century, it is particularly important and urgent to strengthen the work of popularization of science education, enhance the awareness of popularization of science, and cultivate a new generation of outstanding young people who love science, learn science, and use science [6-8].

Popularization of science education not only enables young people to obtain the knowledge and skills needed for life and work, but more importantly, it enables young people to obtain the

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inculcation and cultivation of scientific thought, scientific spirit, scientific attitude and scientific method [9-11]. However, traditional science education is mainly teacher-centered, and the classroom is based on textbook lectures, which is boring and cannot raise students' interest in learning [12, 13]. With the development of information technology, multimedia interactive technology has transformed the way of content presentation in the classroom for popular science education and provided technical support for improving teaching effect [14, 15]. Multimedia interactive technology is based on the effective integration of hardware and software, the text, pictures, sound, images, animation, mind maps and other media mixed application, the teacher's lively and vivid teaching ideas vividly, so that the students in the participation, experience, interactive environment to ensure the effective absorption of knowledge, to achieve the purpose of the ability to cultivate [16-20]. In the science education classroom, the effective use of multimedia interactive technology breaks through the boring and tedious teaching mode of books [21, 22]. And through the use of sound, light, electricity and other means of display in addition to the use of high-tech multimedia technology, modern light, electricity, film and television technology and virtual reality technology, etc., all of these applications, so that the science education classroom into the interactive participation of the exhibition of the new era of education, which greatly increased the learning of fun, interactivity, and stimulate the initiative of students to learn [23-27].

In this study, research tools such as the S-T analysis method and the iFIAS interactive analysis system for analyzing the content of science education classrooms were introduced, and then the course information and analysis latitude of the research objectives were clarified. After that, the starting point is to enhance the effect of science education classroom content presentation, take contextual experiential learning as the perspective, combine the mode and method of virtual reality education application, construct virtual reality education ecosystem, and determine its organizational structure. Combined with the goal of popular science education, we design a more interesting, scientific and interactive virtual reality popular science education model composed of educational ecology, teaching system and teaching environment. Finally, the interactive behaviors of teachers and students in the science education classroom, the behaviors of teachers and students in the classroom, and the effect of classroom content presentation under the virtual reality science education model are analyzed.

2 Construction of virtual reality science education model based on multimedia interactive technology

2.1 Research tools and program design

2.1.1 Research tools

(1) Time series analysis method

Time sequence analysis method [28] is a method of noting and analyzing the teaching process, which mainly represents the interaction between teachers and students in the teaching process through time, actors, and behavioral categories.

(2) Analogical analysis method

The method of analogical analysis refers to a process of looking for recurring phenomena and important concepts that can explain these phenomena in the analysis of qualitative research data.

(3) S-T analysis method

S-T analysis method is mainly used for quantitative analysis of teaching and learning

process. The steps of S-T analysis method are:

① Define teaching behavior.

Generally, the behaviors in classroom teaching are divided into students' (S) behaviors and teachers' (T) behaviors. Teachers' behaviors are expressed as: teachers' lectures, demonstrations and boards, etc.; students' behaviors are expressed as: students' speeches and discussions, exercises and silences.

② Data collection. After reviewing the relevant papers of many scholars and combining with the real classroom situation, this paper believes that a sampling interval of 5 seconds can better decompose and analyze the classroom teaching behaviors.

③ Based on the obtained data, S-T diagram and Rt-Ch diagram were built, which is to show the process of teacher-student interaction in the classroom in the form of images, so as to understand the process of teacher-student interaction, and the Rt-Ch diagram was formed by the teacher's behavioral occupancy rate, Rt, and the teacher-student behavioral conversion rate, Ch, so that we can judge which teaching mode the classroom is in among the practice-type, lecture-type, dialogue-type, and mixed-type teaching modes.

(4) iFIAS Interaction Analysis System

The Improved Flanders Interaction Analysis System, or iFIAS for short, supports the digital classroom [29]. iFIAS changes the number of codes to 14. iFIAS retains the traditional FIAS analysis function and optimizes the ITIAS system, which helps researchers to analyze teacher-student interactions in the classroom teaching in a more objective and specific way. iFIAS's analysis process:

① Coding

According to the coding rules, the teaching process is coded once every 5 seconds, and the reliability should be tested after the coding is completed, and the test method is the same as the reliability test method of S-T method.

② Constructing Matrix

Connect the adjacent codes into sequential pairs, then count the number of the same sequential pairs and fill in the analysis matrix, and finally count the sum of each row and column.

③ Results analysis

The results are generally analyzed using two methods: matrix analysis and ratio analysis. Some cells in the matrix analysis table represent a particular language interaction behavior.

2.1.2 Research program design

(1) Information about the study course

The lecturer of the lesson in this study was an expert teacher in the field of science education, and the same teaching environment was used, differing only in the mode of teaching, i.e., the traditional mode of teaching versus the mode of teaching based on multimedia interactive technology.

In this experiment, two classes were randomly selected from parallel classes in a university and set up as experimental group (35 students) and control group (35 students), with minimal difference in the ratio of male to female students in the two classes. The experimental group was taught with multimedia interactive technology during the class period, and the control group was taught without multimedia interactive technology during the class period, and the two classes were given science education for one semester (September to December 2024), and the total score of the science education course was 100 points. Afterwards, the results of “learning effect, learning satisfaction, and learning immersion experience of science education” of students in the two classes were discussed through pre- and post-tests to determine the results of applying multimedia interactive technology in science education classrooms.

(2) Dimensions of Analysis

Analysis of Teaching Philosophy

This study analyzes the teaching concepts based on the results of classroom analysis, classroom realities, and teachers' own perceptions.

② Analysis of Teaching Structure

This study analyzes the results of S-T and iFIAS analysis and classroom reality.

③ Analysis of teaching activities

According to the “Behavioral Stability Grid” area of the iFIAS system matrix, we analyzed the main activities in the teaching process, such as the teacher's lectures, the students' use of technology, and the students' discussions and interactions, in conjunction with the classroom situation.

