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A study of nonlinear pedagogical teaching models for cognitive and affective development of elementary school students

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ABSTRACT

This research aims to advance the psychomotor, cognitive, and affective abilities of elementary school students through a nonlinear pedagogical approach. The method adopted is research and development which combines quantitative and qualitative analysis. From a total of 2,411 elementary school teachers in 150 elementary schools spread across the Kota District area, 52 teachers were selected as the sample in this study. Data analysis uses a quantitative descriptive approach, with a focus on the use of percentages. The results show teachers' understanding of nonlinear pedagogy with a general average score of 2.705, indicating relatively good performance. However, the lowest rating was found in the item "Teachers' Understanding of the LED Approach", with an average score of 3.247, while understanding of "Cooperative Learning" achieved the highest score, namely 4.325, indicating very good understanding. These findings reveal that overall, teachers' understanding of nonlinear pedagogy is still not optimal, underscoring the need for more in-depth training for physical education teachers, as well as strategies for effective implementation of nonlinear pedagogy in elementary schools. This research invites new initiatives for teachers to embrace and implement innovative learning strategies that suit the demands of 21st-century education while exploring the impact of nonlinear pedagogy on the learning process.

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INTRODUCTION

Physical education plays a very important role in the physical, cognitive, and affective development of elementary school students (Ha et al., 2024; Mealings & Buchholz, 2024; H. Sun et al., 2017; X. Sun et al., 2024). Physical education aims not only to develop gross and fine motor skills, but also to introduce important concepts such as teamwork, leadership, and communication skills (Carballo-Fazanes et al., 2023; Iserte et al., 2023; Warbington et al., 2024). However, the learning methods used in physical education are often limited to a linear approach that is less responsive to the needs and uniqueness of each student (DeMatthews et al., 2021; Eberle & Hobrecht, 2021; Pan et al., 2013). In facing the demands of global development and the need for 21st-century skills (Chow et al., 2021; Hidayatullah et al., 2021), physical education can no longer be tied to traditional teaching models. Therefore, the emergence of interest in nonlinear pedagogical teaching models is becoming increasingly relevant, especially in the context of basic education (Chow et al., 2021; Hou et al., 2023; Lee et al., 2014).

Nonlinear teaching offers a more dynamic, flexible, and adaptive approach to teaching (Erarslan, 2023; Galatti et al., 2019). In the context of physical education, this teaching model enables teachers to better consider students' individual needs and provide greater space for exploration, collaboration, and reflection (Lee et al., 2017). With a focus on 21st-century skills,

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such as critical thinking skills, creativity, communication, and collaboration, a nonlinear approach in physical education can open up opportunities to integrate these important aspects into students' physical learning experiences (Chow, 2013; Cote-Laurence et al., 2008). For example, in a group game activity, teachers can adopt a nonlinear approach by providing students with space to solve problems independently, collaborate with their friends, and formulate innovative strategies (Franco & DeLuca, 2019; Hummel et al., 2015; Magen-Nagar et al., 2019).

However, the successful implementation of nonlinear pedagogical teaching models in physical education is very dependent on the teacher's understanding and skills (Chow et al., 2021; Tri Kaloka et al., 2023). Teachers need to be able to understand the basic principles of nonlinear teaching and have skills in designing, managing, and evaluating learning experiences that are relevant to student needs (Atencio et al., 2014). The main aim of this research is to explore teachers' understanding of nonlinear teaching in the context of physical education for elementary school students. By understanding teachers' perspectives, this research aims to identify the challenges, opportunities, and strategies involved in adopting nonlinear teaching models in physical education.

Through a deeper understanding of teachers' perspectives, this research also aims to identify the 21st-century skills required by teachers to successfully implement nonlinear teaching. This may include the ability to organize an active class, plan stimulative activities, direct group discussions, and provide constructive responses. Thus, this research aims to determine teachers' understanding of nonlinear teaching and identify 21st-century skills from the teacher's perspective.

RESEARCH METHOD

The participants in this research are 52 physical education and sports (Penjas) teachers from a population of 2,411 teachers of 150 elementary schools (SD) in Yogyakarta City. This research uses the R&D method, which according to Kristiyanto, involves 10 different processes described in Figure 1. The research data were collected using a questionnaire and through interviews and document analysis. The questionnaire was used to explore elementary school teachers' needs and understanding of physical education teaching, especially in the context of nonlinear teaching pedagogy. Interviews were conducted to obtain information about the implementation of teaching in elementary schools. Meanwhile, document studies are used to evaluate documents related to elementary school teaching, such as curriculum, time allocation, and learning facilities.

