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Article

# Teaching model of English education in biomechanical environment

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**Abstract:** Traditional English education research mainly focuses on the cultivation of language skills and cognitive levels, ignoring the impact of body movement and emotional expression on language learning. This single teaching model leads to a lack of interaction and participation among students in the learning process, fails to fully mobilize multi-sensory learning experiences, and affects the improvement of learning outcomes. To solve these problems, the principles of biomechanics are applied to English education, and it is proposed to promote language learning through body movement, body language, and posture. This paper constructs a new interdisciplinary teaching model, combines kinematics and sensory cognition, and designs a multi-sensory interactive teaching scenario. In addition, through personalized teaching support, personalized learning strategies are formulated according to students' physical fitness and learning style, and a real-time feedback and evaluation mechanism is implemented to dynamically adjust teaching strategies and improve the adaptability and effectiveness of teaching. 120 intermediate English students are randomly divided into an experimental group and a control group, and a 16-week teaching practice is carried out. Significance analysis shows that the experimental group is significantly better than the control group in terms of learning effect, emotional feedback, individual difference adaptability, interactivity, and teaching adaptability ($p < 0.001$). The results show that the biomechanical teaching model effectively improves students' participation, interactivity, language learning effects, and emotional attitudes, and provides a new teaching strategy for English education.

**Keywords:** English teaching; biomechanical principles; personalized learning; multi-sensory interaction; interdisciplinary teaching model

## 1. Introduction

In the context of globalization, English has become an indispensable part of the education system [1,2]. The traditional English education model usually focuses on vocabulary, grammar, and basic training such as listening, speaking, reading, and writing [3,4]. Most teaching methods focus on the cognitive level of language, helping students master the basic structure and rules of the language through classroom explanations, exercises, and tests [5,6]. This traditional model ignores the influence of non-cognitive factors such as body movement, body language, and emotional expression in language learning.

In recent years, scholars have gradually realized that language learning is not only a cognitive process but also closely related to physical, emotional and social interactions. On the other hand, it is proved that body movement and emotional factors have an important influence on language learning [7,8]. Language learning does not depend solely on visual and auditory inputs but is a multi-sensory process that involves integration of senses including touch, movement, and emotional cognition [9,10]. Body movements can increase brain neural connections and improve language understanding and memory, and body language can enhance language expression [11]. A positive emotional experience can increase the motivation to learn and make classroom interactions more dynamic [12,13]. However, many explorations are still on a theoretical level, with less empirical research and teaching practice. The existing teaching model mostly relies on single cognitive training, which is difficult to effectively improve students' classroom participation, interactivity, and language application ability.

The teaching model in this paper is based on the principles of biomechanics, combining kinematics, neuroscience, and sensory cognition, and uses teaching design to promote students to achieve two-way improvement in the interaction of body expression and language learning. By incorporating body movement, body language, and emotion-driven activities into the class, a multi-sensory learning environment is created. In addition, this paper also pays attention to individual differences among students and proposes personalized teaching support strategies. By analyzing students' physical fitness and learning styles, learning tasks and strategies are customized to suit each student to maximize students' learning outcomes. Through real-time feedback and evaluation mechanisms, this paper also aims to ensure that teaching activities can be dynamically adjusted according to students' learning progress, thereby improving the adaptability and effectiveness of the teaching model.

Through this innovative interdisciplinary teaching model, this paper not only fills the gap in existing research at the practical level, but also provides a practical solution to improve the effectiveness of language learning and expands the research horizon of English education.

## 2. Related work

In the field of biomechanics, there have been some studies on the impact of body movement on learning. Biomechanics mainly studies the movement, posture, and mechanical characteristics of the human body [14]. Its application in education is reflected in optimizing students' cognitive performance and learning effects through movement. In recent years, the research on teaching models, learning effects, and emotional feedback in the field of education has continued to deepen, and related explorations are mainly concentrated in the following aspects.

Interactive teaching can enhance students' learning participation and interactivity and has been widely used [15,16]. Studies have shown that highly interactive teaching methods can significantly enhance students' learning interest and enthusiasm, thereby promoting the improvement of learning outcomes [17,18]. Abdullah M Y studied the effectiveness of the flipped classroom model in improving the English speaking performance of foreign language learners by combining pre-test and post-test oral proficiency tests, observation, and focus group interviews, and found that after implementing the flipped classroom model, students' English speaking performance was significantly improved [19].

The role of emotional feedback in student learning has also been confirmed by many studies. In English language education, self-confidence has a significant impact on student learning [20]. Many studies have found that students' emotional state is related to the improvement of their academic performance and language ability [21,22]. The use of emotional feedback mechanism helps to alleviate anxiety in learning, improve learners' emotional state, and thus optimize learning effects.

Kacetl J found that mobile learning has the potential to improve learners' cognitive abilities, motivation, autonomy, and self-confidence, and can help achieve personalized learning and help low-achieving students achieve their learning goals [23]. Personalized learning is also one of the hot topics in current educational research. By tracking and analyzing learning data, the difficulty, content, and form of learning tasks can be dynamically adjusted to provide each student with a customized learning experience. A personalized learning system based on learners' needs, interests, and ability levels can provide instant feedback during the teaching process and help students achieve maximum progress [24,25].

