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Exploring Expert–Novice Differences in Basketball Free Throw Performance among University Students: A Comparative Study Based on Skill Clustering

Wen-Zhong Wang[1*]

[1] Graduate Institute of Physical Education, National Taiwan Sport University, Taiwan, Province of China.
a982159177169@gmail.com

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ABSTRACT

Objective: Grounded in the expert–novice paradigm of motor learning, this study compared first-year general university students and second-year basketball majors in terms of free throw accuracy, performance stability, and skill-cluster distribution, and examined how different training backgrounds shape performance structure. **Methods:** A cross-sectional design was employed with 326 participants (184 general students, mixed gender; 142 basketball majors, male). All completed three standardized free throw tests (11 attempts per trial). Independent-samples t tests and Cohen's d assessed between-group differences. Technical stability was measured using the coefficient of variation (CV), and skill clusters were categorized using percentile ranks (bottom 25% = low, middle 50% = moderate, top 25% = high). Chi-square tests examined distribution differences. **Results:** Basketball majors significantly outperformed general students across all trials ($p < .001$), with effect sizes ranging from moderate to large ($d = 0.67–0.87$), increasing across trials. Majors demonstrated significantly lower CV values (0.46–0.50 vs. 0.66–0.75), indicating superior stability. Skill-cluster analysis revealed a significantly higher proportion of majors in the high-skill group (50.7% vs. 34.8%, $p < .05$). **Conclusion:** Long-term specialized training enhances not only average accuracy but also performance stability and distribution structure. Incorporating stability indicators and skill-based grouping into physical education may improve instructional effectiveness.

Keywords: basketball; free throw; motor learning; performance stability; expert–novice paradigm; skill clustering

Corresponding Author:
Wen-Zhong Wang

- Graduate Institute of Physical Education, National Taiwan Sport University, Taiwan, Province of China.
- Email: a982159177169@gmail.com

1. Introduction

Basketball free throws represent a typical closed motor skill in which performance success relies heavily on motor programming depth and consistency of execution. In university physical education settings, students often present highly heterogeneous skill levels, ranging from novices with minimal basketball experience to trained athletes with multiple years of systematic practice. Lin (2011) noted that physical education curriculum design and intervention models significantly influence students' skill performance and learning motivation over time. When teaching and assessment focus solely on average performance, the actual needs of students across different ability levels are often overlooked.

Previous free throw research has primarily examined biomechanical parameters such as release angle, initial velocity, ball trajectory, and optimal parabolic path (Okubo & Hubbard, 2006), or explored the effects of different shooting distances and movement patterns on performance stability (Xu, 2004). However, systematic comparative studies examining "technical distribution structure" and "stability" between students with different training backgrounds remain limited. Particularly, empirical research in Taiwan applying the expert–novice paradigm to analyze differences between general university students and specialized basketball majors is notably absent. Recent international studies indicate that free throw performance is influenced not only by technical factors but also by sports experience, neuromuscular control, and temporal movement variation, with expert and novice athletes exhibiting significant differences in movement variability characteristics.

From a practical perspective, if instructors assess student ability based solely on free throw accuracy from a single test, they may overlook the value of "stability" and "ability distribution" for instructional decision-making. For example, two students with identical average shooting scores may exhibit vastly different variability patterns—one stable, the other highly volatile. Quantifying stability indicators and skill clustering to understand within-class ability structures can support more precise differentiated instruction and assessment strategies.

Based on the above, this study addresses the theoretical and practical gap by comparing differences in free throw accuracy, stability, and skill clustering between university students with different training backgrounds, grounded in motor learning theory and the expert–novice paradigm.

1.1 Specific research objectives were:

1. Compare free throw accuracy, technical stability, and effect sizes between first-year general students and second-year basketball majors.

2. Examine distribution characteristics and structural implications of skill clusters (low, moderate, high) across different training backgrounds.

3. Provide practical recommendations for differentiated instruction and assessment design in university physical education courses.

1.2 Research Hypotheses

Based on the theoretical framework and previous research, the following hypotheses were proposed:

1. Basketball majors will demonstrate significantly higher free throw accuracy than general students across all three trials.

2. Basketball majors will exhibit significantly lower coefficient of variation (CV) values, indicating superior performance stability.

3. Basketball majors will have a significantly higher proportion in the high-skill cluster compared to general students.

2. Theoretical Framework

2.1 Fitts and Posner's Stages of Learning

Fitts and Posner (1967) delineated three stages of skill learning: cognitive, associative, and autonomous. General students typically remain in the cognitive or associative stages, requiring substantial attentional resources for movement correction, resulting in performance that is susceptible to contextual interference and instability. In contrast, basketball majors, through prolonged deliberate practice (Ericsson et al., 1993), have automatized their motor programs, enabling precise and consistent free throw execution under lower cognitive load.