Data analysis was carried out using a quantitative descriptive approach, where percentages were used as a method for analyzing data. Determining the quality of the instrument used is done by proving content validity and reliability estimates. Proving content validity uses the Aiken content validity method (Retnawati, 2016). The aim is to evaluate the level of agreement between raters on each item in the research instrument (Newman et al., 2013; Retnawati, 2016). Reliability estimation uses Cronbach Alpha (α) which aims to evaluate the reliability of an instrument (McNeish, 2018; Tavakol & Dennick, 2011). The Cronbach Alpha value ranges between 0 and 1, where a higher value indicates a better level of reliability (Heo et al., 2022).

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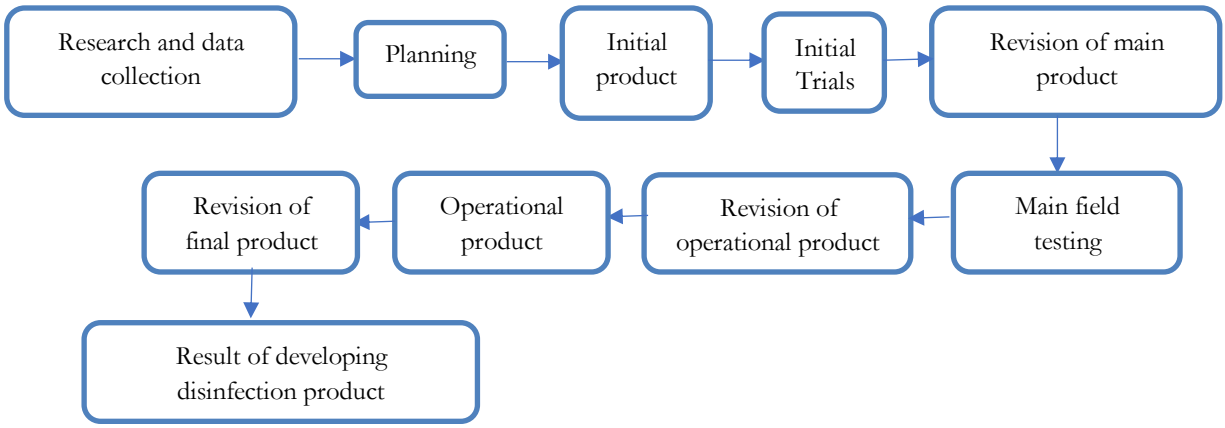

Figure 1. Research and development steps

FINDINGS AND DISCUSSION

Findings

In this research, questionnaires were distributed to a sample consisting of 52 physical education (PE) teachers of elementary schools. The distributed questionnaire produces relevant data for each question asked. This research uses a Likert scale as the measurement method. The selection of the Likert scale was based on the clarity of the interval between response levels and the categorization of data that follows logical standards, making it suitable for the analysis carried out (Stratton, 2018). The Likert scale used has a value ranging from 1 to 5, allowing this research to measure respondents' attitudes or perceptions quantitatively (Norman, 2010).

Furthermore, this study categorized the average of each question to gain deeper insight into the distribution and central tendency of the responses received. The results of the analysis show that the sample of primary school physical education teachers had a minimum score of 2.78 and a maximum of 5.00, as can be seen in Table 1. These results provide an overview of the variations in respondents' perceptions and attitudes towards the topics studied.

Table 1 shows data regarding teachers' understanding of nonlinear pedagogy. It shows 52 respondents rated their understanding using a scale of 1 to 5. The minimum score reported was 2.78, indicating that there were no teachers who gave a low assessment of their understanding of nonlinear pedagogy. Meanwhile, the maximum score is 5.00, which shows that some teachers feel they understand nonlinear pedagogy.

Table 1. Teachers' understanding of nonlinear pedagogy

	N	Min	Max	Mean	SD	Description
Teacher's understanding of nonlinear pedagogy	52	2.78	5.00	2.75	.290	very good
Valid N (Listwise)	52					

The average value is 2.75 with a standard deviation (SD) of 0.290. An average value that is almost the same as the minimum value can indicate that the majority of respondents gave an assessment that was biased toward the minimum value. This may indicate that, overall, these teachers felt they had only a "pretty good" understanding of nonlinear pedagogy. However, it

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should be noted that a lower mean score on the middle scale may indicate that these teachers' understanding is generally at a moderate level, not high (Chyung et al., 2017). The relatively small standard deviation indicates that respondents' responses do not vary significantly, meaning their perceptions of their understanding tend to be uniform (Lipovetsky & Conklin, 2018).