In addition to the above directions, research on the combination of biomechanics and education has also gradually increased in recent years. As a discipline that studies human movement, biomechanics has been gradually applied to the field of education in recent years, and the concept of using body movement to assist learning has gradually been applied and verified. This interdisciplinary combination helps students enhance learning effects through body memory and visual feedback through the synchronization of movement and language and improves the efficiency of language learning. Zhou et al. integrated biomechanical principles into English writing teaching through randomized controlled trials and conducted an 8-week intervention for Chinese college students. The results showed that the experimental group had significantly improved writing quality and comprehension ability compared with the control group [26]. Potop et al. studied the application of biomechanics in kinematics in higher education through surveys and statistical analysis methods and found that students generally had a positive attitude towards the content of biomechanics courses and achieved good teaching results in physical education and sports performance [27].

In summary, current educational research not only focuses on cognitive and emotional factors in the learning process, but also pays more and more attention to how to enhance learning effects through personalization and interactivity. In these fields, the intervention of biomechanics provides new perspectives and possibilities for traditional teaching models, and the research combining body movement and cognitive learning is gradually revealing its positive impact on students' learning effects.

## 3. Teaching model design

### 3.1. Construction of interdisciplinary teaching model

The construction process of the interdisciplinary teaching model mainly revolves around combining language learning with kinematics and sensory cognition, and promoting the improvement of students' language ability through a series of precisely designed activities and tasks.

The classroom activity design focuses on multi-sensory interaction and enhances students' perception and memory of language content through the combination of body movements and language expression. The design uses role-playing activities that simulate real situations. Students complete tasks through oral expression and interact with their peers through body language, facial expressions, and postures.

In the interdisciplinary teaching model, motion sensing games, as a highly interactive and interesting teaching tool, have become an important part of language learning. Through the application of motion sensing devices and mobile devices, students can interact deeply with language learning content through body movements in the game. In these games, students need to complete specific language tasks according to prompts.

The classroom space layout is an important part of the interdisciplinary teaching model. To effectively support students' body movement and multi-sensory learning, the classroom design should focus on openness and flexibility. During the teaching process, students need ample space to move, demonstrate, and interact. The tables and chairs in the classroom are loosely arranged and can be adjusted at any time so that students can move freely during group work and role-playing.

In addition, the classroom is equipped with interactive whiteboards, projectors, sound systems, and motion sensing interactive devices. In each teaching session, teachers monitor students' performance and adjust the difficulty and goals of teaching activities based on real-time data to ensure that every student can learn under appropriate challenges.

The interdisciplinary teaching model emphasizes group cooperative learning. When students complete tasks together in groups, they must communicate through language and cooperate with body movements. In the design of classroom activities, tasks are carried out in groups, and the content of the tasks covers different levels of language. Each group is responsible for different tasks, and students are required to express themselves verbally and collaborate physically during the task completion process.

In general, this model customizes personalized learning strategies based on the results of students' physical fitness and learning style assessment. Then, through role-playing activities that simulate real situations, students' perception and memory of language content are strengthened. The integration of somatosensory games further promotes students' in-depth interaction between language learning content and body movements. At the same time, teachers use real-time monitoring and data analysis to dynamically adjust the teaching difficulty during the teaching process. Finally, through course summary and reflection, students' understanding of learning content is deepened, and feedback is provided for teaching improvement.

### 3.2. Application of biomechanical environment and cognitive augmentation in english teaching

This paper explores the application of biomechanical principles in English teaching, aiming to build a dynamic and interactive learning environment by integrating elements such as body movement, body posture, and facial expression. The construction of this environment involves task design, equipment deployment, and teaching environment optimization to achieve an organic combination of language learning and physical activities.

### 3.2.1. Task design

The core of task design is to combine language instructions with body movements to create a standardized movement template based on kinematic analysis. The template defines parameters such as the amplitude, direction, and time nodes of the movement to promote students' understanding and memory of the language content. Through the multimodal instruction presentation of voice prompts and dynamic visual models, students can gradually complete the target tasks under the guidance of the movement path displayed synchronously by the projection device. The task design improves students' language application ability and enhances students' understanding and memory of daily behavioral phrases by combining step-by-step voice prompts with movement model demonstrations.

### 3.2.2. Equipment deployment and teaching environment optimization

To support the execution of tasks, a motion capture system, wearable sensors, and an expression recognition system are deployed in the teaching environment, as shown in **Figure 1**.

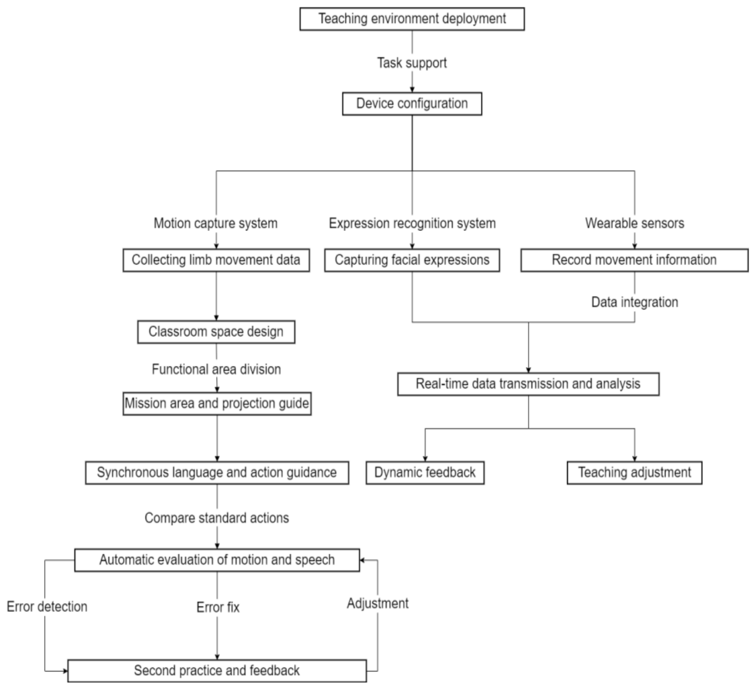


**Figure 1.** Equipment deployment and teaching environment optimization process.

The motion capture system collects the three-dimensional coordinates of students' limb movements, records the spatial position and movement trajectory of the joints, and compares them with standard movement templates in real-time to generate accurate movement quality assessment data. Wearable sensors record the strength and frequency of limb movements and analyze whether students complete specific movement parameters as required. High-definition cameras combined with artificial intelligence algorithms capture students' facial muscle changes and analyze the match between their facial expressions and language content. Data from all devices is transmitted to the central analysis system in real-time via the local area network, and dynamic feedback during the teaching process is adjusted based on the analysis results.

