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Development of an instrument for detecting brain hemisphere dominance in elementary school students

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ABSTRACT

Background. Understanding students' cognitive characteristics is essential for designing differentiated learning strategies in physical education. **Objectives.** This study aimed to develop a valid, reliable, and practical instrument for detecting brain hemisphere dominance among elementary school students. **Method.** A Research and Development (R&D) approach based on the Borg and Gall model was employed, including needs analysis, instrument development, expert validation, small- and large-scale field testing, and product refinement. The large-scale trial involved 106 fifth- and sixth-grade students, while the small-scale trial included 57 fourth-grade students from Tamansari 1 Public Elementary School, Yogyakarta. Data were collected through questionnaires, expert validation sheets, and documentation. **Results.** Content validity assessed using Aiken's V indicated that most items were valid to highly valid, while four items were revised based on expert feedback. Pearson's product-moment analysis confirmed the validity of all revised items ($p < 0.05$). The instrument demonstrated high internal consistency with a Cronbach's Alpha coefficient of 0.932. **Conclusion.** The developed instrument is valid, reliable, and practical for identifying students' brain hemisphere dominance, providing teachers with useful information to support differentiated physical education instruction at the elementary school level.

Key words: Hemispheric asymmetry; brain dominance; detection instruments; differentiated instruction; physical education.

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INTRODUCTION

Elementary education plays a strategic role in shaping students' holistic development, encompassing cognitive, affective, and psychomotor aspects. At the elementary school level, students are in the concrete operational stage of cognitive development, characterized by increasing abilities in logical thinking, problem-solving, and the mastery of motor skills (Piaget, 1970; Santrock, 2011). Cognitive development at this stage is heavily influenced by learning experiences and interactions with the environment; therefore, the learning process must be designed with consideration for students' diverse characteristics and learning needs (Vygotsky, 1978). However, teachers often face difficulties in objectively identifying students' learning characteristics, which results in the inappropriateness of the implemented learning strategies (Tomlinson, 2017; Goyibova et al., 2025). A fundamental problem that arises is the lack of practical

instruments suitable for the developmental level of elementary school students to detect the dominance of their brain hemispheres, making it difficult for teachers to design learning that is adaptive to individual differences (Daugirdiene et al., 2024; Procopio et al., 2024; Walsh et al., 2024).

Various studies indicate that students exhibit different tendencies in receiving, processing, and responding to information during the learning process (Kolb, 1984; Fleming & Mills, 1992; Riding & Cheema, 1991; Dunn & Dunn, 1993). These differences are reflected in how students understand instructions, complete tasks, solve problems, and participate in learning activities (Cassidy, 2004; Coffield et al., 2004). Research on learning styles and information processing preferences has been extensive, but most studies have focused on adolescents and adults, while research on elementary school-aged children remains limited (Sharp et al., 2008). Therefore, identifying brain hemisphere dominance is crucial for supporting the implementation of differentiated instruction that addresses the needs and potential of each student (Cui & Zhang, 2021; Tomlinson, 2017; Hall et al., 2012).

In neuroscience research, the concept of hemispheric asymmetry was developed by researchers such as Roger Sperry (1968) through split-brain studies demonstrating functional specialization between the left and right hemispheres and was further elaborated upon by Gazzaniga et al. (2014) and Corballis (2014). This theory explains that certain cognitive functions tend to be specialized in different brain hemispheres. Language functions, symbolic analysis, and sequential processing generally involve specific areas in the left hemisphere to a greater extent, whereas visuospatial processing, pattern recognition, and global information integration are more strongly associated with the right hemisphere (Gazzaniga et al., 2014; Hartwigsen et al., 2021; Hellige, 1993; Wang et al., 2014). However, modern neuroscience research using functional magnetic resonance imaging (fMRI) shows that nearly all human learning and behavioral activities involve complex interactions between both brain hemispheres; thus, there is no evidence supporting the notion that an individual is predominantly dominated by a single hemisphere (Nielsen et al., 2020; Corballis, 2014; Toga & Thompson, 2003). These findings are significant because they refute the popular view that individuals are permanently classified as "left-brained" or "right-brained"—a notion that has taken root in popular literature and educational practice without a strong scientific basis (Tokuhama-Espinosa, 2018; Howard-Jones, 2014).

