

## **Application of Behavior Change Techniques (BCTs) based on the ADDIE Model in University Tennis**

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### **Abstract**

This study aimed to examine the application and effectiveness of BCTs based on the ADDIE model in college tennis instruction. An experimental approach was employed by integrating the ADDIE model with BCTs. An experimental group received instruction using the ADDIE-based BCTs teaching method, and a control group, which followed traditional teaching methods, was taught for 8 weeks. The results indicated that the experimental group demonstrated superior tennis skills versus the control group. The study concludes that incorporating BCTs based on the ADDIE model into college tennis instruction significantly improves students' tennis skills and enhances their interest in learning.

**Keywords:** Behavior Change Techniques (BCTs), ADDIE model, College Tennis Instruction

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DOI: <https://doi.org/10.21834/e-bpj.v10iSI24.6390>

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### **1.0 Introduction**

With enthusiasm for Chinese tennis gradually rising after Zheng Qinwen's 2024 Olympic tennis win, college tennis teaching plays a specific role in the general tennis curriculum for college students. Therefore, college tennis teaching has been paid attention to. College tennis instruction plays a vital role in improving students' physical fitness, technical tennis skills, and mental ability. However, due to the complexity of the sport and the specificity of the skills, the process of learning and mastering tennis skills will be challenging. Behavior change techniques (BCTs) have been identified as strategies to promote adopting and maintaining desired behaviors in various domains (Michie et al., 2013; Michie & West, 2013), including sports. The ADDIE model, an instructional design framework comprised of analysis, design, development, implementation, and evaluation, has been successfully applied in education and training to improve learning outcomes (Branch, 2009; Adeoye, 2024). Despite the recognized potential of the BCT and ADDIE models, little research has been conducted on their combined application to college tennis instruction.

The primary purpose of this study was to fill this gap in the literature by researching the effectiveness of integrating BCTs with the ADDIE model in college tennis instruction. Another aim of this study was to verify the effectiveness of the ADDIE model integrated with behavioral change techniques (BCTs) in applying university tennis teaching to the tennis skills of university students. To achieve the

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purpose of the study, the following hypotheses were made: the integration of the ADDIE model with behavioral change techniques (BCTs) in the teaching of college tennis has an improvement in the sport skills of college students.

Previous studies have documented BCTs as effective in behavior change in health and skill acquisition (Michie et al., 2013). In sports, BCTs have been shown to enhance physical activity performance and adherence to training programs (Thal, 2023). On the other hand, ADDIE gives a systematic approach to instructional design that can be tailored to the requirements of the learner and the details of the learning environment in question (Branch, 2009). It is suggested that the ADDIE model in designing and developing a functional training program and its effectiveness could be improved (Li, H., 2023).

This study tested the hypothesis that integrating BCTs into the ADDIE model would significantly improve the effectiveness of college tennis instruction. The systematic application of BCTs in each stage of the ADDIE model lets teachers more effectively cope with behavioral and psychological problems of tennis learning and, as a consequence, improve students' acquisition of skills and performance.

## 2.0 Literature Review

This section reviews recent literature on BCTs and the ADDIE model with a focus on their use in physical education over the last five years and, with particular emphasis, their use in college tennis programs.

### 2.1 Behavior Change Techniques (BCTs)

Behavior change techniques are of the essence in promoting the adoption and maintenance of desirable behaviors in several domains, including physical education. French et al. (2014) conducted a systematic review to ascertain the effectiveness of BCTs in promoting physical activity and exercise behaviors. This review suggested that certain BCTs, such as goal setting, self-monitoring, and providing feedback, proved most effective in promoting behavior change in physical activity settings for younger adults. Eisele et al. (2019) further extended BCT by underlining its effectiveness in improving adherence to physical activity programs. They developed the review that techniques like self-reward, social support, and diaries and calendars promote better athlete adherence to training and performance enhancement.

### 2.2 The ADDIE Model

The ADDIE model, one of the cornerstones in instructional design, has been used to guide development and implementation in various instructional programs. Recently, there has been exploration regarding its application to sports coaching. For example, Hamsea et al. (2022) applied the ADDIE model to design an ODL system based on the SPOCs model and to develop professional skills for teachers of Physical and Sports Education. Besides, Bedregal-Alpaca (2022) developed an online training course with the ADDIE model for physical education teachers. In their research work, one can observe how flexible the model is and the possibility that this model offers highly qualified physical education teaching systematically.

