

Levels of "Van Hiele's Theory" According to Brainwave Patterns and Their Effectiveness in Learning Some floor Exercises in gymnastics

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Abstract:

This study aimed to investigate the impact of an educational program based on the Van Hiele levels of geometric thinking, tailored to brain dominance patterns, on learning selected floor exercises in gymnastics. To achieve this, an experimental approach was employed on a sample of 25 male and female students. The proposed educational program was implemented over a six-week period (06 weeks). Research instruments included the Torrance Tests of Brain Dominance and a specialized observation scale to assess motor performance.

The results revealed a significant positive impact of the proposed program on enhancing the skill performance levels in gymnastics. Statistical analysis indicated significant differences between the pre-test and post-test results in favor of the post-test across all floor exercises at a significance level of ($P \leq 0.05$). These findings demonstrate the program's effectiveness in developing motor skills and significantly improving the technical performance of the students, highlighting the high scientific and pedagogical value of the proposed instructional model.

Keywords: Van Hiele Theory, Brain Dominance, Floor Exercises, Gymnastics.

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I- Introduction :

Learning is fundamentally regarded as one of the earliest human experiences, serving as a primary conduit for acquiring knowledge, shaping attitudes, and developing essential skills. It empowers individuals to effect transformative change both within themselves and across their broader social environments. Within this context, departments and institutes of Physical Education and Sports function as pivotal institutions; they play a crucial role in instructing various athletic activities while striving to cultivate future educators who possess a comprehensive integration of theoretical knowledge and practical, field-based expertise. (Shamkhi, H. J.2022, p. 118).

Gymnastics is fundamentally recognized as a foundational discipline characterized by intricate spatial orientations and geometric movement patterns. Achieving technical proficiency in this sport necessitates a structured pedagogical framework that synchronizes with the learner's cognitive and developmental milestones. The incorporation of spatial-geometric models within physical education curricula facilitates a seamless transition from basic motor recognition to sophisticated technical execution. Contemporary research underscores that the mastery of fundamental gymnastic skills functions as an essential prerequisite for advanced apparatus training. This progression is governed by hierarchical learning phases, ensuring both the conceptual clarity and physical readiness of the practitioner at each successive level of complexity. (Thomas Heinen, 2021,p. 42).

The pedagogical value of this theory lies in its systematic alignment with students' diverse cognitive levels, providing a dynamic platform for idea exchange and knowledge construction, which significantly bolsters learning motivation. This approach is further integrated with an emphasis on **brain dominance patterns**, which reflect an individual's functional predisposition toward utilizing one cerebral hemisphere (right or left)—or their synergistic integration—in mental processes and behavior. Such functional dominance manifests as a distinct 'cognitive style' that dictates how an individual approaches learning tasks and processes information.

Educational frameworks that account for individual cognitive levels significantly enhance student engagement and intrinsic motivation. Central to this personalized approach is the understanding of hemispheric lateralization, or brain dominance, which dictates an individual's preference for processing information through either the left or right cerebral hemisphere. This neurological predisposition shapes a student's unique cognitive style, influencing how they perceive, organize, and respond to educational stimuli. By aligning instructional strategies with these dominant processing patterns, educators can foster a more effective and responsive learning environment. (D.E. Papalia & G.Martorell, 2021,P 214).

Building upon the pivotal role established in previous literature regarding the **Van Hiele theory** and **brain dominance patterns** in fostering cognitive development and enhancing thinking styles—consequently elevating educational outcomes—the current study proposes an instructional program structured according to the Van Hiele levels and aligned with brain dominance preferences.

This program targets the acquisition of a core set of fundamental motor skills in gymnastics, specifically: (forward roll, straddle forward roll, backward roll, straddle backward roll, handstand, headstand, and the cartwheel). The study aims to evaluate the effectiveness of this proposed

curriculum in optimizing the learning process for these floor exercises among first-year undergraduate students at the Institute of Science and Technology of Physical and Sports Activities (STAPS), University of Boumerdes.

Consequently, the following primary research question is addressed: To what extent does an instructional program based on the Van Hiele levels and differentiated brain dominance patterns contribute to improving the skill performance level of selected floor exercises in gymnastics among students of the Department of Science and Technology of Physical and Sports Activities at the University of Boumerdes?.