The classroom space design focuses on openness and flexibility. It is divided into functional areas according to task requirements and equipped with relevant interactive equipment. For complex movement tasks, projections are arranged on the ground to guide students' movement trajectories. During the execution of the task, students are helped to integrate language content and body expression through synchronized language and movement guidance. The movement template provides a standardized demonstration path. The students' movement data is mapped to the interactive whiteboard through the capture device and compared with the standard path in real-time. The evaluation of the combination of language and movement is automatically carried out after the movement is completed, and the speech recognition system determines whether the students' language expressions are complete and accurate. When errors or incoherence occur, the device immediately gives another practice opportunity to guide students to adjust their language outputs.

### 3.2.3. Combination of physical activity with cognitive augmentation

This paper combines physical activity with cognitive augmentation, integrates repeated body movements into language learning tasks, optimizes students' memory process, and improves language mastery. The teaching task creates movement templates and decomposes task chains to precisely match body movements with language learning content. In the process of movement repetition, a multi-stage task chain is designed. The chain task starts with word movement exercises and gradually expands to the dynamic expression of phrases and complete sentences. After students complete the phrase practice, contextual tasks are added to require students to express the corresponding movements. As the tasks progress, the complexity of the movements and the refinement of the language expression are simultaneously improved.

To strengthen the synchronous linkage between cognition and movement, haptic feedback devices and auditory enhancement devices are equipped during task execution. Haptic feedback devices are installed on the hands and wrists of students, and prompt the completion of movement nodes through micro-vibration signals. At the key pause points of the movement, the device prompts students to maintain the posture through vibration to enhance the stability of the movement and cognitive impression.

Auditory enhancement devices assist students in synchronizing movement execution with language pronunciation by coordinating voice prompts and background sound effects.

The application of neuroscience is reflected in the memory reinforcement of the combination of movement and language. Repeated body movements strengthen the neural coupling between the motor cortex and the language center of the brain by activating the connection between the two. The teaching design achieves multi-sensory encoding of the target language through high-frequency and low-intensity movement exercises. In multiple repeated tasks, the system dynamically adjusts the task frequency and intensity based on the learner's movement accuracy and language fluency. When students show proficiency, the task design adds new movement elements or combines language content in different contexts to avoid the decrease in learning efficiency caused by single repetition.

To improve students' overall learning efficiency and language memory, the system generates personalized task adjustment plans based on real-time data. By recording the types and frequencies of students' errors in movement execution and language expression, the system automatically evaluates their weak links. For students with insufficient movement execution speed, low-speed and high-frequency repetitive tasks are designed, and for inaccurate language expression, auxiliary means are added to strengthen pronunciation and grammar.

A multifunctional interactive area is set up in the classroom to achieve the combination of body movements and cognitive activities. Dynamic projectors, pressure-sensitive mats, and movement-assisting devices are arranged in each area according to different task requirements. The dynamic projector is used to display the movement trajectory and real-time guidance path. The pressure-sensitive mat records the trajectory of the center of gravity of the student's movement. The movement-assisting equipment provides instant correction signals when the movement is completed.

After the class, a detailed report is generated based on the recording and analysis of movement and language data, covering multi-dimensional indicators such as the time to complete the task, the accuracy of the movement trajectory, and the clarity of the language expression. By analyzing the performance trends of students in repeated movements and language expression, the subsequent teaching design is optimized. The entire process deeply combines body activities with cognitive augmentation through precise movement monitoring, step-by-step task design, and real-time multi-sensory feedback, significantly improving students' memory and application of language content.

### 3.3. Personalized learning support

Personalized learning uses assessment tools to obtain individual data, covering aspects such as physical fitness, learning style, and areas of interest. The physical fitness assessment uses professional assessment equipment to record students' movement coordination, sensitivity, and physical condition. Learning style is comprehensively judged through structured questionnaires and psychological analysis tools, covering dimensions such as hearing, vision, and movement preferences, as shown in **Figure 2**.