### 2.3 The College Tennis Instruction

College tennis has had many problems over the years, such as 'teachers' heavy workload, difficulty in carrying out targeted training, single teaching method, and students lacking enthusiasm' (Li Guang, 2022). The use of inquiry-based teaching methods in tennis teaching clarifies that the main task of tennis teaching is to update the concept of education, change the education method, and rebuild the education system (Jia, 2019). Zhang (2024) pointed out that the implementation of the strategy of the multidimensional systematic feedback method in university tennis teaching can improve the teaching effect more than the traditional teaching method and pointed out that there is a big gap between the traditional tennis teaching method and the western countries in the teaching method and concept, and the efficiency is low. College tennis instruction plays a vital role in improving students' physical fitness, technical tennis skills, and mental ability. Therefore, this study points out that college tennis teaching refers to tennis skills training and teaching activities for college students, which aims to improve college students' tennis skills, physical fitness, and sports interests. This study will design the teaching content related to BCT and implement teaching evaluation and feedback according to students' characteristics.

### 2.4 Application of BCTs and the ADDIE Model in Sports Instruction

The use of behavior change technology and the ADDIE model in physical education has been a major concern for several fields of study. The ADDIE model, an abbreviation for Analysis, Design, Development, Implementation, and Evaluation, is a behavioral approach with a focus on specific learning outcomes (Li & Abidin, 2024). The model has been used to develop a range of training programs, including online applications targeting sedentary behaviors (Zerguine et al., 2024). In the field of physical education, the ADDIE model has been applied to develop educational technology applications in physical education (Hamsea, M. M., & Lotfi, 2022). The SitStand e-Guide was designed and developed using ADDIE with ergonomics and behavioral change perspectives (Zerguine et al., 2024). Secondly, ALM, or the Army Learning Model, is also a framework for instructional design in the Army and has a similar process to ADDIE (Brouillard, A. D. E. 2024). Personalized virtual fitness trainers are also very effective in using behavioral technology in physical education; these make use of artificial intelligence algorithms to provide advice and training programs personalized to each individual (Mokmin, N. A. M. 2020). In conclusion, the integration of BCT and ADDIE models in physical education demonstrates an integrated approach to skill development and training program design. By utilizing these methods, educators and trainers can create effective and engaging learning experiences for athletes and individuals that will enhance their performance in a variety of sports.

### 2.5 Theoretical Framework

The TPB (Theory of Planned Behavior), which focuses on attitudes, subjective norms, and perceived behavioral control, helps explain and predict students' behavioral intentions (Ajzen, 1985) but does not elaborate on how these cognitive variables promote or maintain behavior change to prevent recurrence. Because the intention of behavior is not the behavior itself, although many people have formed a firm intention to change bad health behavior, they may not necessarily put it into action.

BCW (Behavior Change Wheel) includes capability, opportunity, and motivation, which are crucial for achieving behavior change, but it ignores the dynamic nature of the behavior change process (Michie et al., 2011). Therefore, it lacks consideration for its dynamic nature, requiring long-term support and ongoing interventions.

This study combines the strengths of TPB and BCW to systematically explain and predict behavioral intentions and promote behavioral change through practical interventions. TPB focuses on attitudes, subjective norms, and perceived behavioral control, while BCW focuses on competence, opportunity, and motivation. By combining these two theories, we can gain a more comprehensive understanding of the process of behavior change and design more effective interventions.

### 3.0 Methodology

#### 3.1 Research Design

This study is a randomized controlled trial (RCT) to verify the effectiveness of BCTs based on the ADDIE model in improving the effectiveness of college tennis teaching by comparing the differences between the experimental group and the control group in the teaching process. The experimental group selected 16 college students not majoring in physical education as the experimental group and used BCTs based on the ADDIE model to teach tennis. The control group selected 16 college students who matched the experimental group in terms of gender, age, and tennis skill level as the control group and used traditional tennis teaching methods.

The teaching design was first analyzed around the five stages of the ADDIE model and combined with the active ingredients of BCTs. The experimental group then followed this teaching process to proceed with different teaching methods to embody and apply the active ingredients of BCTs, and the experimental period was 8 weeks. The study was approved by the Ethics Committee of Zhuhai College of Science and Technology under the ethical number 2024-017.