Table 2. Teachers' Understanding of Teaching Games for Understanding (TGfU)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	SD	2	3.8	3.8	3.8
	D	5	9.4	9.4	13.2
	NT	10	18.9	18.9	32.1
	A	18	34.0	34.0	66.0
	SA	18	34.0	34.0	100
	Total	53	100	100	

Table 2 shows data regarding the level of teacher understanding of the concept of "Teaching Games for Understanding" (TGfU). It shows that responses are shown in five categories: Strongly Disagree (SD), Disagree (D), Neutral (NT), Agree (A), and Strongly Agree (SA), with frequencies and percentages for each category. The data shows that of the 53 sample teachers, the number who felt 'Strongly Agree' and 'Agree' with their understanding of TGfU was the same, namely 18 people or 34% for each category, which cumulatively covered 68% of the total respondents. This indicates that most teachers have a positive understanding of TGfU. Meanwhile, 10 teachers (18.9%) gave a 'Neutral' response, which could mean that they may not be sure or do not have enough information to make a definite judgment about their understanding of TGfU. This group is significant because they may need additional information or practical experience to form a more conclusive opinion. There were also 7 teachers (13.2%) who stated 'Disagree' or 'Strongly Disagree' with their understanding of TGfU, indicating that there is a small number of teachers who feel they do not understand the concept well. This could be an area that needs to be addressed in professional development, to improve understanding and application of TGfU in teaching practice.

Table 2 indicates that although most teachers feel they understand TGfU, there is still room for improvement in teacher education regarding this approach. Because TGfU is an approach that focuses on developing students' understanding of games and strategies in a physical education context, teachers need to have a strong understanding of these concepts to implement them effectively in their teaching.

Table 3. Teachers' Understanding of the LED Approach

		Frequency	**Percent**	**Valid Percent**	**Cumulative Percent**
Valid	SD	3	5.7	5.7	5.7
	D	9	17.0	17.0	22.6
	NT	22	41.5	41.5	64.2
	A	9	17.0	17.0	81.1
	SA	10	18.9	18.9	100
	Total	53	100	100	

Table 3 shows that teachers' understanding of the LED (Light Emitting Diode) approach varies. The frequency distribution of existing responses shows that the Neutral (NT) category has the highest percentage with 41.5%, which shows that most teachers have not yet determined

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their opinion regarding the understanding of the LED approach or may not be very familiar with the concept. This significant percentage may indicate that there is a need for more information or training on the approach to help these teachers build a stronger understanding. Meanwhile, 9 teachers (17%) stated that they agreed (A) and 10 teachers (18.9%) strongly agreed (SA), indicating that they understood the approach. Almost a third of the total respondents felt that they were quite or very familiar with the approach. On the other hand, there were 12 respondents (22.6%) who disagreed (D) or strongly disagreed (SD) about their understanding of this approach. This shows that there are still groups of teachers who may need more support to understand the LED approach concept effectively.

Table 3 shows that while there is a group of teachers who understand the LED approach, the majority are still in a neutral position or are unsure, and there are also several teachers who feel they do not understand. This requires special attention in professional development and increased resources or training related to the use of LED technology in educational practice.

Table 4. Teachers' Understanding of Physical Education Pedagogy

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	D	5	9.4	9.4	9.4
	NT	9	17.0	17.0	26.4
	A	16	30.2	30.2	56.6
	SA	23	43.4	43.4	100
	Total	53	100	100	

Table 4 shows that teachers' understanding of sports education pedagogy is quite good. Of the total 53 respondent teachers, 23 (43.4%) teachers showed positive understanding, stating 'Strongly Agree' (SA) and 16 teachers (30.2%) stated 'Agree' (A). This indicates that around three-quarters of the total respondents have an affirmative view regarding their understanding of sports education pedagogy. Meanwhile, only 9 respondents (17%) felt 'Neutral' (NT), which may reflect uncertainty or a need for further information before being able to express a firm stance. This group may require additional support to develop a deeper understanding of PE pedagogy. In addition, a small number of teachers, namely 5 respondents (9.4%), stated 'Disagree' (D), indicating that there is a minority who feel they do not understand the concept of sports education pedagogy well. The causes of this can vary and may include a lack of resources, training, or practical experience in this field (Hortigüela-Alcalá et al., 2021). Although a small number of teachers felt they had little understanding of PE pedagogy, the majority felt they were moderate to very competent in this area. This is a positive indicator for PE teaching, but there remains room for improvement through professional development and improvements to the PE curriculum to support teachers who are still unsure or lack understanding.