④ Teaching media analysis

The teaching media utilized in the teaching process and the teaching functions and effects they produce are then combined with the “technology” code in the iFIAS system to make a detailed analysis of the role played by multimedia technology in the classroom and the level of application.

⑤ Teaching behavior interaction analysis

The process of classroom teaching is the interaction between teachers and students, and between students and students, which reflects the nature of teaching to a certain extent. This study uses the iFIAS system to analyze the interactive characteristics of teaching behaviors of the lesson examples in terms of the interaction between people and people, between people and technology, and the type of teacher's language.

⑥ Comparative analysis of teaching effects

The survey on the science performance of the two classes before the beginning of the experiment found that there was no significant difference in the learning effect and satisfaction of the students in the two classes in the science education course, which made it suitable for independent samples t-test analysis. The analysis of covariance and independent samples t-test were used to comparatively analyze the performance of adolescents in the science education classroom.

2.2 Virtual Reality Education Ecosystem Architecture

2.2.1 Virtual Reality Education Ecology

Virtual reality educational ecology expresses the elemental relationship of virtual reality ecosystem. Where the elemental structure of the virtual reality educational ecosystem is similar to the natural ecological structure. The elements of virtual reality educational ecosystem are shown in Figure 1.

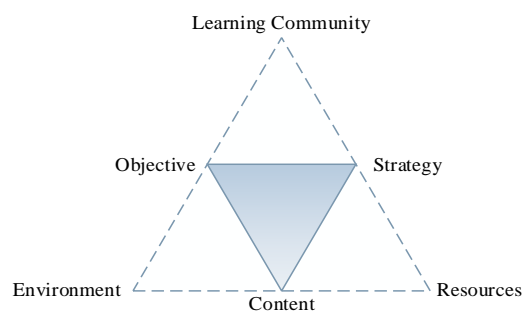


Figure 1: Virtual reality education ecosystem elements

2.2.2 Ecosystem building

(1) System Design Principles

The system design should follow four basic principles: student-centered, experience-centered, resource-centered and activity-centered.

1) Experience-centered

The virtual reality education ecosystem provides learners with “real” learning tasks and learning environments. This study focuses on the learning process of the learner, and takes the learner experience as the main criterion for measuring learning.

2) Learner-centered

The evolution of teacher-student roles has made learners become the “protagonists” of learning, and the technology-enhanced learning environment provides opportunities for learners' independent learning and collaborative learning. Learners can realize self-regulation, self-improvement and self-development.

3) Resource-centered

Resources provide all the support for learner learning in the virtual environment. All learning activities in the ecosystem are centered around resources, and resources are also an important form of technology-enhanced learning, and resource design, development, sharing, and creation are the key to ensuring the smooth operation of the ecosystem.

4) Activity-centered

The virtual reality education ecosystem focuses on the learning activities of the learners, and enhances the learners' motivation and sense of self-participation through full interaction.

(2) Operation mechanism of the system

Virtual reality technology is applied to education, integrating collaborative learning, intelligent learning, situational learning and other modes, and technology is used to help the system operate and build a virtual reality education ecosystem, and the architecture of the virtual reality education ecosystem is shown in Figure 2. It includes the following 5 layers:

1) Learning Layer

The learning layer is a space for learners to conduct learning activities, consisting of learning communities and learning activities. The learning layer is the main space for learners to carry out learning, and it provides five kinds of learning activities, namely, “context creation, real-time interaction, teaching and testing, intelligent assistance, and remote assistance”, to intervene in the learning process and achieve the goal.

2) Application Layer

The application layer consists of software, hardware, platforms and the data they generate. The software, hardware, platform and infrastructure in the resource library are directly facing the learners. The structure and content of the resources are instantly adjusted through the feedback of the learning layer, so that the resources can adapt to the ever-changing learning process and learners, thus adjusting the learning process and promoting learners' self-regulation of learning.

3) Logic Layer

The logic layer is the technology layer, including a variety of technologies needed to constitute the virtual reality education ecosystem: virtual reality technology, augmented reality technology, wearable technology, cloud computing, big data, Web 3d technology, Internet of Things and so on.

4) Data Layer

Data layer is the space for data exchange and storage in the system, including three kinds of raw data, exchange data and other data.

5) Data Warehouse

Data warehouse stores all the data information. Through the flow and exchange of data,

learners provide timely adjustment and feedback on the learning process and the problems of the resource pool, and continuously optimize them, so that the ecosystem can achieve dynamic and continuous changes. The physical and virtual environments support the operation and development of the entire ecosystem.