#### 3.2 Study Sample

In this study, the sample size was calculated to be 34 using G\*Power 3.1 (Figure 1). Participants were recruited through online platforms such as WeChat and social media circles, with the goal of gathering 34 individuals from Zhuhai College of Science and Technology. However, two participants voluntarily withdrew from the study, resulting in a final sample size of 32. Thirty-two boys will be randomly coded with A and B. A will be the control group, and B will be the experimental group.

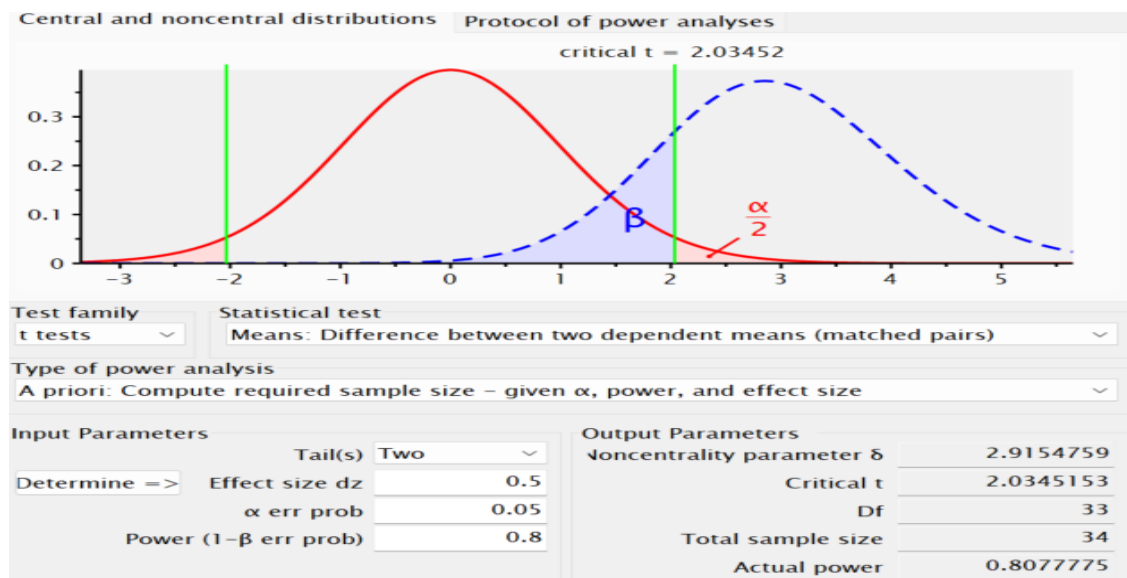


Figure 1 Sample size

#### Inclusion Criteria:

- Must be undergraduate students enrolled and participating in a university tennis program.
- Be between 18 and 22 years of age, male or female.
- Have basic tennis skills and participate in regular tennis training and competitions.
- Participate in this study and sign an informed consent form.
- Able to complete all the pre-test assessments, which included tennis skill tests, before the experiment.

#### Exclusion Criteria:

Not participating in the tennis program; a spectator only and not taking part in formal training and assessment of that program.  
A serious physical illness or injury prevents normal participation in tennis training and competitions.  
Failure to sign an informed consent form during recruitment.  
Failure to complete the pre-test assessment prior to the experiment or missing pre-test data.

Unable to continue to participate in tennis lessons during the experimental period for any reason (e.g., transferring to another school, taking a break from school, or other circumstances).

Students with cognitive impairments or other psychological problems may have a different influence on the teaching method and assessment results.

Failure to comply with the study protocol during the experimental period, e.g., missing the required number of training sessions and failing to complete post-session assignments on time.

By specifying the inclusion and exclusion criteria, this study aims to ensure the appropriateness of the selected sample and the internal validity of the study in order to draw reliable conclusions.

### 3.3 Study instruments

This study used the CTN skill assessment for the dependent variable measurement test. The CTN level is an intelligent assessment to evaluate the skill level of tennis. CTN is a tennis technical grade standard and evaluation method formulated by the China Tennis Association (2018), which has high credibility and reliability. The technical level is divided into 10 levels from high to low, i.e., CTN1, CTN2, CTN3, CTN4, CTN5, CTN6, CTN7, CTN8, CTN9 and CTN10. The specific test methods are in Figures 2, 3, 4, and 5. This test measures the depth, power, and accuracy of the forehand and backhand returns, the success, accuracy, and power of the serve, and the mobility of the subject's stroke, accuracy, and pace of movement. The test consists of four items: 90 points for depth of groundstroke, 84 points for accuracy, 108 points for serve, and 76 points for mobility.