Therefore, the use of hemispheric asymmetry theory in educational research must be approached with caution and avoid reductionism. Howard-Jones (2014) and Tokuhama-Espinosa (2018) point out that the application of neuroscience in education often falls prey to neuromyths—including the myth of left- or right-hemisphere dominance, which has been refuted by empirical

research. Goswami (2006) and Ansari et al. (2012) also emphasize that a responsible neuroscience-based approach to education must critically evaluate scientific evidence and avoid excessive generalizations. In this study, hemispheric asymmetry is not interpreted as individual neurological dominance but rather as a conceptual framework for understanding variations in information-processing tendencies that may emerge during learning activities (Pinto et al., 2023; Sousa, 2017; Zhu et al., 2021). Thus, the theory of hemispheric asymmetry is used as a foundation for developing instruments that help teachers detect students' tendencies toward hemispheric dominance without claiming the existence of biological hemispheric dominance.

Understanding the characteristics of students' information processing plays a crucial role in physical education and sports, as the learning process involves the integration of cognitive, affective, and motor aspects. Students vary in how they understand movement instructions, coordinate motor activities, respond to visual demonstrations, and solve problems during learning activities. Several studies indicate that information processing characteristics are related to differences in students' learning strategies and motor performance (Asonitou et al., 2012; Baduni et al., 2024; Galamandjuk et al., 2015; Kucian et al., 2022). Therefore, Physical Education, Sports, and Health (PJOK) teachers require adequate information regarding students' learning characteristics as a foundation for designing more effective and adaptive learning experiences.

Although the concepts of information processing characteristics and hemispheric asymmetry have been extensively discussed in the educational neuroscience literature (Gazzaniga et al., 2014; Sousa, 2017; Howard-Jones, 2014), their implementation in elementary school teaching practices remains relatively limited. Based on the literature review conducted, there is some empirical evidence pointing to this limitation. First, studies on the application of neuroscience in elementary education are still dominated by research in developed countries, while in Indonesia such studies are still rarely conducted (Pinto et al., 2023; Leisman et al., 2022; Zhu et al., 2021). Second, most of the available instruments for detecting brain hemisphere dominance, such as the *Learning Style Inventory* (Kolb, 1984), VARK (Fleming & Mills, 1992), and the *Hemispheric Preference Inventory* (McCarthy, 1990), were developed for adolescents or adults, and thus use abstract and complex language that is difficult for elementary school students to understand (Daugirdiene et al., 2024; Procopio et al., 2024; Walsh et al., 2024). Third, research on differentiated instruction in elementary schools based on students' information-processing characteristics remains limited (Sharp et al., 2008; Anwar etal., 2025). Fourth, there are no instruments specifically designed to detect brain hemisphere dominance in elementary school students in the context of physical education and sports (Asonitou et al., 2012; Baduni et al., 2024; Galamandjuk et al., 2015;

Kucian et al., 2022). This situation makes it difficult for teachers to obtain systematic information about students' learning characteristics as a basis for implementing differentiated instruction (Tomlinson, 2017; Goyibova et al., 2025).

Given these issues, there is a need to develop a valid, reliable, and practical instrument to help teachers detect brain hemisphere dominance in elementary school students. The novelty of this study lies in three aspects. First, the development of an instrument to detect brain hemisphere dominance in elementary school students that is specifically based on the theory of hemispheric asymmetry as a conceptual framework, without assuming the existence of neurological hemisphere dominance. Second, this instrument is designed with two main categories—the left hemisphere (analytical) and the right hemisphere (visual-spatial)—as well as a "balanced" (integrative) category that reflects dynamic and contextual cognitive tendencies rather than fixed, innate traits. Third, this instrument was specifically developed to support the implementation of differentiated instruction in the context of physical education in elementary schools—a resource that has been lacking until now.

The conceptual framework of this study is built upon the relationship between the theory of hemispheric asymmetry and the two main categories of hemispheric dominance being measured. The left-hemisphere (analytical) category refers to tendencies toward sequential, language-based, and logical thinking, which, in hemispheric asymmetry theory, are associated with the left hemisphere's specialization in language processing, symbolic analysis, and sequential processing (Gazzaniga et al., 2014). Indicators developed for this category include: (1) a preference for written instructions, (2) the ability to organize things sequentially, (3) a preference for mathematics and logic, (4) comfort with reading and writing activities, and (5) a tendency to plan and follow instructions carefully. The right-hemisphere (visual-spatial) category refers to a tendency toward thinking based on images, patterns, and spatial relationships, which, in the theory of hemispheric asymmetry, is associated with the right hemisphere's specialization in visual-spatial processing, pattern recognition, and global information integration (Hartwigsen et al., 2021; Wang et al., 2014). Indicators developed for this category include: (1) a preference for drawing and doodling, (2) the ability to visualize things, (3) a fondness for music and movement, (4) the ability to imitate movements, and (5) a tendency to learn through hands-on practice and visual demonstrations. The balance (integrative) category refers to the tendency to flexibly use a combination of cognitive strategies, reflecting the complex interaction between the two brain hemispheres in daily learning activities (Nielsen et al., 2020). This category is determined based on the difference in scores between the two hemispheres; if the score difference is ≤ 2 points, the student is categorized as having