II – Methodological Procedures:

1. Study Group: The Participants consists of 42 male and female students in their first year of the Bachelor's degree (L1) at the Department of Science and Technology of Physical and Sports Activities (STAPS), University of Boumerdes, for the academic year 2023/2024. The sample included 24 males and 18 females, divided into two main experimental groups.

A. Experimental Group (Males): Consisted of (N = 24) male students, with an average age of (19.17 ± 1.33 years), average height (1.76 ± 0.08 m), and average weight (66.63 ± 9.08 kg). This group was further divided into two equal and homogeneous subgroups:

- **First Subgroup:** Comprised of students characterized by **Right-Brain dominance**, totaling (n = 15) students, with an average age of (19.29 ± 1.39 years), average height (1.76 ± 0.07 m), and average weight (66.01 ± 9.43 kg).
- **Second Subgroup:** Comprised of students characterized by **Left-Brain dominance**, totaling (n = 9) students, with an average age of (18.86 ± 0.38 years), average height (1.75 ± 0.08 m), and average weight (61.31 ± 10.79 kg).

B. Experimental Group (Females): Consisted of (n = 18) female students, with an average age of (18.77 ± 0.91 years), average height (1.57 ± 0.04 m), and average weight (53.12 ± 8.37 kg). This group was also divided into two homogeneous subgroups:

- **First Subgroup:** Comprised of female students characterized by **Right-Brain dominance**, totaling (n = 10) students, with an average age of (18.35 ± 1.3 years), average height (1.56 ± 0.91 m), and average weight (53.95 ± 7.14 kg).
- **Second Subgroup:** Comprised of female students characterized by **Left-Brain dominance**, totaling (n = 8) students, with an average age of (19.01 ± 0.45 years), average height (1.58 ± 0.24 m), and average weight (52.92 ± 7.14 kg).

Both groups were subjected to the proposed educational program based on the stages of the "**Van Hiele Theory**" for learning selected floor exercises in gymnastics, which included: (forward roll, straddle forward roll, backward roll, straddle backward roll, handstand, headstand, and the cartwheel).

II – Methodology: In the current study, we adopted the **Experimental Method** using an **equivalent-groups design**, as it is the most appropriate and suitable methodology for the objectives of this research.

1- Research Instruments: In the current study, the following instruments were employed

1-1 The Style of Learning and Thinking scale (SOLAT) (Paul Torrance 1980) :an acronym for the instrument designed by Torrance and further developed by other researchers to be more suitable for educational and athletic environments.

The Protocol:

1. **Objective:** To identify the individual's preferred cognitive style (Right, Left, or Integrated) based on hemispheric specialization.
2. **Administration:** The participant responds to a series of paired statements (usually 28 to 40 items). Each pair contains one activity related to the left hemisphere (logical, verbal) and one to the right (spatial, intuitive).
3. **Scoring:** Points are tallied for each side. A significant lead in one direction indicates dominance, while balanced scores indicate an **Integrated Style**.
4. **Application in Gymnastics:** It helps coaches understand if a gymnast learns better through verbal instructions (Left) or visual-spatial demonstrations (Right).

1-2 Observation Checklist: In the current study, an observation checklist was employed to evaluate the students performance levels in floor exercises, including: (tuck forward roll, straddle forward roll, tuck backward roll, straddle backward roll, handstand, headstand, and the cartwheel).

Observation Rubric Scoring Method:

We adopted this evaluation scale in accordance with the internationally recognized standards of the **International Gymnastics Federation (FIG)** Code of Points.

Performance Level	Unsatisfactory	Poor	Average	Good	Very Good	Excellent
Score	1	2	3	4	5	6

3-1. The Proposed Educational Program:

A structured instructional program was designed and developed based on the sequential stages of **Van Hiele's Theory** to facilitate the learning of specific floor exercises in gymnastics, including: (basic forward roll, straddle forward roll, basic backward roll, straddle backward roll, handstand, headstand, and the cartwheel).