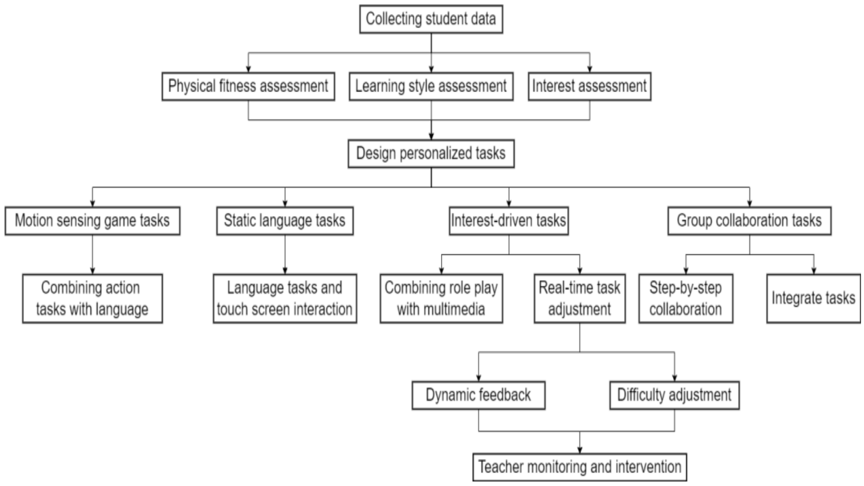


**Figure 2.** Personalized learning support process based on individual assessment.

The design of teaching activities follows the principle of adaptation, and a hierarchical task plan is generated based on the student evaluation results. For students with strong physical fitness and high movement coordination, language learning tasks with motion sensing games as the core are designed. For students with relatively limited movement skills but outstanding language cognitive abilities, the activity content tends to combine static language tasks with small movement exercises. Touch screens or desktop simulation devices are used to complete scene dialogues or vocabulary matching tasks, and language memory and expression abilities are improved through a refined interactive process.

In the interest-driven classroom scenario, thematic learning activities and role allocation mechanisms are added to embed students' interests into language learning tasks. Rich situational modules are designed based on students' interest tags, and language and movement interaction requirements for different roles are set in the tasks. Role task cards and multimedia devices are used in coordination. In the activities, students complete language tasks related to their interests by playing roles.

At the same time, the system records students' performance in the activities. Based on the collected data, the system dynamically adjusts task parameters such as reaction time and language complexity reduction to ensure that all students can complete their learning goals under appropriate task loads. Teachers monitor the progress of the class in real-time through a visual interface and quickly intervene in the class rhythm and task arrangement based on feedback information, such as adding teaching guidance or breaking down task steps when students generally feel difficult.

Another important part of personalized learning support is flexible group collaboration activities. In the group design, students are divided into heterogeneous groups according to their abilities and interests based on assessment data, ensuring that each group includes students with strong movement skills and members with outstanding language expression skills. The task forms include two modes: Step-by-step collaboration and situational simulation. Step-by-step collaboration requires group members to complete part of the task separately and integrate the results. Through group collaboration, each student can play a role in his or her strong areas, while learning and making up for deficiencies in collaboration.

### 3.4. Interactive and collaborative learning

The interaction focuses on the application of students' body movements, postures, balance, strength, and coordination in language learning. The application of biomechanical principles can promote the interaction between students' body movements and language expression, so interactive tasks based on body movements are designed to strengthen the deep integration of students' body perception and language learning through the combination of body language, movement coordination, and language expression.

In the group cooperation task, each student takes on different roles and achieves the task goals through the coordination of body movements and language expression. In the task, students need to convey language information through body movements, posture adjustments, and facial expressions.

Student interaction in pairing tasks and role-playing is optimized from a biomechanical perspective. In pairing tasks, students need to coordinate their limbs, and in tasks, students complete tasks through precise movements and language synchronization. With this design, students not only exercise their language skills, but also improve the precision and coordination of their limbs. The completion of the pairing task is determined by the collaboration between students' body language and language expression, and the task evaluation indicators are the precision, fluency, and coordination of movements.

Role-playing tasks emphasize the adaptability of students' body postures and movements in situations. In role-playing activities, students need to help express language by simulating body postures, gestures, gaits, etc., in different situations. When simulating specific situations, students make corresponding body adjustments according to the task content to ensure that language expression and body movements complement each other, and strengthen the perception and memory of language when completing the task.

The concept of biomechanics is also integrated into the time management of interactive tasks. The time limit in the task not only tests the speed of students' language output, but also requires students to optimize the efficiency of their body movements. The task design sets time requirements based on the fluency and coordination of body movements, requiring students to complete the task within the specified time.

Through real-time motion capture technology and biomechanical analysis equipment, students' body movement process is precisely fed back. The equipment records students' movement trajectory, movement speed, posture correctness, etc., and give real-time feedback through biomechanical analysis methods. These feedbacks not only help students make corrections in their body movements, but also strengthen their perception of the coordination between language expression and body movements. By observing these data, teachers can dynamically adjust the difficulty of the task, adjust the movement requirements and language task settings according to students' actual performance, so as to ensure that each student can fully mobilize body perception while learning language.

### 3.5. Emotion-driven learning design

In the emotion-driven learning design, classroom activities enhance students' language learning experience by adding emotional elements. The class engages students in emotional expression in a task-driven way. Each emotional expression in the task requires students to coordinate with the language content through body language and facial expressions.

During the task execution, multimedia devices are used for assistance. The device records students' emotional expressions in real-time by capturing their voices and movements. Through motion capture technology, the device can detect students' postures, movement amplitudes, gestures, and facial expressions, and evaluate these movements in real-time. This technology helps teachers and students understand the synchronization of language and emotional expression. Students understand their shortcomings in emotional expression through device feedback, and teachers guide students to adjust their body movements and emotional expressions based on feedback.

The spatial layout of classroom activities also helps students express their emotions. The classroom environment is equipped with a movement space where students can move freely and interact with language through body movements. During the task, students need to perform certain body movements according to the emotional context, and these movements are monitored in real-time by the body movement sensing device. The device can sense the changes in students' posture and muscle tension when performing the movement and make adjustment suggestions to the students' emotional expression based on this information. When students complete the tasks, they can adjust their body posture and expression through this real-time feedback.

Before each task begins, students are assigned to different emotional situations. During the task, teachers guide students to use body language and facial expressions to coordinate their language output. Video recording equipment is used to record students' emotional expression process. Teachers provide individual guidance based on students' language and body movements, point out deficiencies, and correct them.