hemispheric balance. The selection of this category is based on neuroscience evidence that, although functional specialization exists, nearly all cognitive activities involve interhemispheric cooperation, making a more flexible categorization approach more appropriate for educational contexts (Corballis, 2014; Sousa, 2017). The contributions of this study encompass both theoretical and practical aspects. Theoretically, this study contributes to the development of educational neuroscience research, particularly in applying the theory of hemispheric asymmetry more accurately and in a non-reductionist manner within the context of elementary education. Practically, this study provides a tool that teachers can use to identify students' brain hemisphere dominance tendencies, which can then serve as a basis for designing differentiated instruction that better aligns with students' needs and potential, particularly in physical education and sports in elementary school.

METHOD

Participant

The study was conducted at Tamansari 1 Public Elementary School in Yogyakarta. The research subjects consisted of two groups. The first group comprised participants in a small-scale pilot study involving 57 fourth-grade students and was used to test the readability, linguistic clarity, and practicality of the instrument. The second group consisted of participants in a large-scale pilot study involving 106 fifth- and sixth-grade students and was used to test the instrument's empirical validity, reliability, and feasibility. The two groups were separated to ensure that the instrument development process proceeded in stages in accordance with research and development procedures.

Research Design

This study employs the Research and Development (R&D) method, adapting the development model proposed by Borg and Gall (1983). In its original form, the Borg and Gall model consists of ten main stages, namely: (1) research and information collecting, (2) planning, (3) develop preliminary form of product, (4) preliminary field testing, (5) main product revision, (6) main field testing, (7) operational product revision, (8) operational field testing, (9) final product revision, and (10) dissemination and implementation. In this study, these ten stages were adapted into eight stages more suited to the context and limitations of the research, namely: (1) needs analysis, (2) drafting of the draft instrument, (3) expert validation, (4) instrument revision, (5) small-scale pilot testing, (6) instrument revision, (7) large-scale pilot testing, and (8) final product refinement. This adaptation was carried out by combining the research and initial information gathering stages with the needs analysis, as well as simplifying the pilot testing stage into two stages (small-scale and large-scale) due to time and

resource constraints. Additionally, the dissemination and implementation stages were not conducted in this study because the primary focus was on the development and feasibility testing of the initial product. The instrument development flowchart is presented in Figure 1.