Table 5. Teachers' Understanding of Cooperative Learning

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	D	1	1.9	1.9	1.9
	NT	1	1.9	1.9	3.8
	A	13	24.5	24.5	28.3
	SA	38	71.7	71.7	100
	Total	53	100	100	

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Table 5 shows the distribution of teachers' perceptions regarding their understanding of cooperative learning. Of the 53 respondents, the majority, namely 38 teachers (71.7%) stated that they strongly agreed (SA) that they understood cooperative learning. This shows that most teachers feel quite familiar with this concept. A total of 13 teachers (24.5%) agreed (A), adding a significant percentage to those who were positive about the understanding of cooperative learning. Cumulatively, 96.2% of respondents had a positive response to their understanding of cooperative learning.

Meanwhile, only a small portion of teachers felt unsure about their understanding, where only one teacher (1.9%) chose Neutral (NT), and one more teacher (1.9%) disagreed (D) that they understood cooperative learning. This indicates that almost all teachers have a good understanding of cooperative learning, with only 3.8% indicating uncertainty or disagreement. These findings may indicate that teachers' experiences in cooperative learning may have been quite effective, but attention still needs to be paid to the small number of teachers who are still unsure or disagree. In an educational context, this is important because cooperative learning is a strategy that is often considered to be able to improve student learning performance through cooperation and interaction between students (Fernández-Ferrer & Espinoza, 2022; Ghufron et al., 2023; Yaduvanshi & Singh, 2019).

Table 6. Teachers' Readiness and Approval in Teaching on Nonlinear Pedagogy

Indicator	Item	Score	(%)
Teacher readiness and approval in teaching on nonlinear pedagogy	5	20	83.33
	6	20	83.33
	7	20	83.33
	8	20	83.33
	9	22	91.67
	10	20	83.33
	11	20	83.33
	12	23	95.83
	13	24	100
	14	20	83.33
	15	20	83.33
		Rate (%)	86.7%

Table 6 describes teachers' readiness and agreement in teaching nonlinear pedagogy. From the indicators shown, the scores obtained range from 20 to 24 with the percentage of each item ranging from 83.33% to 100%. Item 13, which received a perfect score, shows that there are certain indicators that teachers are fully prepared and agree with this non-linear pedagogical approach. Overall, the approval and readiness rate is 86.7%, which reflects a high level.

The data in Table 6 indicate that there is a significant level of agreement and readiness among teachers toward implementing nonlinear pedagogy, which can include a variety of teaching methods that do not follow a traditional linear structure. However, there was variation in scores indicating that although overall agreement was high, there was still room for improvement in certain aspects. Items with lower scores could become a focal point for further professional development for teachers, such as providing additional training or discussing practical applications of this nonlinear pedagogy in the classroom. Apart from that, it is also best to pay attention to how this readiness is realized in real teaching practice because a high level of agreement does not always automatically mean effectiveness in implementation. In the

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current educational context which increasingly emphasizes flexibility and innovation in teaching methods, these findings could be a positive indication of teachers' adaptation to and acceptance of new and more dynamic teaching paradigms.

Discussion

Physical education has long been an important component in the holistic development of students in schools, where the main goal is not only to improve physical health, but also to facilitate their cognitive, emotional, and psychomotor growth (Liu & Lipowski, 2021). According to Werner et al. (2019), effective physical education can enrich students' learning experiences by integrating these aspects thoroughly. However, conventional approaches that are still often used, as identified by Chow & Atencio (2014), are sometimes insufficient to achieve optimal results in student-centered teaching. In this case, nonlinear pedagogy, as researched by Moy et al. (2019) offers an alternative method that emphasizes play and creative use of space to make physical learning more interesting.

Nonlinear pedagogy, which prioritizes learning through exploration and discovery, has been shown to increase positive interactions between students and facilitate collaboration (Chow, 2013). This approach supports the principles of positive psychology by meeting students' intrinsic needs for autonomy, competence, and relatedness. This is in line with research showing that effective physical education involves developing communication and collaboration skills, skills that are vital in preparing students to face the challenges of the 21st century (Ezzedini, 2017; Noel & Liu, 2016; Szabo et al., 2020).

In contrast, traditional linear approaches often encourage student dependence on teacher instruction and can limit interactions between peers, as studies have found (Chow, 2013; Chow & Atencio, 2014). These top-down methods may also inadvertently encourage blaming behavior on others, which hinders independent learning and the assumption of responsibility (Chow & Atencio, 2014). According to Körner and Staller (2018), focusing on skills in a socially valued context can create fear of negative evaluation, which can hinder students' learning and personal development.