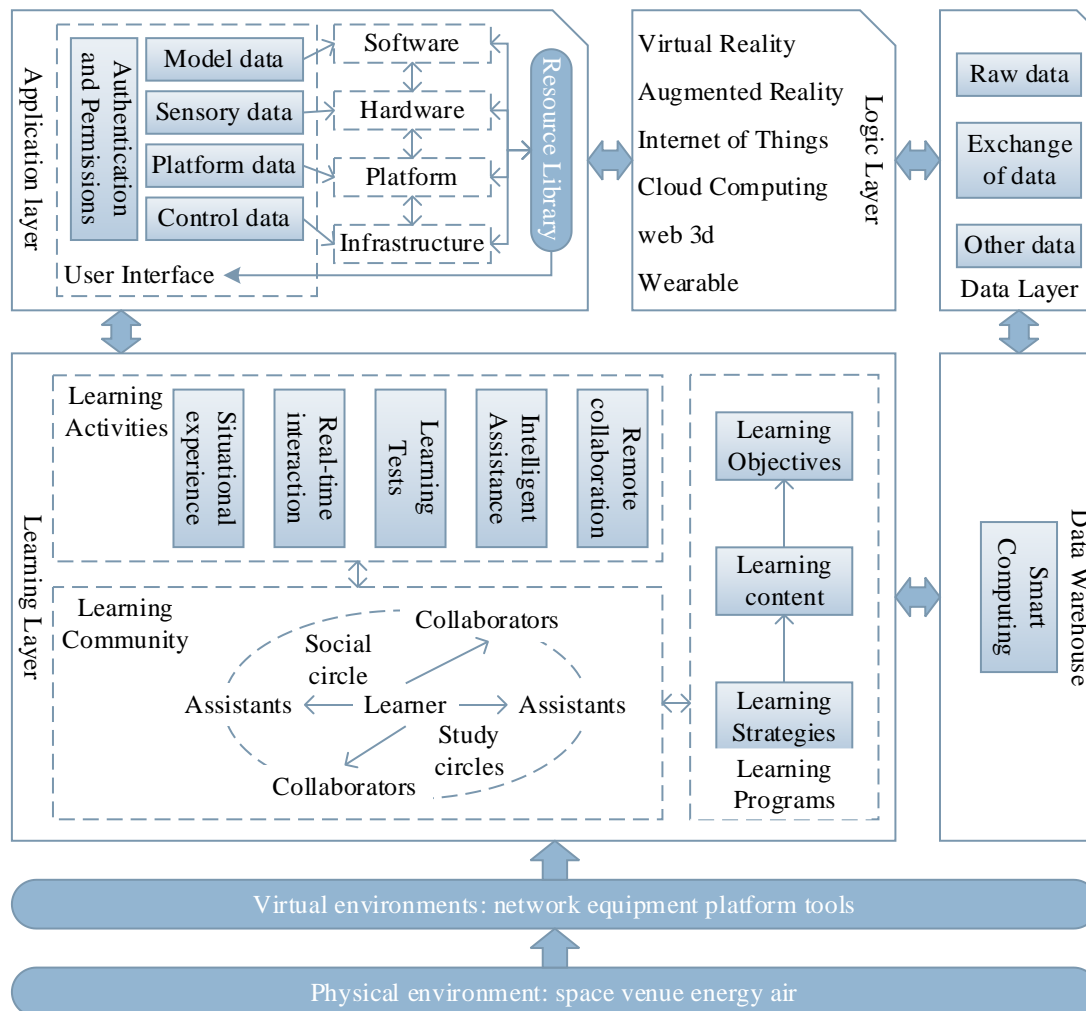


Figure 2: Virtual reality education ecosystem architecture

2.3 Construction of VR-based multimedia interactive science education model

2.3.1 Reconstructing the goals of virtual reality science education

(1) Structure design of science popularization education objectives

Cultivating scientific literacy is the general goal of popular science education and the direction of popular science education. A reasonable hierarchy of objectives helps educators to grasp the specificity of popular science education and provides a foundation for the unfolding of popular science education in the virtual environment. This paper integrates Bloom's cognitive goals and stages of experiential learning to propose a virtual science education goal classification.

(2) Connotation of Coordinate Structure of Popular Science Education Goals

The objectives of popular science education are expressed in a coordinate structure, in which the x-axis represents the cognitive objectives, the y-axis represents the perceptual

objectives, and the shaded area in the coordinates represents the comprehensive knowledge level of the learners, which not only covers the understanding of knowledge, but also includes the hidden feelings, and it is a kind of objective structure that embodies the integration of experiential learning and knowledge learning.

1) Cognitive objectives (x-axis)

Cognitive objectives are divided into two levels: knowing and understanding. Unlike other disciplines that require a high level of knowledge understanding from the learner, science knowledge requires a shallower cognitive goal.

2) Perceptual objectives (y-axis)

The perception goal is divided into two levels: experiencing and sensing. Experience is the primary level of learners' learning, learners gain direct experience through experience and form preliminary impressions, these direct experiences will be contacted with learners' existing experiences in the next learning or communication, so as to internalize them into their own cognitive structure, that is, the perception stage.

2.3.2 Virtual Reality Science Education Model Construction

(1) Integral and dynamic combination

The dynamism of the virtual reality science education [30] model is reflected in the feedback of the learning process on the resources and the environment, as the learning activity unfolds, the learner gives feedback on the resources and the environment at each stage, which facilitates the dynamic change of the resources and the environment. The resources after the learner learns become a regenerative resource that has an impact on subsequent learners. Therefore, when constructing the model, it is necessary to complete the design of each stage, but also to give it room for change, so that dynamic change is combined with the overall design.

(2) Combination of science and fun

In the design of the model, it is necessary to ensure that the structure of the resources is rigorous and logical, but also to play the context of the resources, interesting, so that the learners are happy to learn and take the initiative to learn.

(3) Virtual science education model science education focuses on the learning process and learning experience

Based on virtual reality technology, based on the characteristics of popular science education, guided by the theory of experiential learning and experiential learning, the virtual reality popular science education model is constructed from the learning process, resource design and environment design.

The virtual reality science education model is shown in Figure 3. The three rectangular boxes from top to bottom in the figure represent the learning process, resources and environment respectively. The learning process is that learners participate in learning activities to gain experience so as to realize the goal; the resource design consists of four parts, namely, demand analysis, overall design integration development and test release; the environment is the virtual environment simulated by the computer.