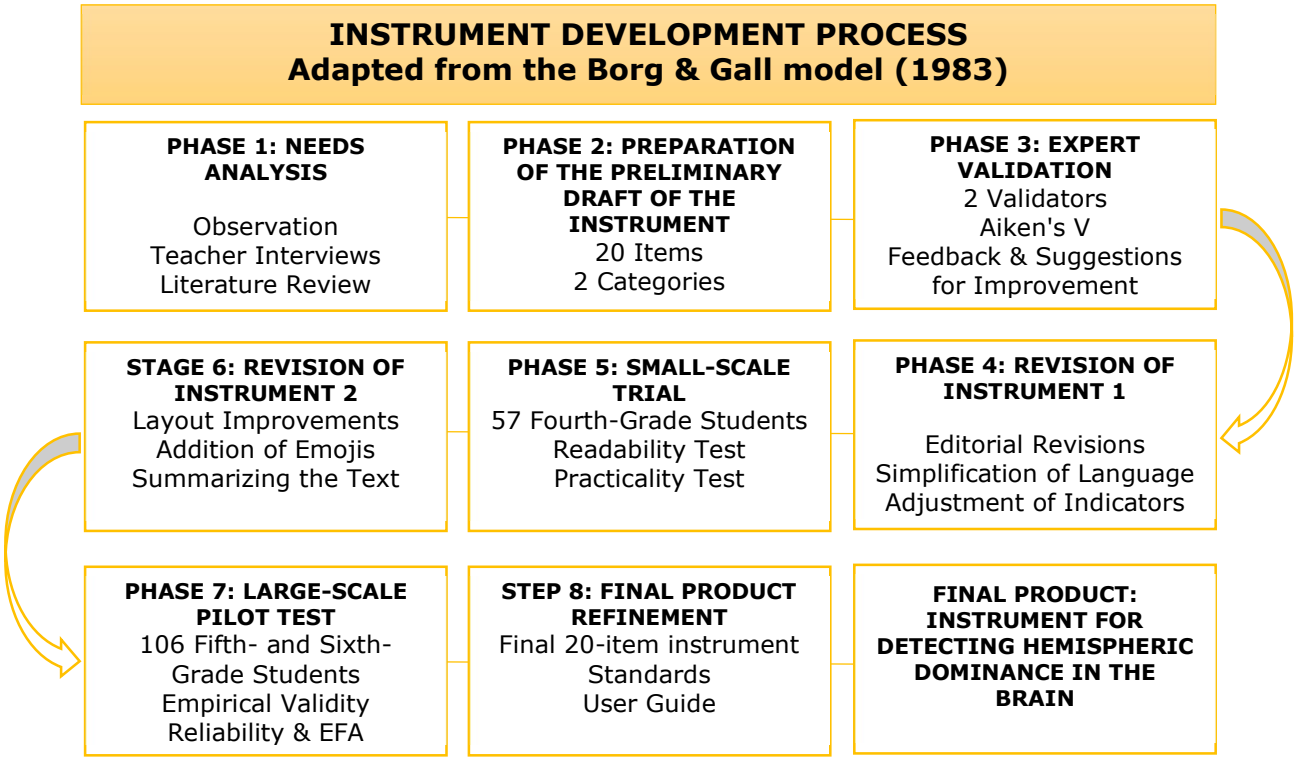

Figure 1. Development process for an instrument to detect brain hemisphere dominance

Instrument

The product developed is an instrument for detecting hemispheric dominance in elementary school students, based on the theory of hemispheric asymmetry. The instrument was designed to help teachers obtain information regarding students' learning tendencies related to how they receive, process, and respond to information during the learning process. The instrument is not intended to measure neurological dominance of the left or right hemisphere in individuals, but rather to detect hemispheric dominance tendencies associated with the concept of hemispheric functional specialization in neuroscience.

The development of the instrument is based on studies of hemispheric asymmetry theory (Gazzaniga et al., 2014; Sousa, 2017), characteristics of information processing, and differentiated instruction (Tomlinson, 2017; Hall et al., 2012). The instrument's indicators encompass two main categories: (1) the left hemisphere (analytical), which reflects a tendency toward sequential, language-based, and logical thinking, with indicators including: a preference for written instructions, the ability to organize things sequentially, a fondness for

mathematics and logic, comfort with reading and writing activities, and a tendency to plan and follow instructions meticulously; and (2) the right hemisphere (visual-spatial), which reflects a tendency toward image-based, pattern-based, and spatial-relationship thinking, with indicators including: a preference for drawing and doodling, the ability to visualize things, a fondness for music and movement, the ability to imitate movements, and a tendency to learn through hands-on practice and visual demonstrations. Each category was expanded into 10 items, resulting in a total of 20 items tailored to the language and cognitive developmental levels of elementary school students. The response format used a four-point Likert scale consisting of Strongly Agree (4), Agree (3), Disagree (2), and Strongly Disagree (1).

Expert validation in this study was conducted by two validators with expertise in educational neuroscience and elementary school physical education. The first validator was Prof. Dr. Erwin Setyo Kriswanto, M.Kes., aifo., a full professor and expert lecturer in health education with experience in developing instruments based on cognitive theory. The second validator was Dr. Pasca Tri Kaloka, S.Pd., M.Pd., an expert lecturer in the field of elementary school physical education with experience in validating educational instruments. Both validators have relevant academic track records in the field of educational instrument development and have been involved in various instrument development studies at the elementary school level. The validation process was conducted by providing the draft instrument to both validators to assess aspects of construct validity, indicator relevance, linguistic clarity, readability, and ease of use.

The instrument validation and revision process was based on feedback from both validators. The first validator suggested removing the conjunction “and” from several statements because it caused ambiguity and double meanings. The changes made included: (1) item number 8 from “I like listening to music and moving my body to the rhythm” to “I like listening to music”; (2) item number 16 from “I like making crafts and experimenting with shapes” to “I like making crafts”; and (3) item number 17 from “I feel comfortable when learning by reading and writing” to “I feel comfortable when learning by reading.” The rationale for these changes was to ensure that each statement measures a single specific construct and does not lead to differences in perception among students. The second validator suggested that item number 11, which originally read “I prefer working alone rather than in a group,” be changed to “I feel comfortable learning by writing.” This change was based on the reasoning that the previous statement did not describe a specific left-hemisphere activity, whereas writing is a concrete representation of language functions and logical analysis controlled by the left hemisphere. After the revisions were made, the experts assessed that the instrument was content-valid, conceptually consistent, and ready for field testing.

Data Analysis

Data collection was conducted using a questionnaire to detect brain hemisphere dominance, expert validation forms, and documentation. Content validity analysis was performed using Aiken's V coefficient to determine the degree of alignment between each item and the indicator being measured. Items that scored below the established criterion (V < 0.60) were revised based on the validators' recommendations before being used in the next pilot testing phase. Empirical validity was analyzed using Pearson's product-moment correlation to determine the relationship between each item's score and the total score. The instrument's reliability was analyzed using Cronbach's alpha to assess its internal consistency.