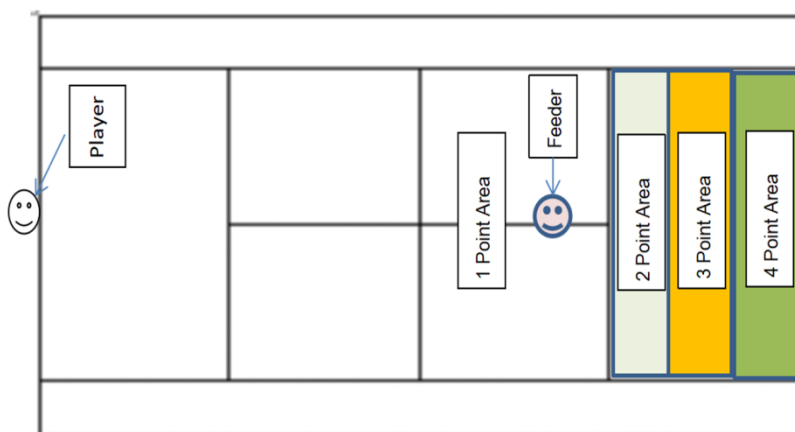


Figure 2 Bottom Line Depth Stroke Skills

(Depth Test (out of 90 points), 10 alternating forehand and backhand shots from the baseline, each landing in the scoring area and scoring accordingly.)

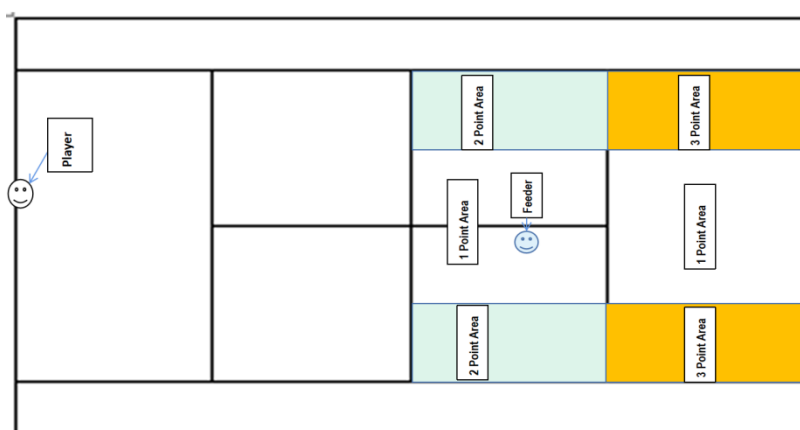


Figure 3 Forehand and backhand baseline hitting accuracy

Bottom Line Shot Accuracy Test (out of 84 points), 6 bottom line forehand and backhand straight shots, 6 bottom line forehand and backhand diagonal shots landed in the scoring area and are scored accordingly.)

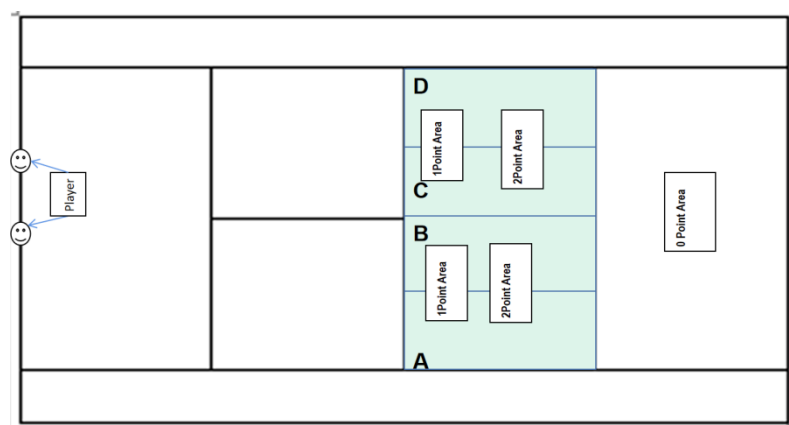


Figure 4 Serve

(Serve (108 points), a total of 12 balls, 4 target zones (A, B, C, D), each target zone to send 3 respectively landed in the scoring area, to obtain the corresponding score, for example, send C, into the D zone scored 1 point, into the A, B zone 0 points)