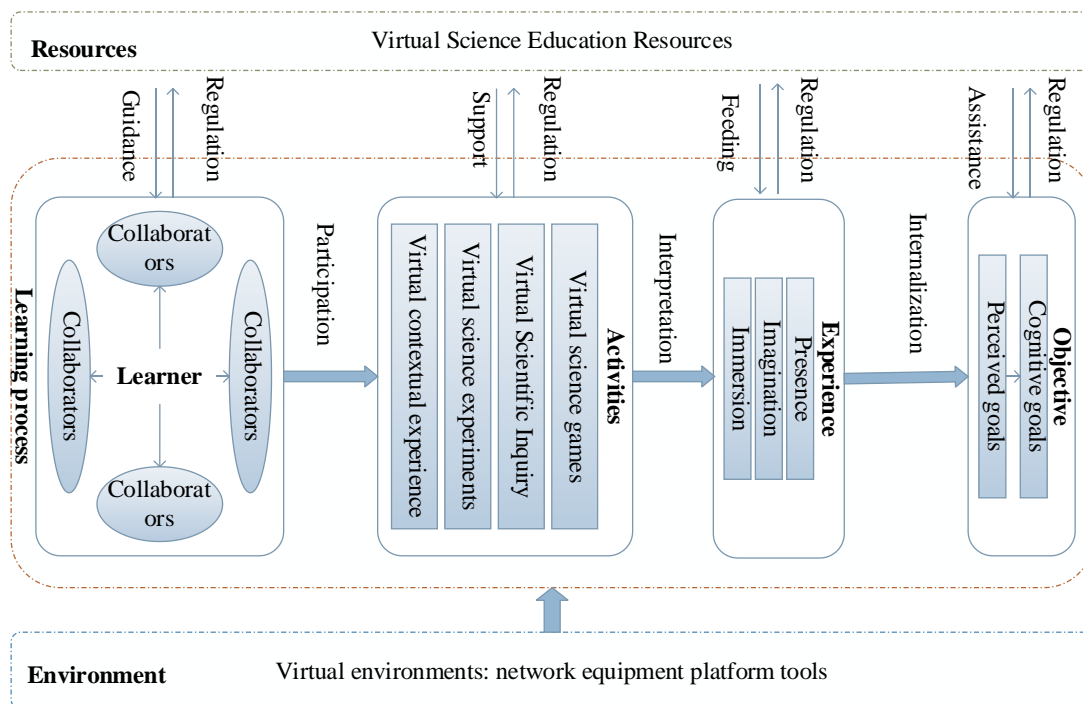


Figure 3: Virtual reality science education model

3 The effect of the presentation of multimedia interactive technology in the youth education classroom

3.1 Analysis of teachers' and students' interactive behavior in the science classroom

3.1.1 Descriptive behavioral analysis

(1) Frequency data analysis of classroom teacher-student interaction behaviors

Teacher-student behaviors account for the proportion of belonging behaviors as shown in Table 1. It can be seen that in this section of the science education classroom, the top three frequencies of classroom teacher-controlled behaviors are A4 (teacher questioning behavior), A5 (teacher explaining behavior), and A6 (criticizing and maintaining authority), whose frequencies are 40, 25, and 20 times, respectively, and the total proportion of behaviors of A4, A5, and A6 reaches more than 75%. Among the classroom student control behaviors, the highest ranking is B4 (student active speaking behavior) (24 times), followed by B5 (student collaborative behavior) (10 times), and the sum of the behavioral share of B4 and B5 reaches 65.3846%; while the rest of the control behaviors have a frequency of less than 10 times, and the share of the behaviors to which they belong is low.

In VR-based multimedia interactive science education teaching, the teacher prefers to use the way of asking questions to trigger students' answers to achieve the transmission of teaching knowledge, rather than using the way of explaining to teach directly, although the teacher's control behaviors accounted for 0.6538462% of the total classroom behaviors, but through the analysis, it was found that the majority of the behaviors in the teacher's control behaviors were the teacher's questioning behaviors, which ultimately aimed at guiding the teaching.

The students' teaching activities in the classroom are all active participation, and no passive speech occurs, indicating that the students have great interest in the way of virtual reality

education and teaching and are willing to take the initiative to respond to the behaviors initiated by the teacher; the teacher's encouragement (A3), acceptance of students' viewpoints, and guiding behaviors (A2) appear in the middle to upper number of occurrences, which means that after the students' report or active speech, the teacher is not disregarded, but will take behaviors to respond to students, increasing the degree of students' learning experience in the VRE classroom.

Table 1: The proportion of teachers 'and students' behaviors in their behaviors

Respondent	Action	Number of times	Percentage of related actions (%)
Teacher Control Behavior	A1	2	1.78571
	A2	10	8.92857
	A3	13	11.60714
	A4	40	35.71429
	A5	25	22.32143
	A6	20	17.85714
	A7	2	1.78571
Student Control Behavior	B1	3	5.76923
	B2	3	5.76923
	B3	1	1.92308
	B4	24	46.15385
	B5	10	19.23077
	B6	2	3.84615
	B7	6	11.53846
	B8	3	5.76923

(2) Analysis of the duration of classroom teacher-student interaction behaviors

The results of the percentage of the duration of each behavior of teachers and students are shown in Table 2. It can be seen that in this section of the youth science education classroom teacher behavior appears duration from high to low in the following order: A4, A2, A6, A5, A3, A7 and A1, whose duration is between 28.41s~411.21s; student interaction behavior duration belongs to the highest proportion of behavior is B4, the rest of the interaction behavior duration belongs to the proportion of behavior is between 4.0740% ~ 14.4834, with a relatively even distribution.

The highest percentage of teacher-controlled behavior duration is A4 (teacher questioning behavior) accounting for 23.5961%; the highest percentage of student-controlled behavior is student collaboration B4, accounting for 31.6818%. The duration of student-initiated speaking behavior B4 is the highest duration of each behavior of the classroom teachers and students, which is due to the nature of the curriculum and the arrangement of teaching tasks in this section of the youth science education classroom. And the duration of B5 (student collaboration behavior) is the second, which just reflects that in the teaching of virtual reality education classroom, teachers focus on students' collaboration ability and strengthen students' understanding of cooperation.

Table 2: Results of the duration ratio of each behavior of teachers and students

Respondent	Action	Duration(s)	Percentage of related actions (%)
Teacher Control Behavior	A1	28.41	1.6302
	A2	351.83	20.1888
	A3	203.81	11.6951
	A4	411.21	23.5961
	A5	305.92	17.5544
	A6	338.59	19.4290
	A7	102.93	5.9064
Student Control Behavior	B1	116.92	12.2135
	B2	91.75	9.5842
	B3	39.00	4.0740
	B4	303.29	31.6818
	B5	138.65	14.4834
	B6	74.56	7.7886
	B7	114.48	11.9586
	B8	78.65	8.2158