Additionally, construct validity was tested using Exploratory Factor Analysis (EFA) to identify the factor structure of the developed instrument. EFA was used to determine whether the instrument's items clustered according to the two theoretically defined categories: the left hemisphere (analytical) and the right hemisphere (visual-spatial). The EFA analysis was performed using the Principal Component Analysis (PCA) extraction method and Varimax rotation with the aid of statistical software. The criteria for factor selection were based on eigenvalues > 1.0 and factor loadings > 0.40 (Hair et al., 2019). Data suitability for EFA was assessed using the Kaiser-Meyer-Olkin (KMO) test and Bartlett's Test of Sphericity. A KMO value > 0.60 and a significance level for Bartlett's Test < 0.05 indicate that the data are suitable for factor analysis (DeVellis, 2017). Data analysis was performed using quantitative descriptive methods with the aid of statistical software to determine the validity, reliability, and suitability of the developed instrument.

FINDINGS AND DISCUSSIONS

Findings

Content validation by two experts showed that of the 20 items in the instrument, 16 items (80%) received an Aiken's V score in the valid to highly valid category (V ≥ 0.80), while 4 items (20%) received a score of 0.50, which falls into the less valid category and requires revision. The items that were revised were items 4, 10, 15, and 16. The revisions were made based on the validators' recommendations, particularly regarding simplifying the language, shortening sentences, and adjusting the context of the statements to align with the learning experiences of elementary school students. After revision, all items in the instrument were deemed suitable for use in the field trial phase. The results of the instrument's content validation are presented in Table 1.

Tabel 1. Hasil validasi ahli

No Item	Aiken' s V	Description
1	0.83	Valid
2	1.00	Very Valid
3	1.00	Very Valid
4	0.50	Less Valid (Revision)
5	1.00	Very Valid
6	1.00	Very Valid
7	0.83	Valid
8	1.00	Very Valid
9	1.00	Very Valid
10	0.50	Less Valid (Revision)
11	1.00	Very Valid
12	1.00	Very Valid
13	1.00	Very Valid
14	1.00	Very Valid
15	0.50	Less Valid (Revision)
16	0.50	Less Valid (Revision)
17	1.00	Very Valid
18	1.00	Very Valid
19	1.00	Very Valid
20	1.00	Very Valid

The revision process, based on feedback from the two validators, resulted in changes to several items in the instrument. Details of the revisions are presented in Table 2.

Table 2. Instrument revisions based on feedback from the first and second validators

No	Validator 1 Input	Validator 2 Input	Follow-up
1	-	Item 11: "I prefer to work alone rather than in a group" does not describe a specific left-hemisphere activity	Changed to: "I feel comfortable when I study by writing"
2	Item number 8 has two meanings (music and movement)	-	Changed from: "I like listening to music and moving my body to the beat" to: "I like listening to music"
3	Item number 16 has two meanings (crafts and experiments)	-	Changed from: "I like making crafts and experimenting with shapes" to: "I like making crafts"
4	Item number 17 has two meanings (reading and writing)	-	Changed from: "I feel comfortable studying by reading and writing" to: "I feel comfortable studying by reading"

5	There should be sample responses to help students understand the Likert scale	Some terms are still too abstract for elementary school students	Terminology was simplified and examples of how to fill out the instrument were added at the beginning
6	There should be clear and simple instructions for completing the questionnaire	The layout needs to be improved to make it more engaging	The layout was simplified with clear instructions

After revision, the final instrument consisted of 20 items, as detailed in Table 3.

Table 3. Final instrument for detecting brain hemisphere dominance

NO	Statements	Category
1	I prefer to read instructions before doing something.	Left Hemisphere (Analytical)
2	I often draw or doodle when I'm bored.	Right Hemisphere (Visual-Spatial)
3	I enjoy organizing things in order.	Left Hemisphere (Analytical)
4	I can easily visualize things in my mind.	Right Hemisphere (Visual-Spatial)
5	I like math class.	Left Hemisphere (Analytical)
6	I can easily mimic movements when dancing or playing sports.	Right Hemisphere (Visual-Spatial)
7	I like making lists of daily activities.	Left Hemisphere (Analytical)
8	I like listening to music.	Right Hemisphere (Visual-Spatial)
9	I enjoy playing with words, such as solving puzzles or writing stories.	Left Hemisphere (Analytical)
10	I can recognize shapes and colors quickly.	Right Hemisphere (Visual-Spatial)
11	I feel comfortable learning by writing.	Left Hemisphere (Analytical)
12	I like telling stories through pictures or movements.	Right Hemisphere (Visual-Spatial)
13	I follow the teacher's instructions in order and carefully.	Left Hemisphere (Analytical)
14	I understand things more easily when they're explained with pictures or movements.	Right Hemisphere (Visual-Spatial)
15	I enjoy solving logic or math problems.	Left Hemisphere (Analytical)
16	I like doing crafts.	Right Hemisphere (Visual-Spatial)
17	I feel comfortable learning by reading.	Left Hemisphere (Analytical)
18	I learn more easily through hands-on practice.	Right Hemisphere (Visual-Spatial)
19	I like making plans before starting something.	Left Hemisphere (Analytical)