2.2 Schmidt's Schema Theory

Schmidt (1975) proposed the generalized motor program (GMP) and schema theory, suggesting that individuals accumulate feedback experience through varied practice, enabling adjustment of movement parameters across different contexts. Experts establish stable schema structures that reduce output variability, whereas novices, with immature schemas, exhibit highly volatile performance (Schmidt et al., 2019).

2.3 Cognitive Load Theory and Performance

Sweller (2011) indicated that excessive cognitive load interferes with learning and performance. Wulf (2013) emphasized the impact of attentional focus on motor control: experts predominantly adopt external focus (e.g., aiming at the back edge of the rim), facilitating movement automatization; novices tend to over-focus on internal details (e.g., wrist angle), leading to movement rigidity and reduced stability.

3. Methods

3.1 Participants

This study employed a cross-sectional design with 326 participants from a private university in Taiwan, including 184 first-year general students (mixed gender) and 142 second-year basketball majors (all male). All participants had enrolled in or were currently enrolled in basketball-related courses and provided informed consent. Ethical approval was obtained from the institutional review board (Approval No.: TYGHI132020).

3.2 Procedure and Operational Definitions

Participants performed three standardized free throw trials on an indoor court using identical equipment and official basketballs. Each trial consisted of 11 attempts. All three trials were completed within the same session, with a fixed 1–2 minute rest interval between trials to minimize fatigue and short-term learning effects.

Skill clustering used percentile rank methodology based on total free throws across three trials. Participants were ranked and categorized as: bottom 25% = "low-skill group," 26%–75% = "moderate-skill group," top 25% = "high-skill group."

3.3 Data Analysis

SPSS statistical software was used for analysis. Descriptive statistics (mean, standard deviation) were calculated for both groups across three trials. After testing normality and homogeneity of variance assumptions, independent-samples t tests compared group differences, with Cohen's d calculated to assess effect size magnitude. Technical stability was measured using the coefficient of variation (CV = SD/Mean). Skill cluster distribution differences were examined using chi-square tests.

4. Results

4.1 Between-Group Differences in Free Throw Performance and Stability

As shown in Table 1, basketball majors demonstrated significantly higher mean free throw scores across all three trials compared to general students ($p < .001$). Effect sizes ranged from moderate to large ($d = 0.67$ in Trial 1, $d = 0.82$ in Trial 2, $d = 0.87$ in Trial 3), showing an increasing trend across trials. This indicates that the performance gap between groups not only persists but expands with repeated testing.

Regarding stability, general students exhibited CV values ranging from 0.66 to 0.75, whereas basketball majors maintained consistently lower CV values (0.46–0.50), demonstrating significantly superior performance consistency. Notably, although general students showed slight improvement in mean scores (2.78 → 3.01), their CV did not decrease, suggesting that their improvement may stem from occasional successful shots rather than establishment of stable movement patterns.

According to Cohen's criteria, effect sizes of $d = 0.20$ represent small, $d = 0.50$ represent medium, and $d = 0.80$ represent large effects. The observed effect sizes in this study ($d = 0.67–0.87$) indicate medium to large differences between groups.

Table 1. Free Throw Performance and Variability Analysis by Group

Trial	Group	N	Mean	SD	CV	t	p	Cohen's d
1	General	184	2.78	2.08	0.75	-5.99	<.001***	0.67
1	Majors	142	4.18	2.11	0.50			
2	General	184	2.91	1.93	0.66	-7.29	<.001***	0.82
2	Majors	142	4.54	2.10	0.46			
3	General	184	3.01	2.12	0.71	-7.75	<.001***	0.87
3	Majors	142	4.88	2.23	0.46			

$^{***}p < .001$

4.2 Skill Cluster Distribution Analysis

As shown in Table 2, skill clustering revealed that basketball majors had a significantly higher proportion in the high-skill group (50.7%) compared to general students (34.8%). Conversely, general students were predominantly concentrated in the moderate-skill group (54.3%). Chi-square testing indicated significant differences in distribution between groups ($\chi^2 = 12.45$, $p < .05$).

These results reveal not only average ability differences but also distinct "ability distribution patterns": basketball majors exhibit a concentrated high-performance distribution, whereas general students show a near-normal distribution centered in the moderate range.

Table 2. Skill Cluster Distribution and Chi-Square Test by Group

Group	Low-skill	Moderate-skill	High-skill	χ^2	p
General	10.9%	54.3%	34.8%	12.45	<.05*
Majors	7.0%	42.3%	50.7%		

$^{*}p < .05$

5. Discussion

5.1 Essential Differences in Movement Stability between Experts and Novices

This study demonstrates that basketball majors exhibited significantly lower coefficient of variation values, indicating higher consistency in free throw

movement execution. According to Fitts and Posner's (1967) stages of learning theory, general students remain in the cognitive or associative stages, requiring explicit control and working memory resources for movement execution, resulting in frequent real-time corrections and greater performance variability. In contrast, basketball majors have reached the autonomous stage, with movement programs internalized as stable generalized motor programs (GMP), enabling stable output under lower cognitive load (Schmidt, 1975; Schmidt et al., 2019).