3.1.2 S-T analysis

(1) S-T behavior analysis

Figure 4 shows the interaction process of teachers and students in the virtual reality education classroom. It can be seen that the lesson is roughly divided into six stages this lesson is roughly divided into six stages. Stage A includes the introduction of the situation and the release of Task I; Stage B is a completely horizontal coordinate direction, this is because students are reporting on Task I under the guidance of the teacher at this time; Stage C begins to have a clear horizontal and vertical direction of the line segments, at this time, the teacher will organize the students' critique of Task I, so there will be a teacher-controlled behavior of the horizontal direction of the line segments and the vertical student-controlled critique behaviors; line segment D is a pure vertical coordinate type of the Line segment D is a pure vertical coordinate type, which contains students' collaborative exploration of task two and the reporting behavior of task two, both of which are student-controlled behaviors; Stage E presents an obvious wave-like ascending type of line segment, and this stage is a review and supplemental link between Chuanxing students and the teacher on task two, so it will present obvious characteristics of teacher-student interaction; Stage F is a purely horizontal coordinate direction because at this time, the class has been close to its conclusion, and the teacher F stage is purely horizontal coordinate, because at this time the lesson is nearing the end, the teacher needs to summarize the classroom and set up after-school homework, so this stage is all teacher-controlled behavior, and ultimately also form the vertical coordinate direction of the line segment.

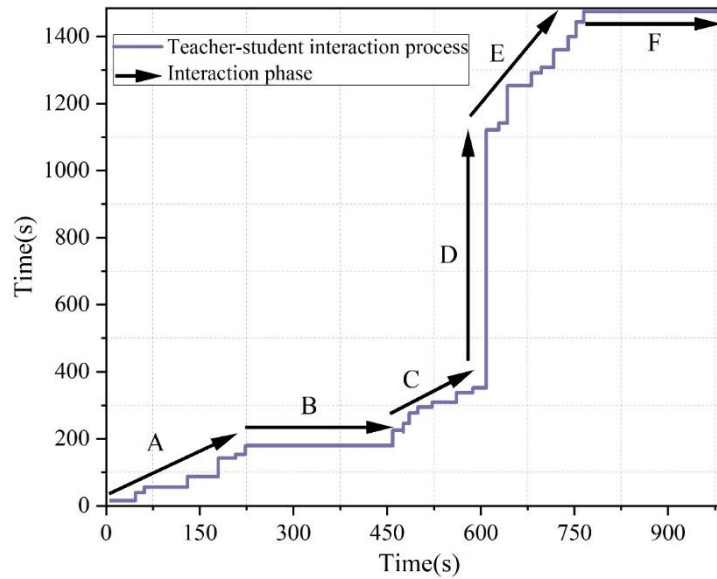


Figure 4: Teacher-student interaction in virtual reality education classroom

(2) Rt Ch analysis

The results of Rt Ch analysis of teacher-student classroom interaction behavior are shown in Figure 5. The calculation of behavioral occupancy (Rt), student behavioral occupancy (Rs), and conversion rate (Ch) shows that the Rt of students in the virtual reality education teaching classroom is 0.4514, the Rs is 0.5486, and the Ch is 0.3702. According to the numerical aspects of Rt and Ch, the teaching mode of this paper's course is distributed in the hybrid area, which is in line with the virtual reality education technology in the youth science education classroom, which is completely consistent with the type of application in the classroom, and further confirms that virtual reality education technology in science education classroom shows great assistance to the learning process of adolescents. In addition, the conversion rate of teacher-student interaction behavior reached 0.3702, which shows that both teachers and students have better application of virtual reality education technology.

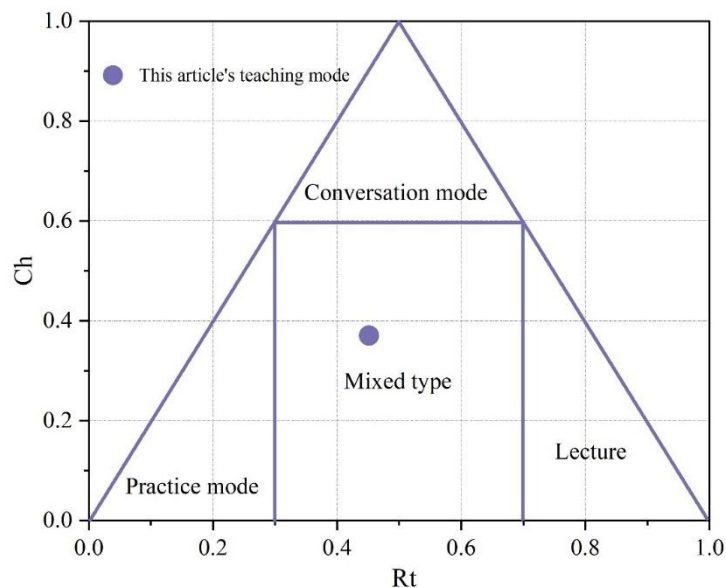


Figure 5: Rt Ch analysis of teacher-student classroom interaction behaviors

3.1.3 Analysis of RC values

The RC values of teacher and student behaviors in the science education classroom are shown in Table 3. The average relative centrality of teachers' questioning behavior in A4 was relatively high at 1.1569. In the "moderate" category, the average relative centrality of students' active speaking in B4, teachers' explaining behavior in A5, and teachers' guidance in A6 ranked the top three, which were 0.4837, 0.4325, and 0.3791 respectively. From the perspective of average centrality, it further indicates that in the virtual reality education classroom teaching model, the behavior of teachers' habit of asking questions occupies a core position, and accordingly, students are also willing to actively speak up and participate in the teaching activities in class.