A small-scale pilot study involved 57 fourth-grade students. The results of the observations showed that most students were able to understand the instructions for completing the instrument and the content of the statements well. However, several issues were identified that led to revisions, namely: (1) students had difficulty selecting answers on the Likert scale, so emoticon symbols were added as a guide; (2) some sentences were too long, so they were shortened; and (3) the appearance was not very appealing, so the layout was simplified. After the revisions, the instrument demonstrated good readability and practicality.

A large-scale pilot test involved 106 fifth- and sixth-grade students. The measurement results showed the following distribution of brain hemisphere dominance: 40 students (37.7%) in the right hemisphere (visual-spatial) category, 18 students (17.0%) in the left hemisphere (analytical) category, and 48 students (45.3%) in the balanced (integrative) category. The distribution of brain hemisphere dominance among the students is presented in Table 4.

Table 4. Distribution of brain hemisphere dominance among students

Hemisphere Dominance Categories	Number of Students	Percentage
Right Hemisphere (Visual-Spatial)	40	37.7%
Left Hemisphere (Analytical)	18	17.0%
Balanced (Integrative)	48	45.3%
Total	106	100%

By gender, male students (n=55) showed a right-hemisphere proportion of 49.1%, a left-hemisphere proportion of 12.7%, and a balanced proportion of 38.2%; whereas female students (n=51) showed a right-hemisphere proportion of 25.5%, a left-hemisphere proportion of 21.6%, and a balanced proportion of 52.9%. It should be noted that these findings are descriptive in nature and were not tested for statistical significance.

The determination of students' brain hemisphere dominance categories was based on scores obtained from two main categories: the left hemisphere (items 1, 3, 5, 7, 9, 11, 13, 15, 17, 19) and the right hemisphere (items 2, 4, 6, 8, 10, 12, 14, 16, 18, 20). The procedure for determining categories is as follows: (1) item scoring—each statement is scored based on the response options: Strongly Agree = 4, Agree = 3, Disagree = 2, Strongly Disagree = 1; (2) category score calculation—the total score for each category is calculated by summing the scores of the items in that category: Left Hemisphere Score = the sum of the scores for items 1, 3, 5, 7, 9, 11, 13, 15, 17, and 19, and Right Hemisphere Score = the sum of the scores for items 2, 4, 6, 8, 10, 12, 14, 16, 18, and 20; (3) Category determination: if the Left Hemisphere score > Right Hemisphere score → Left Hemisphere Category (Analytical); if the Right Hemisphere score > Left Hemisphere score → Right Hemisphere Category (Visual-Spatial); and if the

score difference is ≤ 2 points → Balance Category (Integrative). The instrument norms are presented in Table 5.

Table 5. Norms for the instrument to detect hemispheric dominance in students

Category	Number	Score Range	Mean	Standard Deviation	Interpretation
Left Hemisphere (Analytical)	10	10 - 40	28.5	5.2	Score > 33.7 = High tendency; Score 23.3–33.7 = Moderate tendency; Score < 23.3 = Low tendency
Right Hemisphere (Visual-Spatial)	10	10 - 40	29.2	5.5	Score > 34.7 = High tendency; Score 23.7–34.7 = Moderate tendency; Score < 23.7 = Low tendency

The empirical validity test using Pearson's product-moment correlation showed that all items in the revised instrument had a significance level of *p* < 0.05, thus confirming their validity. The item-total correlation coefficients ranged from 0.412 to 0.678, indicating a significant relationship between each item and the total score of the instrument. The reliability test using Cronbach's Alpha yielded a value of 0.932 for the entire instrument, which falls into the very high category. This value indicates that the instrument has excellent internal consistency and is capable of providing stable and consistent measurement results.