After each task, teachers and students can evaluate the quality of emotional expression based on the feedback provided by multimedia devices. The system scores students based on their intonation, movements, and facial expressions, and teachers adjust subsequent task settings based on this information. Teachers ask students whose emotional expressions are more blunt to repeat the exercises and help them better combine language and emotions by adjusting the context, movement prompts, and other means.

In the task, students should participate in group cooperation to strengthen emotional communication. Group tasks require students to jointly perform a dialogue with specific emotions, and adjust their body movements and voice so that each group member can fully express their emotions during the communication process. In this collaborative learning model, students not only improve their language expression ability through emotional communication with each other, but also realize the transmission of emotions in actual dialogue. Each group member contributes according to his or her own emotional understanding and language ability, and mobilizes different ways of emotional expression in collaboration.

Emotional learning tasks also enhance their authenticity by simulating emotional exchanges in real life. In these tasks, students simulate conversation scenes in daily life and express certain emotions as required. The tasks require students to complete emotional expression dialogues within a certain period of time, and the equipment records students' language output, body movements, and emotional changes in real-time to ensure the accuracy of emotional expression. After the tasks are completed, the teacher gives individual feedback based on the students' performance to help them understand how to express emotions more accurately through language and body movements.

A quantitative scoring system is used to evaluate the effectiveness of students' emotional expression. In each emotional task, students are scored based on their consistency of speech expression, body language, and emotional expression. After each task, teachers judge whether the students' emotional expression meets the task requirements through observation and data analysis.

### 3.6. Real-time feedback and evaluation mechanism

The real-time feedback and evaluation mechanism is based on sensor technology and artificial intelligence algorithms. By deploying motion capture systems and voice recognition software, students' body movements and voice data are collected in real time. Data is transmitted to the central processing system and analyzed using machine learning algorithms to evaluate students' performance and generate instant feedback. Multiple sensors and monitoring devices are established inside the classroom, which trace students' body movements and voice output. Each student wears a sensor on their body in order to record postures, gestures, and body movement trajectories. It feeds real-time feedback to the angle and direction of body movement, which is beneficial for teachers to determine if the students' movements satisfy the task requirements.

The speech recognition system monitors the students' speech output, while the system performs the analysis on the students' speech. Pronunciation errors, intonation deviations, and other problems in real-time are identified through a comparison with the standard speech model by the device. The system will be scoring the speech output of students in real-time when they are reading aloud or answering questions and provides feedback to the students on the accuracy of pronunciation through the display screen in the classroom.

The system also combines students' facial expression recognition to capture students' emotional reactions during the learning process through cameras. During the language learning process, the changes in students' expressions are closely related to their emotional involvement. The system analyzes students' emotional states through the movement of facial muscles and gives feedback to teachers.

Through the integrated data fusion system, data from multiple dimensions such as students' speech, body movements, and facial expressions are integrated in real-time to form a comprehensive feedback report. Each student's feedback report includes the precision of the movements, the standardization of the speech, and the stability of the emotional expression. These data are presented to teachers in real-time through the display system in the classroom. Based on the information, teachers identify students' performance in class and adjust their teaching strategies.

The equipment in the classroom also includes interactive feedback tools, which allow students to provide self-evaluations immediately after completing each task. Students use the touch screen to fill out feedback questionnaires to evaluate their learning experience and classroom interaction. Teachers use these self-evaluation data to further judge students' understanding and completion of tasks.

Another part of real-time feedback is the summative evaluation after each task is completed. After each round of tasks, the system automatically generates a comprehensive evaluation report. The report summarizes the scores of students in multiple dimensions such as body language, speech output, emotional response, and marks the strengths and weaknesses of students in the tasks. Based on these feedback reports, teachers adjust the difficulty of subsequent tasks or design exercises that are more suitable for students.

## 4. Application effect of teaching model

To comprehensively evaluate the application effect of the English teaching model in the biomechanical environment, this experiment randomly selects 120 students from the intermediate English class of the same school and evenly divides them into two groups, with 60 students in each group. The experimental group adopts a teaching model combined with biomechanics, and the control group uses a traditional English teaching method. All participants receive the same pre-test before the experiment to assess their initial English level and ensure consistency between the two groups at the baseline level. During the experiment, the two groups of students are taught by the same teaching team to reduce the interference of other variables. All teaching activities are carried out in their designated classrooms. Each group has four 90-minute English classes per week for a total of 16 weeks. During the experiment, through tests, classroom observations, questionnaires, and real-time data monitoring, data on the participation, interactivity, learning effects, and other aspects of the two groups of students is collected to quantitatively evaluate the effectiveness of the teaching model.

### 4.1. Participation and interactivity

Participation and interactivity are key indicators for measuring the effectiveness of teaching models and are used to assess students' enthusiasm and interaction in class. The participation and interactivity of the experimental and control groups during the 16-week classes are shown in **Figure 3**.