Table 3: RC value of teacher-student behavior in science education classes

Classroom behavior	Average Relative Centrality	Classify
A1	-0.2494	Moderate
A2	-0.1388	Moderate
A3	-0.0765	Moderate
A4	1.1569	Higher
A5	0.4325	Moderate
A6	0.3791	Moderate
A7	-0.3965	Moderate
B1	-0.3189	Moderate
B2	-0.2486	Moderate
B3	-0.407	Moderate
B4	0.4837	Moderate
B5	-0.1982	Moderate
B6	-0.3907	Moderate
B7	-0.2561	Moderate
B8	-0.2731	Moderate

The trajectory of RC value changes in teacher and student behaviors is shown in Figure 6. It can be seen that, at the beginning of the classroom, the average relative centrality in the teacher's questioning behavior A4 soared sharply, and continuously until the end of the classroom RC values are more prominent; A6 behavior from the beginning of the class is located in the highest value of the entire class, and then the RC value gradually fell, fell for a period of time and then re and elevated and continued to the end; In contrast, A4 student-initiated speech began to emerge some time after the class was conducted, lasted for a period of time that covered all subsequent classroom time, and at some point also coincided with the average relative centrality of the teacher's explanation of A5, suggesting that the two behaviors occurred concomitantly and with a consistent importance to the classroom within that period of time; The RC values for the three behaviors, A4 teacher questioning behavior, A5 teacher explaining behavior, and B4 student-initiated speaking behavior, had similar magnitude of change in the whole-lesson behavior, indicating that the teacher's questioning behavior was linked to the student-initiated speaking behavior throughout the lesson.

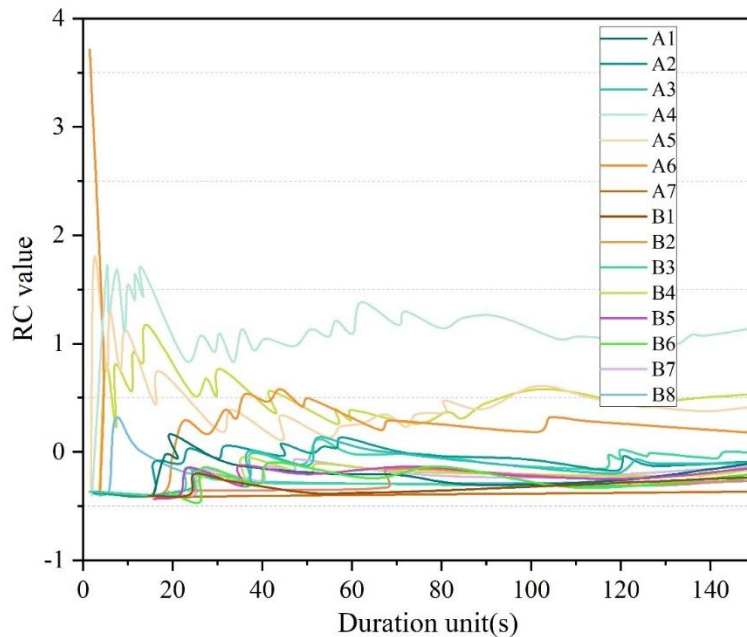


Figure 6: Teacher-student behavior RC value trajectory

3.1.4 Lagged series analysis

Lagged sequence analysis requires the initial formation of the code to be organized, transformed into a matrix plot, and then the residuals are transformed using GSEQ lagged sequence analysis software, and finally the residuals value is greater than 2.00 as a criterion to measure whether the sequence is significant or not, and the significant sequences are visualized and transformed. Teacher and student behavior sequences and residual values are shown in Table 4. It can be seen that there are significant sequences between all the teacher and student behaviors in this section of the science education classroom, and there are 22 groups in total. The top three groups with the most significant behavioral sequences are B2-A3, B6-A5 and A5-A4, indicating that the three kinds of interactive behaviors that are likely to occur in this class are: after secondary teaching to students, the teacher will emphasize the content of the lesson in time for the class in relation to the completion of the task by the students of the class; after the teacher asks a question, the students will take the initiative to speak to the content of the teacher's answer; when the students make an oration or a demonstration, the teacher will comment on or correct the response.

Table 4: Teacher and student behavior sequence and residual value

Source	Target	Weight
A1	A1	2.6345
A1	A2	4.7474
A1	A6	2.5121
A2	B5	2.7961
A4	B8	2.2015
A4	B4	2.9118
A5	A1	3.0981
A5	A4	8.7007
A6	A2	2.6143
A6	B2	4.0097
A6	B7	2.1772
A6	B8	2.195
A6	B9	5.002
B1	A1	2.8042
B2	B1	2.3276
B2	A3	12.8926
B4	A5	2.4588
B4	A2	5.3237
B5	A4	5.9108
B6	A5	9.9268
B7	B1	2.2755
B8	B1	2.6063

3.2 Teachers' and students' behavior in the science classroom

In order to have a more intuitive understanding of the dynamic process of the use of teachers' and students' verbal and technological manipulative behaviors in the youth science education classroom, this study conducted a statistical analysis of the frequency of the four types of behaviors, namely, “teacher's verbal behavior (T), student's verbal behavior (S), teacher's multimedia manipulative technology (TT), and student's multimedia manipulative technology (ST)”, in the classroom in each minute. The frequency of the four behaviors in each minute was counted. In this section of the experiment, Teacher W and Teacher L have similar teaching modes, and both teachers are specialized in the field of science popularization. In this paper, we let teacher W teach the experimental class and let his teaching process apply the multimedia interactive science education mode based on VR; let teacher L use the traditional teaching mode. The analysis compares the two teachers' verbal behaviors and the frequency of the use of multimedia manipulation technology between teachers and students in different teaching modes.

The ratio chart of teacher-student interaction behavior in teacher W's classroom is shown in Figure 7. The results show that the classroom motivation of students and teachers is significantly improved under the VR-based multimedia interactive science education mode of Teacher W. The specific interactions are as follows:

(1) Teacher's verbal and technical manipulation behaviors in Teacher W's classroom

Teacher W's verbal behavior in the whole classroom is almost the whole classroom, which is higher than other teaching behaviors. Secondly, Ms. W's use of technology was also high. In the first 13 minutes of the class, the teacher mainly explains and operates the technology, therefore, the proportion of students' speech and behavior and the frequency of technology operation are relatively low in this period of time, and at this time, the main behavior of students

is to watch the teacher's operation demonstration. In terms of the number of peaks formed by teacher W's technology manipulation curve, it is more than the ratio of students' speech and technology manipulation behaviors. Combined with the recorded video, it was found that Mr. W was used to explaining while operating during the teaching process to increase students' understanding and mastery of the technical operation, indicating that the class was still a teacher-led classroom.