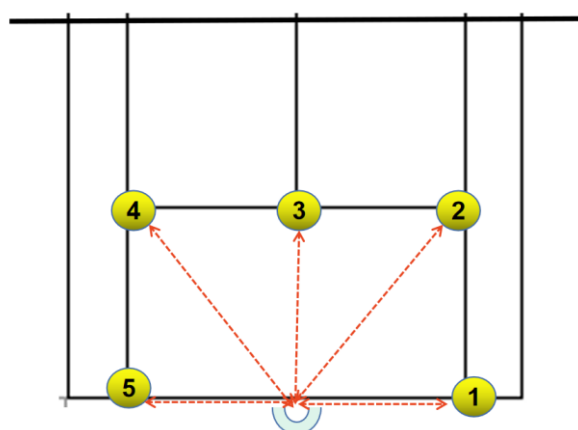


Figure 5 Speed

(Mobility test (out of 76 points), the time it takes for the participant to retrieve 5 tennis balls and place them in a specified position.) (Qian Wang, 2020)

### 3.4 Process

Teachers in the experimental group were trained in BCTs based on the ADDIE model before the experiment to ensure that they mastered the relevant teaching methods and skills. At the same time, a pre-test was conducted on the tennis skills of the students in both groups. During the implementation of the experiment, the experimental group used BCTs based on the ADDIE model to teach tennis, and the control group used traditional teaching methods. The teaching cycle was 8 weeks, with 2 sessions per week, and the duration of each session was 90 minutes. After the experiment, a post-test was conducted on the tennis skills of the two groups of students, and the data of the experimental and control groups were collected at the same time.

### 3.5 Teachers, student training, and curriculum programs

Prior to the start of the experiment, teachers in the experimental group received a two-week training on BCTs based on the ADDIE model. The training includes the five phases of the ADDIE model, principles and applications introduced by BCTs, instructional design activities, simulation of instruction, feedback, and coaching. A teacher training manual and a student manual are provided throughout the training. The manuals contain detailed explanations of the five stages of ADDIE, how BCTs are introduced, and how to guide and design instructional activities.

Analysis phase: Identifying students' tennis skill levels and learning needs.

Design phase: Designing the teaching objectives, content, and methodology, including the application of BCTs.

Development phase: Develop and prepare teaching materials such as instructional videos, practice guides, and feedback forms.

Implementation phase: Teaching according to the teaching plan and applying BCTs to facilitate students' learning.

Evaluation phase: Evaluating the effectiveness of teaching through observation, student feedback, and skill testing.

Table 1 is about a lesson plan for a class. It shows how BCTs are introduced and the importance.