With a nonlinear approach, the teacher becomes a facilitator who allows students to explore and discover through results-oriented activities and the use of analogies. It encourages creativity and imagination (Hopper, 2010) and can help students develop critical and creative thinking, which is necessary in this fast-changing world. Creativity and innovation emerge when students engage with each other's actions and ideas, often resulting in new behaviors and effective problem-solving. Nonlinear pedagogy also promotes greater peer contact and increases students' ability to collaborate, thereby reducing disagreements (Chow & Atencio, 2014; Tan et al., 2012). Because the teacher's job is to guide and not direct, there are also opportunities for students to provide feedback to each other. Nonlinear pedagogical methods, which encourage learning through inquiry, problem-solving, and creative thinking, encourage positive relationships between instructors and students to mutually evolve and jointly create new functional movement solutions (Dupri et al., 2021; Erdem & Adiguzel, 2019).

This technique allows students to meet internal (i.e., autonomy, competence, and relatedness) and external (i.e., performance-related) constraints (Chow, 2013). The increased connectedness and cooperation demonstrated by the NP group, as expressed in the interview sessions, can result in improved interaction management and interpersonal awareness (Chow &

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Atencio, 2014; Tan et al., 2012), leading to improved communication and collaboration skills, which are an important part of the Ministry of Education's 21st-century competencies.

Because teachers in the Linear Pedagogy (LP) approach are required to guide students in carrying out activities correctly, teachers state that students often wait for instructions (Chow, 2013; Lee et al., 2014). Teachers said that LP's top-down strategy was not effective, because it created space between teachers and students, resulting in limited peer contact. Additionally, instructors and students stated that LP strategies were associated with students blaming others and engaging in conflict. This is like the previous theme where students shift the blame for their success or failure onto others so as not to take responsibility. The problem with skills-focused learning settings is that skills must be performed in a socially evaluative context, which can lead to fear of unfavorable evaluation by others, avoidance, or self-defeating actions (Körner & Staller, 2018; Machado et al., 2019).

The teacher instructs the NP with exploration. This includes results-oriented considerations such as "eyes on the ball" or "ball flight," and using analogies such as "bounce shots" to maintain rhythm while hitting the ball repeatedly. The way students acquire knowledge seems to influence their cognitive abilities during group activities (Haataja et al., 2019; Renshaw, 2012). The emphasis on inquiry and the use of analogies encourages the development of students' creative imagination, as they develop their analogies using fictional events and characters as a means of engaging in longer discussions. In the context of competitive games, NP treatment requires a focus on outcomes and the use of analogies to gain an advantage. This statement illustrates that the NP technique allows exploration within the limits of the tasks given by the teacher, allows students to solve problems, shows creativity, and develops new strategies to win the game. Creativity and innovation are most likely to emerge when students are engaged, respond to other students' actions and ideas, and develop new behaviors (Hopper, 2010). The NP method is relevant to the development of creative and critical thinking, which is the main competency of the 21st century. It is relevant to the development of creative and critical thinking, one of the basic competencies of the 21st century (Casado-Robles et al., 2022; Humphries, 2014).

CONCLUSION

Descriptive analysis of teachers' understanding of nonlinear pedagogy shows variation in understanding of concepts important for students' cognitive, motor, and affective development, with scores generally good but highlighting specific areas requiring improvement. A high mean on understanding cooperative learning indicates acceptance of this concept, but a lower score on understanding of the LED Approach indicates a need for further professional development. In the context of elementary school education, a nonlinear pedagogical approach plays a role in providing a richer experience for students, emphasizing the motivation and skills necessary to maintain lifelong physical activity.

The implication is that future research should explore more deeply how teacher training can be optimized to encompass a broader and deeper understanding of different pedagogical approaches, including nonlinearity. There needs to be a study of the direct impact of using nonlinear pedagogy on student learning outcomes and the sustainability of their motivation in the long run. Additionally, a suggestion for future research is to conduct longitudinal studies that assess how knowledge and skills acquired through nonlinear pedagogy impact students'

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physical health and emotional well-being in the long run. This research can also be complemented with qualitative studies to understand students' perceptions and experiences more deeply about this learning. Finally, it is critical to integrate interdisciplinary research involving experts in education, psychology, and sports medicine to develop holistic and inclusive learning strategies that can be widely adopted in schools.

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Conflict of interests

There are no known conflicts of interest associated with this publication.

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