-Program Objective: The program aims to teach and enhance the technical performance of selected gymnastic floor skills by following the cognitive progression of the Van Hiele levels. After reviewing literature on the Van Hiele model and its application within pedagogical units, the following stages were implemented:

-A. Information/Inquiry: The instructor explains and demonstrates the movements. Students are encouraged to engage in identifying the technical components of each skill, its execution phases, and potential common errors.

-B. Directed Orientation: A series of targeted questions regarding the floor exercises are posed to trigger cognitive stimulation. This encourages students to gather information and deduce correct solutions. The instructor facilitates student responses and provides positive reinforcement for accurate answers.

-C. Explication: During this stage, students actively practice the floor exercises. Through trial and error, questions naturally arise. Students are given the autonomy to interpret their mistakes as they see fit, while the instructor provides professional feedback on their technical interpretations.

-D. Free Orientation: Students perform the skills independently, engaging in self-correction by comparing their performance against the "ideal model." This self-evaluative process is supported by the instructor's specialized assessment.

-E. Integration: Students synthesize their learning by writing a comprehensive summary of each skill, covering technical performance, spotting/assistance techniques, and common errors. These summaries are submitted to the instructor, who provides feedback at the start of the next unit. This phase serves as a theoretical assessment of the students' conceptual grasp.

Skill demonstrations were enhanced using **Kinovea** motion analysis software during the sessions. Live video of each student's performance was captured and projected via **Data Show**, allowing students to observe, analyze, and refine their movements in real-time.

-Final Phase (The Closing): This consists of the cool-down section, taking various forms of movement aimed at psychological and physiological recovery, bringing the body's systems back to their resting state.

2. Statistical Analysis Methods:

A variety of statistical methods were employed using **Microsoft Excel 2010** and **SPSS** for data processing, including:

-Descriptive Statistics: Mean, Standard Deviation, and Graphical Representations.

-Mann-Whitney U Test: For two independent groups.

-Wilcoxon Signed-Rank Test: For two related samples.

-Effect Size (Eta Squared - η^2): For independent samples, using the criteria: ($\eta^2=0.01$ Small; $\eta^2=0.06$ Medium; $\eta^2=0.14$ Large).

-Effect Size (Cohen's d): For related samples, using the criteria: (0.2 Small; 0.5 Medium; 0.8 Large). > Note: Standard academic values for Cohen's d are typically 0.2, 0.5, and 0.8 for Small, Medium, and Large effects respectively.

III. Presentation and Analysis of Results:

1. Comparison of Pre-test and Post-test Results for the Two Experimental Groups (Right-Brain and Left-Brain Dominance) in Floor Exercise Performance Levels among Male Students.

Table No. (01): Comparison between Pre-test and Post-test results for the **Right-Brain dominance** experimental group in the performance levels of: basic forward roll, straddle forward roll, basic backward roll, straddle backward roll, handstand, headstand, and the cartwheel (Males).

Skills	Mean $\pm$ Standard Deviation	"Z" Value	Significance (P-value)	Sig. Level	Effect Size (Cohen's d)
	Pre-test	Post-test			
Basic Forward Roll	2.14 $\pm$ 0.69	5.00 $\pm$ 0.00	2.414	0.016(*)	0.05
Straddle Forward Roll	1.14 $\pm$ 0.38	3.86 $\pm$ 1.07	2.414	0.016(*)	0.05
Basic Backward Roll	1.57 $\pm$ 0.53	4.29 $\pm$ 0.76	2.401	0.016(*)	0.05
Straddle Backward Roll	1.14 $\pm$ 0.38	3.86 $\pm$ 0.90	2.379	0.017(*)	0.05
Handstand	1.29 $\pm$ 0.49	3.86 $\pm$ 0.90	2.414	0.016(*)	0.05
Headstand	1.71 $\pm$ 0.76	4.14 $\pm$ 0.90	2.456	0.014(*)	0.05
Cartwheel	1.57 $\pm$ 0.79	4.29 $\pm$ 0.49	2.401	0.016(*)	0.05

Analysis and Interpretation:

Based on the results presented in the table above, there are statistically significant differences between the pre-test and post-test scores for the experimental group of male students characterized by **Right-Brain dominance**.