Table 1 Lesson Plans

| C<br>l<br>a<br>s<br>s | T<br>h<br>e<br>m<br>e<br>s                                                               | Tennis<br>con<br>te<br>nt                                           | Teachi<br>ng<br>strategi<br>es                                           | Teaching<br>Objectiv<br>es                                                                                                                                                                                                                                                                                                                                                                                      | BCTs<br>Groups                                                                                                                                                                                                                                                                                          | How to implement (activities)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Significance                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Heart<br>rate | time       |
|-----------------------|------------------------------------------------------------------------------------------|---------------------------------------------------------------------|--------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------|------------|
| 1                     | In<br>tr<br>o<br>d<br>u<br>c<br>t<br>i<br>o<br>n<br>t<br>o<br>T<br>e<br>n<br>n<br>i<br>s | Tennis<br>rules,<br>game<br>overvi<br>ew,<br>basic<br>positi<br>ons | Explan<br>ation,<br>Discus<br>sion,<br>Demon<br>stration<br>Practic<br>e | 1. .<br>Students<br>understa<br>nd the<br>basic<br>overview<br>of tennis,<br>familiariz<br>e themse<br>lves with<br>class<br>rules,<br>and<br>clarify<br>the<br>learning<br>content<br>and<br>requirem<br>ents.<br>2. Stude<br>nts<br>master<br>the basic<br>knowled<br>ge of<br>tennis<br>courts,<br>learn the<br>correct<br>grip<br>techniqu<br>es, and<br>improve<br>ball<br>sensitiv<br>ity and<br>control. | 1. Goals<br>and<br>planning<br>2.<br>Feedbac<br>k and<br>monitori<br>ng<br>4.<br>Shaping<br>knowled<br>ge<br>5.<br>Natural<br>consequ<br>ences<br>6.<br>Compari<br>son of<br>behavior<br>8.<br>Repetitio<br>n and<br>substituti<br>on<br>9.<br>Compari<br>son of<br>outcome<br>s<br>15. Self-<br>belief | 1. Introduce course objectives and the content for this semester (1.4. Action planning).<br>2. Use PPT or short videos to present basic tennis knowledge and history while incorporating celebrity influence (Zheng Qinwen) and the learning experiences of the school's tennis team students (6.2. Social comparison, 9.1. Credible source). 15.1 Self-belief).<br>3. The teacher provides an overall explanation and demonstration of basic tennis techniques, such as grip, stance, and basic stroke actions (4.1. Instruction on how to perform the behavior).<br>4. Discuss the importance of techniques: emphasize the impact of correct techniques on health and sports performance (5.1. Information about health consequences, 5.2. Alliance of Consequences, Antecedents, 9.2. Pros and cons).<br>5. Explain tennis rules and classroom rules. Introduce the basic rules and etiquette of tennis matches. Emphasize classroom discipline and safety rules (4.2. Information about antecedents, 9.1. Credible source, 12.1 Restructuring the physical environment).<br>6. Student Q&A session and planning session. Students raise their own questions for discussion with the teacher (1.2. Problem-solving). Develop next practice plans and improvement measures. 1.4. Action planning, 8.1. Behavioral practice/rehearsal, 8.2. Behavior substitution).<br>7. Students record their performance and feelings from this lesson, and the teacher provides a summary and feedback (2.2. Feedback on behavior, 2.4. Self-monitoring of outcome(s) of behavior).<br>8. Assign homework, encouraging students to practice after class (1.4. Action planning). | 1. By observing actual technical movements, students can intuitively understand and master correct tennis techniques.<br>2. Through comparisons, students can identify gaps, stimulate self-improvement motivation, and learn successful skills and methods from others.<br>3. Enhancing students' awareness of tennis enhances their motivation to participate and sustain involvement.<br>4. By emphasizing the positive outcomes of sports, students' appreciation of tennis is heightened, encouraging active participation.<br>5. Providing problem-solving strategies enhances students' confidence and coping abilities, improving learning outcomes.<br>6. Timely feedback helps students quickly correct errors, reinforce correct movements, and promote technical improvement.<br>7. Self-monitoring helps students understand their progress, adjust learning plans and goals, and improve self-management skills.<br>8. Specific technical guidance enables students to accurately grasp tennis skills and reduce the occurrence of erroneous movements.<br>9. Understanding and mastering the precursors of actions helps students better prepare and respond, enhancing performance in competition.<br>10. Enhancing the persuasiveness and reliability of information from credible sources improves students' acceptance and trust in instructional content.<br>11. Comprehensive pros and cons analysis enables students to make wiser decisions and optimize their learning and training processes. | Low           | 90<br>mins |

### 3.6 Data analysis

SPSS 26.0 software was used for the analysis of data. First, an independent samples t-test was conducted on the pre-test data from the experimental and control groups to check if there was a significant difference in the tennis skills of the two groups of students before the experiment. Independent samples t-test was conducted on the post-test data of the experimental and control groups to compare the tennis skill levels of the two groups of students after the experiment, and finally, the data were analyzed.

## 4.0 Findings

### 4.1 Results of data analysis

The descriptive data of the experimental and control groups measured before and after the experiment are shown in Tables 2 and 3 below. Statistical analyses showed that there was no statistical difference between the two groups at baseline for all the baseline indicators investigated ( $p > 0.05$ ). This suggests that there was no difference between the experimental and control groups in the pre-experiment. However, after the intervention, the experimental group showed significant improvements compared to the control group in four key performance areas: baseline hitting depth, baseline hitting accuracy, serve, and movement ( $p < 0.05$ ). Specifically, in terms of baseline stroke depth, no significant difference was observed before the experiment ( $t(32) = 0.46, p = 0.64$ ), but after the intervention,