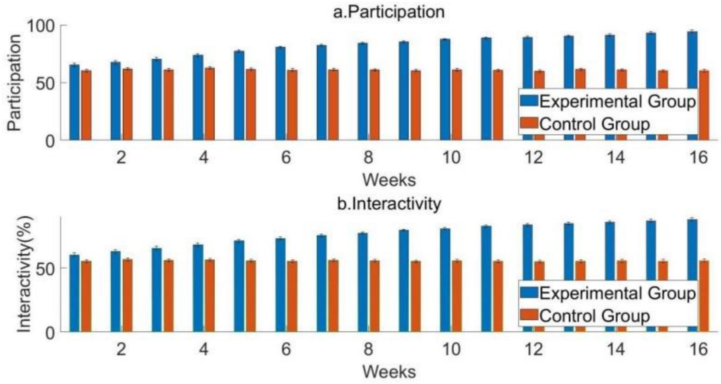


**Figure 3.** Participation and interactivity. **(a)** Participation; **(b)** Interactivity.

**Figure 3a** shows the changes in participation of the experimental group and the control group within 16 weeks. The participation of the experimental group gradually increases from 65.23% to 94.22%, while the average of the control group is about 60.84%. This shows that the teaching model with biomechanics of the experimental group effectively promotes students' classroom participation. **Figure 3b** shows the changes in interactivity of the experimental group and the control group within 16 weeks. The interactivity of the experimental group gradually increases from 60.15% to 87.92%, indicating that the teaching model with biomechanics effectively improves students' interactivity. The score of the control group changes little, fluctuating around 55.53%, indicating that traditional teaching method has limited effect on improving interactivity.

## 4.2. Vocabulary and grammar learning effects

The learning effect is evaluated by testing and comparing the students' language mastery in vocabulary and grammar. Through these test data, the language progress made by the students during the experiment can be quantified, and the relative effectiveness of the teaching model with biomechanics and the traditional teaching method can be evaluated. The vocabulary and grammar learning effects of the control group and the experimental group in the 16-week classes are shown in **Figure 4**.

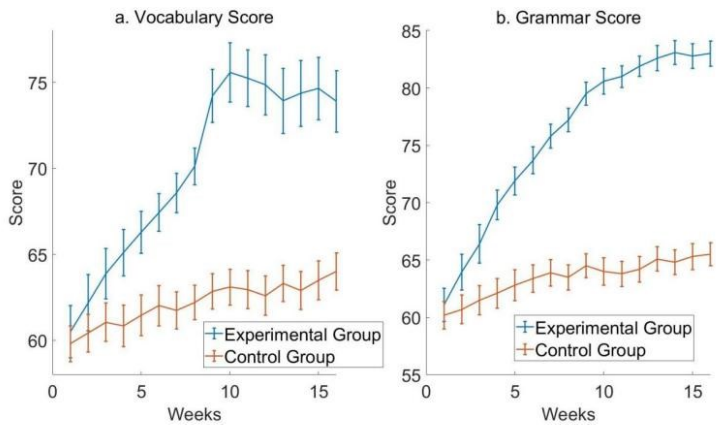


**Figure 4.** Vocabulary and grammar learning effects. **(a)** Vocabulary score; **(b)** Grammar score.

**Figure 4** shows that the experimental group's vocabulary scores increase from 60.5 to 73.89, and the grammar scores increase from 61.1 to 83, with a large increase. The control group's vocabulary scores increase from 59.8 to 64, and the grammar scores increase from 60.2 to 65.5, with a small increase. The data shows that the teaching model with biomechanics promotes the improvement of students' academic performance.

### 4.3. Individual difference adaptability

Individual difference adaptability is assessed through indicators such as learning effect, emotional feedback, personalized satisfaction, and teaching adaptability. These indicators help measure the adaptability of teaching models to different students, reflecting students' language mastery, emotional response, satisfaction of personalized needs, and flexibility of teaching methods.

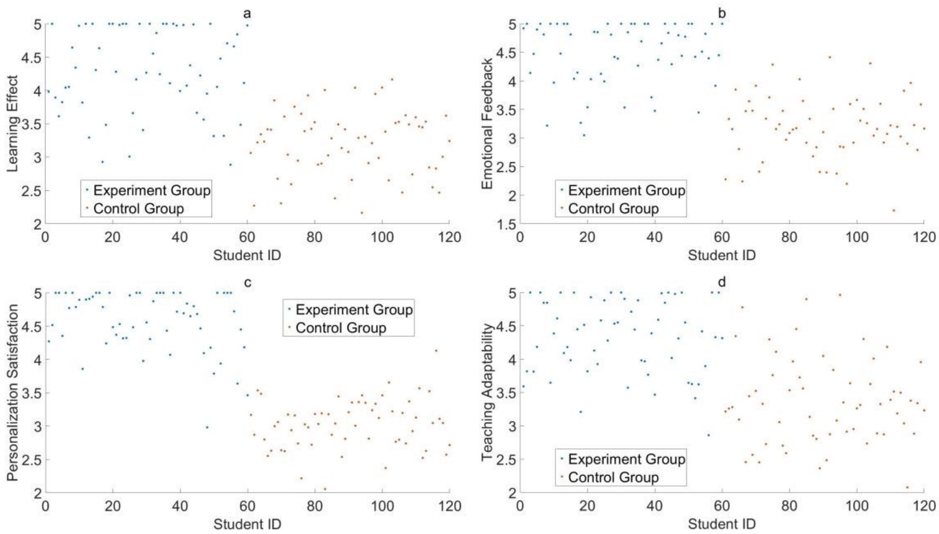


**Figure 5.** Individual difference adaptability. **(a)** Experimental group; **(b)** Experimental group; **(c)** Experimental group; **(d)** Experimental group.