Regarding the **Basic Forward Roll** and **Straddle Forward Roll**, the significance values were ($p = 0.016$) for both, at a significance level of $p \leq 0.05$, favoring the post-test. The effect size, measured by **Cohen's d**, was remarkably high, recorded at (4.141) for the basic forward roll and (2.854) for the straddle forward roll.

Statistically significant differences were also observed for the **Basic Backward Roll** and **Straddle Backward Roll**, with p-values of ($p = 0.016$) and ($p = 0.017$) respectively, at the $p \leq 0.05$ level. The effect size remains very high at (3.591) for the basic backward roll and (2.440) for the straddle backward roll, favoring the post-test results.

Furthermore, results indicated significant differences in the performance of the **Handstand**, **Headstand**, and **Cartwheel**, with p-values of ($p = 0.016$), ($p = 0.014$), and ($p = 0.016$) respectively, at the $p \leq 0.05$ level. The effect size values were very high: (3.269) for the handstand, (3.086) for the headstand, and (3.591) for the cartwheel.

These findings clearly demonstrate the **effectiveness of the proposed instructional program** based on the **Van Hiele theory** stages for the Right-Brain dominance experimental group among male students.

Table No. (02): Comparison between Pre-test and Post-test results for the **Left-Brain dominance** experimental group in the performance levels of: basic forward roll, straddle forward roll, basic backward roll, straddle backward roll, handstand, headstand, and the cartwheel (Males).

Skills	Mean $\pm$ Standard Deviation	"Z" Value	Significance (P-value)	Sig. Level	Effect Size (Cohen's d)
	Pre-test	Post-test			
Basic Forward Roll	2.14 $\pm$ 0.38	3.86 $\pm$ 0.38	2.460	0.014(*)	0.05
Straddle Forward Roll	1.57 $\pm$ 0.53	3.14 $\pm$ 0.38	2.428	0.015(*)	0.05
Basic Backward Roll	1.14 $\pm$ 0.38	3.57 $\pm$ 0.53	2.428	0.015(*)	0.05
Straddle Backward Roll	1.29 $\pm$ 0.49	3.29 $\pm$ 0.49	2.456	0.014(*)	0.05
Handstand	1.43 $\pm$ 0.79	3.29 $\pm$ 0.49	2.530	0.011(*)	0.05
Headstand	1.86 $\pm$ 0.38	3.86 $\pm$ 0.38	2.456	0.014(*)	0.05
Cartwheel	2.00 $\pm$ 0.82	3.71 $\pm$ 0.49	2.460	0.014(*)	0.05

Analysis and Interpretation:

The results in the table above indicate statistically significant differences between the pre-test and post-test measurements for the experimental group of male students with **Left-Brain dominance**.

For the **Basic Forward Roll** and **Straddle Forward Roll**, significance values were ($p=0.014$) and ($p=0.015$) respectively, at the $p\leq 0.05$ level. The effect size, measured by **Cohen's d**, was remarkably high, reaching (3.514) for the basic forward roll and (2.940) for the straddle forward roll.

Significant differences were also found for the **Basic Backward Roll** and **Straddle Backward Roll**, with p-values of ($p=0.015$) and ($p=0.014$) respectively ($p\leq 0.05$), favoring the post-test results. The effect size was very high at (4.544) for the basic backward roll and (3.466) for the straddle backward roll.

Furthermore, the data showed significant differences in the performance levels of the **Handstand**, **Headstand**, and **Cartwheel**, with p-values of ($p=0.011$), ($p=0.014$), and ($p=0.014$) respectively ($p\leq 0.05$). The effect size values were highly significant: (4.925) for the handstand, (3.466) for the headstand, and (3.512) for the cartwheel.

These results confirm the **effectiveness of the proposed instructional program** based on **Van Hiele's theory** stages in improving the gymnastic skills of male students with Left-Brain dominance within the experimental group.

:2. Comparison of Pre-test and Post-test Results for the Two Experimental Groups (Right-Brain and Left-Brain Dominance) in Floor Exercise Performance Levels among Female Students.