the experimental group performed significantly better ( $t(32) = 2.448, p = 0.02 < 0.05$ ). Similarly, in terms of baseline accuracy, there was no significant difference between the two groups before the experiment ( $t(32) = 0.142, p = 0.88$ ); however, the post-experimental results showed that the experimental group performed significantly better than the control group ( $t(32) = 2.062, 0.048 < 0.05$ ). A similar pattern was observed in serving. There was no significant difference between the experimental and control groups before the experiment ( $t(32) = -1.016, p = 0.318$ ), but post-experimental analyses showed that the experimental group performed significantly better ( $t(32) = 2.872, p = 0.007 < 0.01$ ). In terms of speed, no significant difference was found in the pre-experiment ( $t(32) = -1.342, p = 0.19$ ), while the experimental group performed significantly better in the post-intervention ( $t(32) = 2.882, p = 0.007 < 0.01$ ).

Overall, these results highlight the effectiveness of the intervention in improving specific aspects of athletic performance, as evidenced by the fact that the experimental group showed a significant improvement over the control group on all four assessment indices after the experiment.

Table 2. Differences between experimental and control groups in the pre-experimental

|                        | EG(n=16)<br>x ± S | CG(n=16)<br>x ± S | t      | p     |
|------------------------|-------------------|-------------------|--------|-------|
| Baseline Depth Hitting | 1±0.82            | 1±0.72            | 0.46   | 0.64  |
| Baseline Accuracy      | 1.13 ± 1.20       | 1.06 ± 1.29       | 0.142  | 0.88  |
| Serving                | 1.06±0.93         | 1.38±0.81         | -1.016 | 0.318 |
| Speed                  | 13.13±4.63        | 15.50±5.35        | -1.342 | 0.19  |

Table 3. Differences between experimental and control groups in the post-experimental

|                        | EG<br>x ± S | CG<br>x ± S | t     | p          |
|------------------------|-------------|-------------|-------|------------|
| Baseline Depth Hitting | 42.63±10.86 | 33.75±9.61  | 2.448 | 0.02<0.05  |
| Baseline Accuracy      | 42.56±9.35  | 36.31±7.72  | 2.062 | 0.048<0.05 |
| Serving                | 68.63±13.24 | 56.38±10.77 | 2.872 | 0.007<0.01 |
| Speed                  | 23.25±6.42  | 18.38±2.213 | 2.882 | 0.007<0.01 |

#### 4.2 Finding

Based on the above data and analysis, the following FINDINGS were derived from this study:

BCTs based on the ADDIE model were effective in improving the baseline depth hitting skills of college tennis students. Students in the experimental group significantly outperformed the control group in terms of bottom-line depth hitting after the experiment.

Regarding baseline accuracy, the improvement observed in the experimental group was significant, providing evidence that students were more capable of mastering baseline accuracy skills through the integrated application of the ADDIE model and BCTs.

Besides, the improvement of the serving and movements in the experimental group serves as an indicator that with BCTs applied in a proper manner, this group can work out more skillful ways for improvement of serving and mobility together with strengthening resilience during gaming.

BCW states that behavior change is influenced by ability, opportunity, and motivation and that BCTs interventions vary in providing the skills and knowledge needed to perform tennis skills correctly and in a fun way, providing students with a variety of opportunities for communicative learning, which enhances students' ability, motivation to learn, opportunities to refine skills, and improves students' confidence and self-efficacy. From the perspective of the Theory of Planned Behavior, it was shown that positive changes in students' attitudes toward practicing tennis skills, which may have been influenced by the perceived benefits of success and mastery of the skills in BCTs, were introduced into the design process of teaching and learning, which included teamwork social support and communication, thus creating a supportive social environment, which reinforced positive norms about skill improvement and encouraged students to perform at their best. The structured nature of BCTs may have increased students' perceived behavioral control, providing them with the skills and knowledge to effectively execute the tennis technique. This, in turn, may have increased their intentions to engage in the behavior and their confidence in their ability to perform the behavior. The goals set by the BCTs effectively increased students' intentions to improve their tennis skills by enhancing their attitudes, subjective norms, and perceived behavioral control.

Overall, the application of BCTs has improved college students' tennis skills and provided them with a solid foundation in basic techniques.