The results of the construct validity test using EFA showed a Kaiser-Meyer-Olkin (KMO) value of 0.871 and a Bartlett's Test of Sphericity with a χ^2 value of 1245.67 and a significance level of $p < 0.001$, indicating that the data are suitable for factor analysis. The results of EFA using the Principal Component Analysis (PCA) extraction method and Varimax rotation revealed the formation of two main factors with eigenvalues > 1.0, explaining 58.3% of the total variance. The first factor (eigenvalue = 6.82) consists of right-hemisphere (visual-spatial) items with factor loadings ranging from 0.451 to 0.712. The second factor (eigenvalue = 4.91) consists of left-hemisphere (analytical) items with factor loadings ranging from 0.438 to 0.698. These results confirm that the instrument's factor structure aligns with the formulated theoretical construct.

Discussion

The results of the study indicate that the instrument for detecting cerebral hemisphere dominance in elementary school students—based on the theory of hemispheric asymmetry—meets the criteria for validity, reliability, and

practicality. These findings should be interpreted within a theoretical framework and compared with previous research to strengthen their validity.

Content validation results indicate that the majority of the instrument's items fall into the "valid" to "highly valid" categories, suggesting that the instrument demonstrates good alignment between the statement items and the indicators being measured. These findings align with the research by Putri Hadji Djafar (2026), which states that neuroscience-based educational instruments require a comprehensive validation process to produce objective measurements. The use of Aiken's V in content validation in this study reinforces Azwar's (2019) finding that expert validation is a crucial stage in the development of psychological and educational instruments. However, this finding differs from the research by Procopio et al., (2024) and Walsh et al., (2024), which found that many neuroscience-based instruments fail content validation tests due to a lack of involvement from experts with dual expertise in neuroscience and education. This difference can be explained by the involvement of validators with interdisciplinary backgrounds in this study.

The revision process based on feedback from the first and second validators highlights the importance of editorial refinement to ensure the instrument better aligns with the learning context of elementary school children and the theory of brain dominance. The first validator revised item number 11 from "I prefer to work alone rather than in a group" to "I feel comfortable when learning by writing" because the previous statement did not describe a specific left-hemisphere activity, whereas writing is a concrete representation of language functions and logical analysis controlled by the left hemisphere. This aligns with the research by Gazzaniga et al. (2014), which emphasizes that the left hemisphere specializes in language processing and text-based activities. The second validator suggested removing the conjunction "and" from several statements because it created ambiguity and multiple meanings, in accordance with the principle of instrument development that each statement must measure a single specific construct (DeVellis, 2017; Azwar, 2019).

The reliability test results, with Cronbach's Alpha value of 0.932, indicate that the instrument exhibits very high internal consistency. This value is significantly higher than the reliability of similar instruments reported by Daugirdiene et al., (2024) and Procopio et al., (2024), who obtained a value of 0.78 for an elementary school student learning style instrument, and is also higher than that of the Hemispheric Preference Inventory reported by McCarthy (1990), which had reliability ranging from 0.70 to 0.80. The high reliability of this instrument can be explained by several factors: (1) the instrument items were formulated based on clear and well-defined indicators; (2) the language used was simple and concrete, thereby reducing variations in interpretation among respondents; and (3) the number of items (20) was sufficient to measure

each category consistently. These findings support DeVellis's (2017) view that instruments with an adequate number of items and well-defined indicators tend to have high reliability.

The results of the construct validity test using EFA indicate that the instrument measures two main factors consistent with the theoretical construct: the left hemisphere (analytical) and the right hemisphere (visual-spatial). A KMO value of 0.871 and a significant Bartlett's Test ($p < 0.001$) indicate that the data are suitable for factor analysis (Hair et al., 2019). The emergence of two factors with eigenvalues > 1.0, explaining 58.3% of the total variance, confirms that the instrument's factor structure aligns with the theory of hemispheric asymmetry. These findings are consistent with the research by Toga and Thompson (2003), which showed that hemispheric functional specialization can be identified through response patterns to various cognitive tasks.

The finding that the majority of students—45.3%—fell into the balanced (integrative) category indicates that elementary school students tend to use various cognitive strategies flexibly. This finding aligns with the research by Nielsen et al. (2020), which showed that cognitive activity involves complex interactions between both brain hemispheres; therefore, it is inaccurate to categorize an individual exclusively as left-brained or right-brained. This is also consistent with research by Leisman et al. (2022), which found that elementary school students demonstrate adaptive abilities in using different learning strategies for different tasks. This contrasts with the study by Pinto et al. (2023), which still employed a dichotomous approach and found dominance of one hemisphere in the majority of students. This discrepancy can be explained by differences in the theoretical frameworks used; this study adopted a more nuanced approach by including a "balanced" category, whereas the study by Zhu et al., (2021) continued to use a traditional dichotomous approach.