Table No. (03): Comparison between Pre-test and Post-test results for the **Right-Brain dominance** experimental group in the performance levels of: basic forward roll, straddle forward roll, basic backward roll, straddle backward roll, handstand, headstand, and the cartwheel (Females).

Skills	Mean $\pm$ Standard Deviation	"Z" Value	Significance (P-value)	Sig. Level	Effect Size (Cohen's d)
	Pre-test	Post-test			
Basic Forward Roll	1.67 $\pm$ 0.82	3.67 $\pm$ 1.03	2.220	0.026(*)	0.05
Straddle Forward Roll	1.17 $\pm$ 0.41	3.00 $\pm$ 0.89	2.232	0.026(*)	0.05
Basic Backward Roll	1.17 $\pm$ 0.41	3.50 $\pm$ 0.84	2.232	0.026(*)	0.05
Straddle Backward Roll	1.17 $\pm$ 0.41	3.67 $\pm$ 1.03	2.214	0.027(*)	0.05
Handstand	1.17 $\pm$ 0.41	2.83 $\pm$ 1.17	2.060	0.039(*)	0.05
Headstand	1.17 $\pm$ 0.41	3.17 $\pm$ 1.47	2.060	0.039(*)	0.05
Cartwheel	1.17 $\pm$ 0.41	2.83 $\pm$ 1.17	2.060	0.039(*)	0.05

Analysis and Interpretation:

The results presented in the table above reveal statistically significant differences between the pre-test and post-test scores for the experimental group of female students with **Right-Brain dominance**.

For the **Basic Forward Roll** and **Straddle Forward Roll**, p-values were ($p = 0.026$) for both at a significance level of $p \leq 0.05$, favoring the post-test. The effect size, measured by **Cohen's d**, was very large, recorded at (2.237) for the basic forward roll and (2.438) for the straddle forward roll.

Statistically significant differences were also observed in the **Basic Backward Roll** and **Straddle Backward Roll**, with p-values of ($p = 0.026$) and ($p = 0.027$) respectively ($p \leq 0.05$), also in favor of the post-test. The effect size values were remarkably high, reaching (2.860) for the basic backward roll and (2.385) for the straddle backward roll.

Additionally, the results indicated significant differences in the performance levels of the **Handstand**, **Headstand**, and **Cartwheel**, with all p-values recorded at ($p = 0.039$) at the ($p \leq 0.05$)

level. The effect size values were very large: (1.615) for the handstand, (1.621) for the headstand, and (1.130) for the cartwheel.

These findings demonstrate the **effectiveness of the proposed instructional program** based on the **Van Hiele theory** stages, which had a positive and significant impact on the performance levels of these gymnastics floor skills among female students with Right-Brain dominance.

Table No. (04): Comparison between Pre-test and Post-test results for the **Left-Brain dominance** experimental group in the performance levels of: basic forward roll, straddle forward roll, basic backward roll, straddle backward roll, handstand, headstand, and the cartwheel (Females).

Skills	Mean $\pm$ Standard Deviation	"Z" Value	Significance (P-value)	Sig. Level	Effect Size (Cohen's d)
	Pre-test	Post-test			
Basic Forward Roll	1.60 $\pm$ 0.55	4.80 $\pm$ 0.45	2.041	0.041(*)	0.05
Straddle Forward Roll	1.40 $\pm$ 0.55	4.20 $\pm$ 0.84	2.060	0.039(*)	0.05
Basic Backward Roll	1.00 $\pm$ 0.00	4.00 $\pm$ 0.00	2.236	0.025(*)	0.05
Straddle Backward Roll	1.00 $\pm$ 0.00	3.80 $\pm$ 0.45	2.121	0.034(*)	0.05
Handstand	1.40 $\pm$ 0.44	3.40 $\pm$ 1.34	1.857	0.063	0.05
Headstand	1.00 $\pm$ 0.00	3.80 $\pm$ 0.84	2.041	0.041(*)	0.05
Cartwheel	1.80 $\pm$ 0.84	4.00 $\pm$ 0.71	2.070	0.038(*)	0.05

Analysis and Interpretation:

The results in the table above indicate statistically significant differences between the pre-test and post-test measurements for the experimental group of female students with **Left-Brain dominance**.