#### 5.0 Discussion

The results of this study suggest that BCTs based on the ADDIE model are significantly effective in improving college tennis skills. However, the poor performance of the control group may be due to a number of factors. Firstly, traditional teaching methods may lack relevance and individualization to meet the learning needs of different students. Second, traditional teaching methods may lack effective feedback mechanisms to correct students' errors in a timely manner. In addition, traditional teaching methods may lack incentives to stimulate students' interest and motivation in learning.

Based on my existing knowledge, no research is referencing BCTs to empirical studies in the tennis classroom. Therefore, the discussion part of this study will incorporate the enhancement of tennis skills by other different teaching methods.

In this study, it was found that the introduction of BCTS based on the ADDIE model significantly improved college students' tennis baseline depth stroke skills. This is in line with the previous study by Thijail et al. (2021), which used information processing strategies and the seven-cycle learning cycle to effectively enhance the learners' stroke accuracy and depth control, providing them with personalized feedback and phased instructions. This suggests that the optimized behavioral change technique of the ADDIE model is effective in improving the students' hitting technique, as shown by Liu et al. (2023), who showed that functional training during exercise routines resulted in a more consistent technical movement, which led to improved stroke accuracy. Students in the experimental group showed significant changes in serving and movement skills, which is consistent with the results of Zahra's (2024) educational program using highly interactive multimedia and maker tools to improve students' tennis serving skills. The present study is supported by Weissman et al. (2022) findings that behavioral modification techniques promote sports participation and physical literacy development in children of varying abilities. Qian Wang (2020) used the Quick and Easy Tennis Teaching Method to positively impact high school students' tennis-playing skills. The present study further supports this idea and provides new insights into a systematic model of teaching and learning.

Previous studies have only focused on the effects of behavioral change techniques applied alone; this study combined them systematically with the ADDIE model for the first time and verified their significant effects on tennis skill training. The current literature has paid less attention to college students' tennis training, and this study fills the gap in this area. There is a relative scarcity of research on Chinese college students, and this study provides regionally significant data.

## 6.0 Conclusion & Recommendations

This study verified the significance of behavioral change techniques (BCTs) based on the ADDIE model in improving the effectiveness of teaching tennis skills to college students through a randomized controlled trial. This instructional design not only improved college students' baseline depth strokes and accuracy but also significantly improved serve and movement skills. This study systematically combines the ADDIE model and BCTs for the first time, which fills the research gap in the existing literature on college tennis teaching and provides a practical basis and theoretical support for the future application of the two in physical education teaching. The study conducted on Chinese college students makes up for the geographical deficiency in the current literature and provides valuable data references for domestic educators. This study has important implications for policy and curriculum design in physical education, and stakeholders should consider these evidence-based teaching strategies for incorporation into teacher training, as well as revising teacher teaching curricula and encouraging teachers to explore new ways of incorporating them to improve teaching and learning. Institutions should create a more engaging and distinctive tennis curriculum that fosters interest and motivation in the sport and promotes healthy physical and mental development.

This study also has corresponding shortcomings, such as a small sample size and a small time span. Future research could explore the applicability of BCTs in different programs, expand the sample size, select more genders, and lengthen the experimental period so as to explore the sustained effects of BCTs in long-term training, and could also add qualitative research to explore students' perceptions. In addition to this, there may be some bias here in that although consistency in age and tennis skill levels were considered in this study, other factors such as motivation and exposure to similar pedagogies, and even pupil personality traits, may have had an impact on the intervention. Besides, aspects of tennis skill assessment may be subject to unconscious bias in terms of teacher expectations.

## Acknowledgement

I would like to express my appreciation to the participating hard-working teachers and students, as well as to the supervisors who gave valuable advice during the research process.

## Paper Contribution to Related Field of Study

This study contributes to the field of physical education teaching and instructional design by demonstrating the effectiveness of BCTs in college tennis lessons based on the ADDIE model. The results of this study provide empirical evidence to the existing body of knowledge that demonstrates the use of BCTs in physical education and that the combination of instructional design and BCTs provides a unique approach to instructional design that addresses both the technical and psychological aspects of physical education learning. This contribution bridges the gap between instructional design and behavior change theory and provides a comprehensive framework for enhancing physical education instruction. It is also an innovation in college physical education pedagogy that provides coaches and teachers with a new instructional strategy.

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