**Figure 5a–d** show the comparison between the experimental group and the control group in terms of learning effect, emotional feedback, personalization satisfaction, and teaching adaptability. The mean learning effect of the experimental group is 4.3, while that of the control group is 3.2, indicating that the experimental group performs better in memory and mastery of language learning. In terms of emotional feedback, the mean of the experimental group is 4.5, while that of the control group is 3.2, reflecting that the students in the experimental group have a higher emotional acceptance of the teaching model. In terms of personalization satisfaction, the experimental group has an average score of 4.6, which is higher than the control group's 3, indicating that personalized teaching is more effective in the experimental group. In addition, the mean teaching adaptability of the experimental group is 4.5, while that of the control group is 3.2. The data as a whole reflects the superiority of the teaching model combined with biomechanics in all aspects.

## 4.4. Student satisfaction

Student satisfaction is evaluated through five indicators: Teaching model, teaching environment, teaching method, interactivity, and teacher feedback. These indicators help to fully understand students' evaluation of various elements in the teaching process. **Table 1** lists the statistical results.

**Table 1.** Student satisfaction survey.

| Evaluation Dimension | Group | Mean | Standard Deviation | Minimum Value |
|---|---|---|---|---|
| Teaching Model | Experimental Group | 4.45 | 0.55 | 3 |
| | Control Group | 3.2 | 0.65 | 2 |
| Teaching Environment | Experimental Group | 4.6 | 0.5 | 3 |
| | Control Group | 3.1 | 0.7 | 2 |
| Teaching Method | Experimental Group | 4.5 | 0.6 | 3 |
| | Control Group | 3.3 | 0.65 | 2 |
| Interactivity | Experimental Group | 4.7 | 0.4 | 3 |
| | Control Group | 3 | 0.75 | 2 |
| Teacher Feedback | Experimental Group | 4.55 | 0.5 | 3 |
| | Control Group | 3.4 | 0.6 | 2 |

**Table 1** displays the students' satisfaction with the teaching model. The scores of the experimental group in each dimension are generally higher than those of the control group. The mean score of the experimental group in "teaching model" is 4.45, which is higher than 3.2 of the control group. In terms of "teaching environment" and "teaching method", the mean scores of the experimental group are 4.6 and 4.5 respectively, which are also better than the mean of the control group. In terms of "interactivity", the experimental group also scores higher than the control group. Overall, the students in the experimental group show high satisfaction with the teaching model, environment, methods, and feedback.

## 4.5. Changes in emotional attitudes

Changes in emotional attitudes are evaluated by three indicators: Self-confidence, anxiety, and overall attitude. The changes in emotional attitudes each week during the 16-week classes is shown in **Figure 6**.

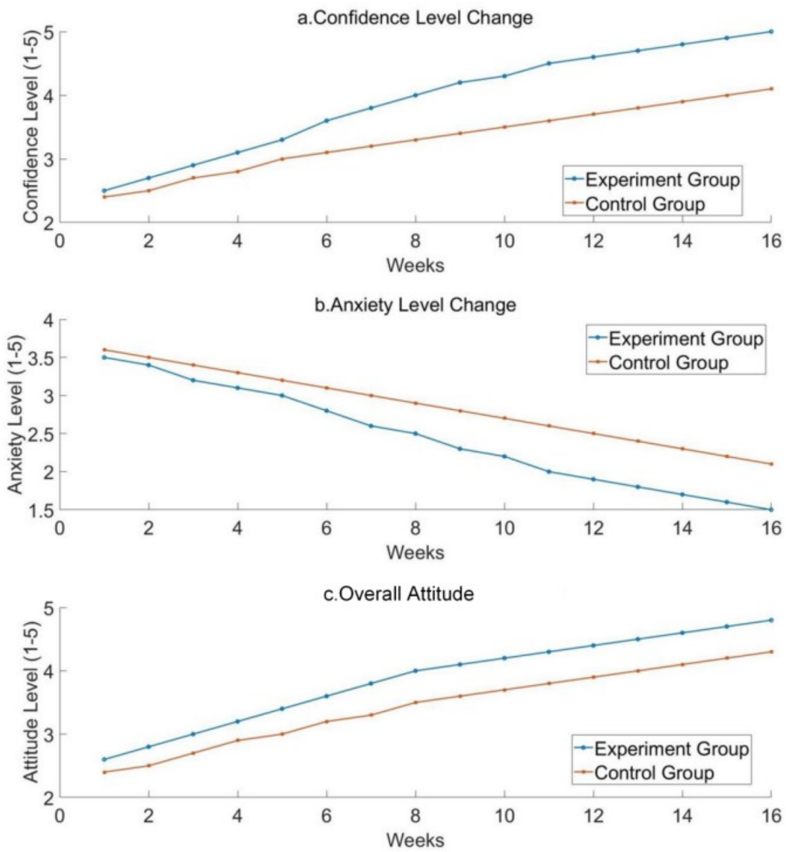


**Figure 6.** Changes in emotional attitudes. **(a)** Confidence level change; **(b)** Anxiety level change; **(c)** Overall attitude.

**Figure 6** shows the changes in self-confidence, anxiety, and overall attitude of the experimental and control groups. The experimental group's self-confidence increases from 2.5 points to 5 points; anxiety decreases from 3.5 points to 1.5 points; overall attitude increases from 2.6 points to 4.8 points. The control group's self-confidence, anxiety, and overall attitude change less, while the experimental group's emotional attitude improves more significantly, indicating that the teaching model combined with biomechanics has a positive effect on improving students' emotional attitudes.

### 4.6. Significance analysis

This paper compares the differences between the experimental group and the control group in terms of learning effect, emotional feedback, individual difference adaptability, interactivity, and teaching adaptability. The comparison results are shown in **Table 2**.