(2) Students' Speech and Technology Use in Ms. W's Classroom

From the curve of the ratio of students' speech and technology use in Mr. W's classroom, it can be seen that in the 0-20 minutes time period, the ratio of students' operation and technology behaviors in coordination with students' speech and actions is low, while in the 20-35 minutes time period, the ratio of students' operation and technology behaviors in coordination with students' speech and actions has increased, indicating that this stage is mainly based on the students' classroom operation and practice or communication and discussion and sharing of questions asked by the teacher in the classroom.

(3) Overall teacher-student verbal and technical interaction in Mr. W's classroom

On the whole, the technology used by Mr. W in the teaching process can play the role of teaching aid, and the use of technology can be organically integrated with classroom teaching, and the classroom teaching interaction is relatively harmonious. In the 25th-45th minutes of the class, the teacher's verbal behavior peaked significantly, and the frequency of students' verbal and technological operations was relatively high. In combination with specific practical observation, it can be found that at this time, the teacher mainly allows students to report and exchange and share their work with the classroom practice, and the teacher will comment and summarize the students' work.

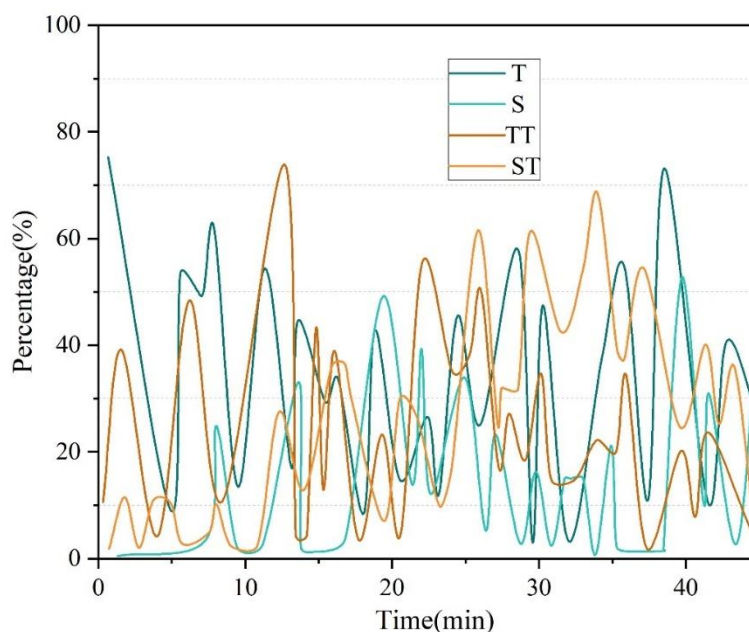


Figure 7: W's classroom teacher-student interaction ratio chart

The graph of the ratio of teacher-student interaction behavior in Teacher L's classroom is shown in Figure 8. The results show that students' classroom motivation and technology manipulation behaviors decreased significantly in the traditional model used by Teacher L. The specific teacher-student interactions were as follows:

The teacher-student verbal and technical interaction behavior situation mainly includes the following aspects:

(1) Within 0~20 minutes teacher L's classroom is mainly teacher behavior, student verbal behavior and technical operation behavior accounted for less than 5%, indicating that in this stage, the teacher's activities are mainly the state of knowledge explanation of science education, and the teacher is operating demonstration while explaining, at this time the students' verbal behavior that occurs in the classroom may be a passive answer to the teacher's closed questions or a short classroom chaos.

(2) The ratio of teacher-student verbal and technical interaction behaviors increased in the classroom of teacher L and students during 20~35 minutes, but the peak verbal and multimedia operation behaviors of students were still significantly lower than those of the teacher, which reflected that the teacher's classroom was not active enough and the teacher was in the position of a strong authoritative leader.

(3) Within 5 minutes before the end of the lesson, the ratio of teacher behaviors in Mr. L's classroom rebounded, and the teacher's speech showed a peak direction. Combined with the specific practical observation, we can understand that the teacher at this time is mainly to summarize the teaching content of the whole lesson. On the whole, Mr. L's overall control of the classroom was greater, and in the early part of the classroom teaching period, the teacher's teaching interaction with students was insufficient, which was mainly manifested in the students' technical operation and low verbal interaction.

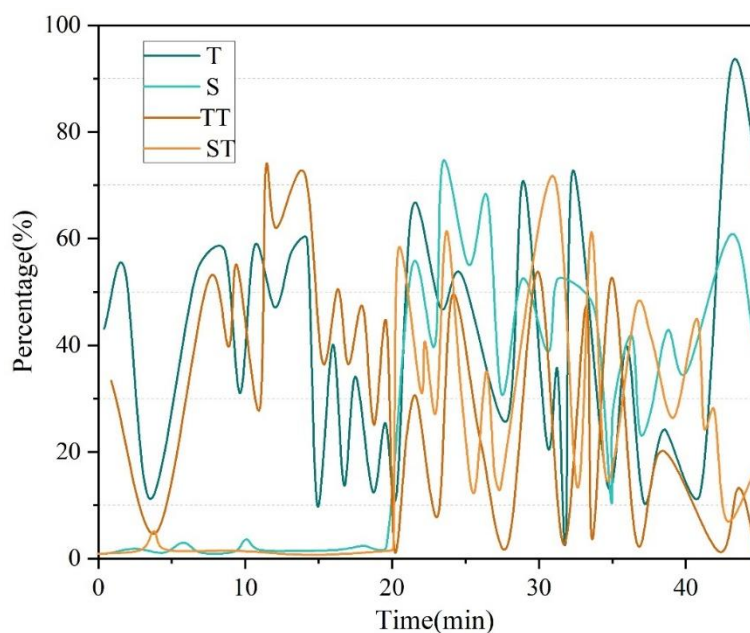


Figure 8: L Teacher's Classroom Teacher-Student Interaction Ratio Chart

Overall, students' motivation and participation in the science classroom are significantly related to the teaching mode of the classroom, in which the use of VR-based multimedia interactive science education mode can significantly improve students' enthusiasm for communication and multimedia operation skills in the classroom; whereas, in the traditional education mode, the students behave more calmly in the classroom, and the overall motivation in the classroom is significantly lower than that of the experimental class. The above results show that the use of VR-based multimedia interactive science education model can better present the content of science education.