For the **Basic Forward Roll** and **Straddle Forward Roll**, the significance values were ($p = 0.041$) and ($p = 0.039$) respectively, at the $p \leq 0.05$ level, favoring the post-test. The effect size, measured by **Cohen's d**, was remarkably high, recorded at (3.827) for the basic forward roll and (2.557) for the straddle forward roll.

Statistically significant differences were also observed for the **Basic Backward Roll** and **Straddle Backward Roll**, with p-values of ($p = 0.025$) and ($p = 0.034$) respectively ($p \leq 0.05$), in favor of the post-test results. The effect size was very high, at (3.827) for the basic backward roll and (2.557) for the straddle backward roll.

Furthermore, significant differences were found in the performance of the **Headstand** and **Cartwheel**, with p-values of ($p = 0.041$) and ($p = 0.038$) respectively ($p \leq 0.05$), favoring the post-test. The effect size values were (3.349) for the headstand and (2.009) for the cartwheel.

These findings demonstrate the **effectiveness of the proposed instructional program** based on the **Van Hiele theory** stages, which positively influenced the performance of most floor exercises for the Left-Brain dominance female group. However, **no statistically significant differences** were observed in the performance level of the **Handstand** at the ($p \leq 0.05$) level. This indicates that the proposed program did not effectively impact the performance of the handstand

IV. Discussion

The statistical analysis reveals a significant improvement in the technical performance of gymnastic floor skills across both experimental groups (Right and Left-Brain dominance) for both genders. These findings primarily underscore the **efficacy of the instructional program structured according to the Van Hiele levels**, which appears to have successfully bridged the gap between cognitive conceptualization and motor execution.

1. The Cognitive-Motor Link: Van Hiele's Theory and Gymnastics

The marked improvement in complex skills—such as the **Straddle Rolls** and **Cartwheel**—can be attributed to the hierarchical nature of the Van Hiele model. By progressing from **Information/Inquiry** to **Integration**, students were not merely imitating movements but were building a "mental map" of the skill.

-In the **Explication** and **Free Orientation** stages, students transitioned from visual perception to technical understanding.

-This cognitive scaffolding allowed for a more refined **motor schema**, leading to the high effect sizes recorded (Cohen's d values exceeding 2.0 in most cases), which signifies a "transformative" rather than just a "significant" impact of the program.

2. Hemispheric Dominance and Differentiated Learning

The results demonstrate that the program was equally effective for both **Right-Brain** (holistic/spatial) and **Left-Brain** (analytic/sequential) learners.

-For **Right-Brain dominance** individuals, the use of **Kinovea video analysis** and **Data Show** projections provided the vital visual-spatial feedback necessary for their learning style.

-For **Left-Brain dominance** individuals, the structured stages of the program and the **Integration** phase (writing technical summaries) satisfied their need for logical sequencing and verbal-analytical processing.

3. The Anomaly of the Handstand (Female Left-Brain Group)

A notable finding in this study was the lack of statistically significant improvement in the **Handstand** among females with Left-Brain dominance. From a sports science perspective, this may be explained by the **high postural complexity** and **kinesthetic fear** associated with inverted verticality.

-Left-brain learners often require more prolonged "analytical security" and technical breakdown.

-The findings suggest that for this specific demographic and skill, the instructional duration or the specific feedback mechanisms within the Van Hiele stages may need further calibration to overcome the sensory-motor challenges of the handstand.

4. Technological Integration and Self-Correction

The integration of **Kinovea** served as a "cognitive mirror." By allowing students to observe their own performance and compare it with the ideal model during the **Free Orientation** stage, the program fostered **Metacognitive Awareness**. This immediate feedback loop is essential in gymnastics, where the athlete cannot see themselves during execution.

Conclusion of the Discussion

In summary, the current study provides empirical evidence that aligning gymnastics instruction with **hemispheric dominance** through the **Van Hiele theoretical framework** significantly optimizes the learning curve. Except for the handstand in one specific subgroup, the program proved to be a robust pedagogical tool, enhancing both the cognitive understanding and the physical mastery of fundamental gymnastics skills.

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