**Table 2** shows the results of the significance analysis of the experimental group and the control group in the five evaluation dimensions. The $t$-value of each dimension reflects the mean difference between the two groups, and the $p$-value indicates whether these differences are statistically significant. The data shows that the $p$-values of all dimensions are less than 0.001, and the scores of the experimental group in all aspects are significantly higher than those of the control group. These differences show that the teaching model combined with biomechanics has higher results in improving learning effects and enhancing interactivity.

**Table 2.** Multidimensional significance analysis results.

| Evaluation Dimensions | *t*-value | Degrees of Freedom | *p*-value |
|---|---|---|---|
| Learning Effect | 10.32 | 118 | < 0.001 |
| Emotional Feedback | 8.75 | 118 | < 0.001 |
| Personalization Satisfaction | 9.12 | 118 | < 0.001 |
| Interactivity | 9.55 | 118 | < 0.001 |
| Teaching Adaptability | 8.40 | 118 | < 0.001 |

## 5. Discussion

From the detailed analysis of the empirical research results of the English teaching model in the biomechanical environment, it can be seen that the model has significant advantages in improving students' language learning effects and emotional attitudes, but it also exposes some challenges and limitations in the implementation process.

This model integrates multi-sensory input into teaching and effectively develops students' language memory and comprehension abilities. Such a multimodal learning environment stimulates the collaborative work of multiple areas of the brain, thereby better learning the language. From the experimental data, it can be seen that compared with the control group, the experimental group students make significant progress in vocabulary and grammar tests, proving that the biomechanical teaching model is effective in improving students' language ability.

However, the implementation of this model depends on equipment such as motion capture systems and expression recognition systems, which are expensive to purchase and maintain. Therefore, this model is not very popular in educational environments with limited resources. In addition, it also places high demands on the technical proficiency of teachers, requiring teachers to operate these equipment proficiently and flexibly adjust teaching strategies based on real-time feedback.

Through the assessment of students' physical fitness, learning style and interest areas, students are given personalized learning tasks, and personalized learning support is provided. This can better meet the personalized needs of different students, thereby improving the adaptability and effectiveness of teaching. This type of personalized teaching requires more time and effort for preparation, and therefore may increase the workload of teachers.

In terms of emotional attitude, the changes in self-confidence, anxiety, and overall attitude of the experimental group are significantly better than those of the control group, which shows that through the biomechanical teaching model, students' emotional attitudes are positively affected and their overall attitude towards English learning becomes better. However, there are also some problems with this model in practice. Considering that different students have different learning styles, how to design and adjust tasks to meet the requirements of effective participation of each student needs further research.

Through 16 weeks of teaching practice, this study has initially shown significant advantages in improving student participation, interactivity and language learning effects. In order to comprehensively evaluate the long-term effectiveness of this model, future research needs to conduct long-term follow-up studies to examine the lasting impact of students' language ability improvement. The follow-up study of long-term effects will help reveal the long-term contribution of this model to students' language ability improvement, especially in terms of vocabulary memory, grammar mastery and language application ability.

As a core component of this model, the in-depth discussion of emotion-driven learning design is particularly critical. Future work will focus on how to more effectively integrate emotional elements into teaching activities to promote long-term positive changes in students' emotional attitudes and learning motivation. The integration of emotional elements can not only enhance students' learning experience, but also enhance students' language memory and comprehension ability, which is particularly important for language learning.

When exploring the adaptability of this teaching model, different educational environments, such as urban and rural schools, may pose different challenges to the implementation of the model. Therefore, it is necessary to further analyze the adaptability of this model in diverse educational environments and put forward corresponding adjustment suggestions to ensure the wide applicability of the model. In addition, in-depth analysis of student feedback will provide valuable first-hand information for the continuous improvement of the model, especially for those unsatisfactory feedback, which may reveal key areas that need improvement in the model.

Given that the model puts forward new skill requirements for teachers, teacher training becomes the key to ensure the smooth implementation of the teaching model. Effective teacher training should include technical operation, teaching strategy adjustment, and student emotional guidance to ensure that teachers can make full use of the model to improve teaching effectiveness. The scalability of the teaching model is also an important issue, especially when it is promoted and applied in schools of different sizes, the model may need to be appropriately adjusted.

In terms of cost-benefit analysis, although this paper mentions the cost issue, future research needs to provide a more detailed cost analysis, including initial investment and long-term maintenance costs, to evaluate the economic feasibility of the model. At the same time, the sustainability of the teaching model, including factors such as technology updates, teacher training, and changes in student needs, is also an issue that needs to be considered in future work.

Considering the differences in teaching in different cultural backgrounds, the cultural adaptability of the model should not be ignored. Future research will explore the adaptability and possible adjustments of the model in different cultural environments to achieve cross-cultural educational equity. In addition, optimizing the real-time feedback mechanism to provide more timely and effective learning support and teaching adjustments is also an important direction to improve the effectiveness of the teaching model.

In summary, although the English teaching model in the biomechanical environment shows positive teaching effects, it still needs further research and discussion in terms of long-term effects, in-depth integration of emotion-driven learning design, limitations of the model, teacher training, student feedback, motivational influence, adaptability, cost-effectiveness, sustainability, cultural adaptability, and optimization of feedback mechanisms. These discussions not only provide guidance for future research directions, but also provide references for educational practitioners to implement and improve this teaching model.

## 6. Conclusion

In this paper, the principles of biomechanics are integrated into English teaching, and an interdisciplinary teaching model is constructed. Through the comparison between the experimental group and the control group, it is found that the students in the experimental group have significantly improved in terms of participation and interactivity. However, the actual operation of this model requires high-tech equipment and is costly. Further research is needed on how to reduce dependence on technology, optimize personalized teaching strategies, and improve the operability and sustainability of this model.

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