3.3 The effect of classroom content presentation under the virtual reality science education model

3.3.1 Results of analysis of covariance for learning outcomes

In this paper, covariance analysis was conducted with the form of teaching content presentation as a fixed factor, whether or not virtual reality technology was used as a dependent variable, and pretest scores as a covariate. The results of the covariate analysis of the learning effects of the two groups of students are shown in Table 5. The results show that the covariate effect reached a significant level in the experiment, indicating that the explanatory power of the covariate for the dependent variable is high. The students in the experimental class using PPT recording and dynamic background achieved mean scores of 73.44 and 75.06, respectively; while the control group's scores were 63.46 and 67.88, respectively, in the instructional mode without PPT recording and dynamic background; at this time, the experimental class $F = 9.874$ ($p = 0.027 < 0.05$) and the control class $F = 3.256$ ($p = 0.5219 > 0.05$), there is a significant difference between the average scores of the two classes. It can be seen that the use of PPT recording and virtual reality with dynamic backgrounds in science education classroom will have a significant impact on students' learning outcomes.

Table 5: Covariance analysis of learning outcomes between two groups of students

Respondent	Content presentation	Mean	Standard error
Experimental group	PPT screen recording	73.44	9.1743
	Dynamic Background	75.06	15.8615
Control group	No PPT screen recording	63.46	24.3149
	No Dynamic Background	67.88	19.8207

3.3.2 Independent samples t-test for learning satisfaction

In order to investigate the effect of different content presentation on satisfaction, independent sample t-test was conducted with the form of content presentation as the independent variable and learning satisfaction as the dependent variable, and the results of independent sample t-test for learning satisfaction are shown in Table 6. The variance of the two groups of subjects is chi-square ($p > 0.05$), and the learning satisfaction of the students in the experimental class reaches 95.65%, while that of the control class is 77.84%, and there is a significant difference in the mean value of satisfaction between the two groups with a difference of 17.81% ($p = 0.0000 < 0.05$). It can be seen that there is a significant difference in the effect of the two forms of content presentation, PPT recording and dynamic background, on learners' learning satisfaction in the teaching video, i.e., students' satisfaction in the science education classroom based on virtual reality technology is higher than that of the class that does not use virtual reality technology.

Table 6: Independent samples t-test results for learning satisfaction

	Levene's test for variance		t-test for mean equations		
	F	Sig.	t	df	Sig.(double)
Assume equal variance	3.1507	0.1014	-0.6982	35	0.0000
Assume unequal variances			-0.6314	35	0.0000

3.3.3 Independent samples t-test for learning about immersion experiences

In order to explore the effect of the form of content presentation on learners' learning immersion

experience, the independent sample t-test was conducted with the total score of learning immersion experience as the dependent variable and the form of content presentation (PPT recording and dynamic background) as the independent variable, and the results of the independent sample t-test for learning immersion experience are shown in Table 7. The variance of the two groups of subjects is chi-square ($p > .05$), and in the classroom teaching mode of science education, the mean value of students' satisfaction with the learning immersion experience in the experimental class reaches more than 98%, whereas that of the control group is less than 70%, so it is obvious that there is a significant difference between the two classes in terms of the learning immersion experience ($p = 0.000 < 0.05$). In addition, the teaching video with PPT recording and the teaching video with dynamic background had a significant effect on the learners' learning immersion experience, i.e., teaching with virtual reality technology helps students to realize the immersion experience in the science education classroom.

Table 7: Independent samples t-test for learning immersive experiences

	Levene's test for variance		t-test for mean equations		
	F	Sig.	t	df	Sig.(double)
Assume equal variance	0.9408	0.3211	-4.1982	35	0.0000
Assume unequal variances			-4.0314	35	0.0000

4 Conclusion

Based on the S-T analysis method and the iFIAS interactive analysis system, this study combines virtual reality technology with the ecosystem to construct a VR-based multimedia interactive youth science popularization education model. By comparing and analyzing the interactive behaviors and teaching behavior characteristics of teachers and students in the virtual reality science popularization education model classroom and the traditional teaching classroom, to explore the impact of multimedia interactive technology on the content presentation effect in youth science popularization education classrooms. The main conclusions are as follows:

(1) In the classroom based on the virtual reality science education model, the teacher-student interaction is diversified, the number of interactions is frequent, the interaction between teachers and students is structurally complete, the students take the initiative to respond to the teacher's initiating behavior, and the teacher will also give feedback to the students' response in a timely manner, and the classroom forms a teaching structure with the teacher as the leader and the students as the main body.

(2) Classroom behaviors are all mutually cooperative, not a single behavior, the appearance of a classroom behavior is often accompanied by two other classroom behaviors. However, half of the time in the classroom belongs to the teacher, only the teacher of the classroom for the correct and reasonable guide to summarize, in order to give greater play to the frequency of the effective use of virtual reality technology in the classroom, so that the classroom content of the presentation of the effect is better.

(3) Different forms of content presentation in the science education classroom will produce significant differences in the learning effect of young people. For example, in terms of learning experience, students' learning satisfaction is higher when they learn the teaching video with dynamic background, and the teaching video with dynamic background is better than the teaching video with PPT recording screen in terms of learning satisfaction and learning immersion.

In addition, this paper finds that the characteristics of the current status of teaching

interaction in the science education classroom are also affected by objective factors such as teachers' strength, teaching resources, students' learning situation, etc. Therefore, when exploring the behavior of teaching interaction, the synthesis of a variety of analytical methods and approaches can make up for the shortcomings of these objective conditions.

About the Author

Fei Chen was born in Hangzhou, Zhejiang, P.R. China, in 1981. He obtained his bachelor's degree from Zhejiang University. He is currently working at the Zhejiang Provincial Science and Technology Museum, engaged in the of science popularization exhibits and the dissemination of scientific knowledge. His main research direction is the study of science popularization strategies in science and technology museums.

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