Previous research by Schmidt et al. (2019) indicates that athletes with extensive training experience demonstrate superior coordination and smaller performance variability in high-precision skills, particularly under repeated shooting and high-pressure situations. This study supports this trend and further suggests that "stability" may be a more critical indicator of skill maturity than average accuracy alone.

5.2 Mechanism Explaining Increasing Effect Sizes across Trials

The finding that effect sizes increased across trials indicates that the performance gap between groups amplifies with repeated testing. This phenomenon can be explained through "fatigue regulation capacity" and "movement automatization anti-interference ability." Long-term training enables basketball majors to possess superior neuromuscular coordination and energy regulation capacity, maintaining stable movement rhythm and release parameters even during continuous shooting. Conversely, general students are more prone to attentional distraction, micro-fatigue, or self-evaluation interference during repeated execution, leading to increased movement parameter variability.

These results align with Wulf (2013) and Zachry et al. (2005) research on attentional focus: experts maintain external focus more effectively, concentrating consciousness on the target outcome while reducing excessive attention to body details; novices, after repeated failures, often shift to high focus on movement details, further destabilizing performance.

5.3 Structural Implications of Skill Cluster Differences

Skill cluster results showing concentrated high-skill distribution among basketball majors suggest that skill development is not simply linear accumulation over time but may involve "threshold effects" and qualitative

transformation processes (Ericsson et al., 1993). When practice volume, feedback quality, and training density accumulate to a certain level, individuals' movement control strategies and psychological adjustment mechanisms undergo qualitative changes, transitioning from high-variance zones to high-stability performance zones.

This structural finding has specific instructional implications: if university physical education employs homogeneous curricula and assessment standards, it will struggle to address both low-skill students' entry needs and high-skill students' advancement needs. Differentiated course design based on skill clustering may include:

1. Low-skill group: Focus on movement simplification, observational learning, and basic confidence building.
2. Moderate-skill group: Increase contextual variation and random practice to enhance adaptability and stability.
3. High-skill group: Introduce pressure simulation, technology-assisted training, and movement micro-adjustments to maintain performance under high pressure.

6. Study Limitations

This study's general student group included mixed genders while the basketball major group was all male; gender differences may constitute a potential confounding variable. Previous research indicates that gender may produce differences in force output and movement control (Lyons et al., 2006). However, this study's results suggest that training experience effects on stability may exceed gender factors. Future research should:

1. Control for gender variables using same-gender samples to enhance internal validity.
2. Incorporate biomechanical and physiological indicators (e.g., release angle, velocity, EMG, heart rate) to more comprehensively explain stability difference sources.

7. Practical Implications for Teaching

This study provides at least three implications for university physical education:

1. Differentiated instruction design: Plan teaching objectives with varying difficulty and content based on skill clustering, avoiding application of single curricula to classes with excessive ability differences.

2. Stability-priority training: Assessment should not rely solely on accuracy; incorporating coefficient of variation (CV) or multi-trial consistency should serve as important reference indicators.

3. Structured deliberate practice: The advantages of basketball majors demonstrate that high-frequency, feedback-rich deliberate practice design is critical for skill automatization. Future courses may incorporate simple data recording and feedback mechanisms to enhance practice quality.

8. Recommendations for Future Research

Future studies should further:

1. Employ longitudinal design to track the same cohort's skill development from freshman to senior year, examining how expert–novice differences change over time.

2. Combine motion capture, eye-tracking, and psychological scales to establish integrated technical-perceptual-psychological databases, explaining stability and accuracy changes from multiple dimensions.

3. Compare different training strategies (e.g., error-oriented vs. enhancement learning) on free throw precision and long-term retention, further linking motor learning theory with instructional practice.

9. Conclusion

Long-term specialized basketball training significantly enhances not only free throw accuracy but also, more critically, performance stability and ability distribution structure. General university students, compared with basketball majors, demonstrate lower accuracy, higher variability, and concentration in moderate-skill ranges. Basketball majors exhibit concentrated high-skill distribution with superior stability. These findings support incorporating stability indicators (e.g., CV) into physical education assessment and implementing skill-based differentiated instruction to improve overall instructional effectiveness.

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Conflict of Interest Statement

The author declares no conflict of interest regarding the publication of this article.

Author Contributions

Conceptualization, Study Design, Data Collection, Statistical Analysis, Manuscript Writing, Final Approval — 100%

This is a single-author study. The author conducted all aspects of the research and manuscript preparation.

Submission Declaration

This manuscript is original, has not been published previously, and is not under consideration elsewhere. All ethical guidelines have been followed, and all participants provided informed consent.

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