The distribution by gender revealed interesting variations in proportions, although their significance was not tested. Male students showed a higher proportion in the right-hemisphere category (49.1%) compared to females (25.5%), while female students were more numerous in the balance category (52.9%) compared to males (38.2%). These findings are consistent with a meta-analysis conducted by Kucian et al. (2022), which found small but consistent differences in visual-spatial processing between males and females, although these differences are strongly influenced by social and cultural factors. However, these findings should be interpreted with caution as they are purely descriptive and have not yet been statistically tested. Further research involving inferential analysis is needed to confirm these findings.

This instrument is designed for use by elementary school teachers, particularly those teaching Physical Education, Sports, and Health (PJOK), to identify students' brain hemisphere dominance tendencies. The procedure for

using the instrument includes: (1) the teacher prepares the printed instrument and explains the purpose of completing it to students in simple language; (2) students complete the instrument independently for approximately 20 minutes with teacher assistance if needed; and (3) the teacher checks the completeness of the responses and ensures no items were missed. This instrument can be used at the beginning of the semester or the start of the school year to map students' brain hemisphere dominance as a basis for planning differentiated instruction. Scoring is done by summing the scores in each category.

The instrument's norms, developed based on data from 106 students, indicate that the average score for the left hemisphere is 28.5 (SD = 5.2) and for the right hemisphere is 29.2 (SD = 5.5). Results can be interpreted by comparing students' scores with the available norms: scores > mean + 1 SD indicate a high tendency, scores between mean - 1 SD and mean + 1 SD indicate a moderate tendency, and scores < mean - 1 SD indicate a low tendency. These findings align with Azwar's (2019) view that instrument norms are essential for interpreting measurement results meaningfully.

Limitations

The finding that students exhibit variations in brain hemisphere dominance suggests that a one-size-fits-all teaching approach will not be effective for all students. In the context of physical education, understanding students' brain hemisphere dominance tendencies can help teachers design more adaptive lessons. For example, for students with a right-hemisphere (visual-spatial) tendency, teachers can provide more movement demonstrations and use visual aids. For students with a left-hemisphere tendency (analytical), teachers can provide structured verbal instructions and logical explanations of movement techniques. For students with a balanced (integrative) profile, teachers can combine both approaches. These findings align with the principles of differentiated instruction proposed by Tomlinson (2017) and supported by Hall et al. (2012), which emphasize the importance of tailoring instructional strategies to students' learning profiles. Furthermore, these findings expand the body of research on differentiated instruction in physical education, a field that has so far been rarely studied empirically (Anwar et al., 2025). The instrument developed in this study provides a practical tool for physical education teachers to identify students' brain hemisphere dominance profiles, thereby enabling them to design more personalized and effective learning experiences.

CONCLUSION

This study successfully developed an instrument for detecting brain hemisphere dominance in elementary school students based on the theory of hemispheric asymmetry. The instrument developed meets the criteria of validity,

reliability, and practicality for use in elementary school education. The results of the content validity analysis show that most of the instrument's items fall into the valid to highly valid categories, while several items that received low validity scores have been revised according to the validators' recommendations. The results of the empirical validity test show that all revised items meet the validity criteria, while the reliability test using Cronbach's Alpha yielded a value of 0.932, which falls into the very high category. The results of the construct validity test using EFA confirm that the instrument measures two main factors consistent with the theoretical construct. The developed instrument is capable of detecting students' brain hemisphere dominance in the categories of left hemisphere (analytical), right hemisphere (visual-spatial), and balanced (integrative).

The measurement results can serve as a source of information to help teachers understand students' learning characteristics and support the implementation of differentiated instruction in physical education and sports in elementary schools. This study contributes to the development of an educational instrument based on the theory of hemispheric asymmetry that can be practically applied by teachers. Further research with a broader sample size, as well as the development of a digital technology-based instrument, is needed to enhance its effectiveness and ease of use in various learning contexts. Future research is also recommended to conduct construct validity testing using Confirmatory Factor Analysis (CFA) on a larger sample, as well as to examine the correlation between the instrument's results and students' academic and motor performance to strengthen criterion validity.

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AUTHOR CONTRIBUTION STATEMENT

FRIF is the corresponding author and is responsible for the conduct of this study, from its implementation through the data analysis stage. RGW assisted in developing the research concept and conducting data analysis. SIM & ADH assisted with the literature search and with revising the final manuscript and preparing it for publication.

AI DISCLOSURE STATEMENT

The authors declare that this research was prepared, researched, written, and edited without the aid of artificial intelligence (AI) techniques.

CONFLICT OF INTEREST

The authors declare that there are no conflicts of interest regarding the publication of this article.

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