ISSN 2010-3093

RESEARCH BRIEF

No. 14-004

An Investigation of Nonlinear Pedagogy and its Application in Singapore Schools

Chow Jia Yi, Clara Tan Wee Keat, Miriam Lee Chang Yi and Chris Button

A NONLINEAR PEDAGOGY (NP) approach encourages exploratory learning with Physical Education (PE) teachers, applying key pedagogical principles that focus on manipulating task constraints and creating representative learning designs to enhance skill-learning. This research project showed that students taught with an NP approach demonstrated more individualized and creative movement solutions to learn a motor skill and, despite the reduced emphasis on prescriptive instruction and drill, still achieved success. Importantly, these students also showed more effective game play characteristics after a series of PE lessons based on NP principles. Interview data from students and teachers provided insights on their positive perception of NP and its potential impact on teacher education and professional development.

INTRODUCTION

Traditional pedagogical approaches in PE are viewed as technique dominated, involving the use of prescriptive instructions and repetitive drills, which may limit learning opportunities for children to develop movement skills (Chow, Davids, Button, Shuttleworth, Renshaw & Araújo, 2007; Bunker & Thorpe, 1982). In contrast, NP is student-centred, and encourages children to explore individualized movement solutions and develop cognitive and decision-making skills for game play (Chow et al., 2007; Renshaw, Chow, Davids & Hammond, 2010). NP encourages teachers to manipulate key task constraints (such as equipment) to set boundaries within which the learner explores functional movement solutions (Chow, Davids, Button, Rein, Hristovski & Koh, 2009; Chow & Tan, 2009). NP provides a framework for practitioners to incorporate "representativeness, manipulation of constraints,

KEY IMPLICATIONS

- Nonlinear Pedagogy questions the traditional one-size-fits-all, outcome-based philosophy that has dominated PE historically. Further consideration should be given to how motor competency should be assessed in the PE curriculum.
- The use of Nonlinear Pedagogy and its pedagogical principles can provide teachers with a pathway to better structure the delivery of instructions and the organization of practices to promote effective teaching and learning of motor skills and game play. In addition, the efficacy of a Nonlinear Pedagogy approach can provide educators with a pedagogical platform to deliver the new PE curriculum.
- The potential benefits of a Nonlinear Pedagogy approach may have important implications for teacher education and professional development of PE teachers in Singapore.

focusing on movement outcome rather than form, infusing variability in practice, and maintaining the dynamics of the movement intact for effective design of motor learning interventions (Chow, 2013). However, little is known about the underlying processes that occur in learners when a Nonlinear Pedagogy approach is used. In addition, what changes can be observed at the three levels (i.e., individual, game, and physical education lesson) when an NP approach is undertaken?

This research consisted of three main phases aimed at examining the effectiveness of an NP approach analysed at the individual, pair, and class levels. The three main research objectives were: a) To investigate the effectiveness of an NP approach to learning a sports skill (i.e., tennis forehand stroke); b) To investigate the effectiveness of a Nonlinear Pedagogical approach to learning a modified net/barrier game (modified tennis); c) To investigate the effectiveness of an NP approach in teaching and learning a unit of modified tennis in a physical education context.

The current research is an important step in showing educators how they may adopt student-centred pedagogical practices that develop in our students the 21st century competencies that we wish to inculcate in them. Individual differences abound in our classrooms and an NP approach can provide teachers with the means to engage students in addressing their individual needs as they search for their own movement solutions within the task boundaries set in PE lessons. Such a student-centred approach should be the basic principle underlying teaching and learning in Singapore schools. In addition, the enactment of a student-centred approach in schools would inform teacher educators on how they might review NIE and MOE (Ministry of Education) teacher education and professional development programmes for PE teachers.

RESEARCH DESIGN

The research design consisted of three phases targeting the levels of the individual, pair and school.

Phase 1

Phase 1 was an intervention study involving a controlled experimental school setting with the level of analysis on the individual. Twenty-four right-handed female participants, of age 9 to 10 years, with limited experience in playing racquet sports, were selected for this study and randomly assigned to either the NP or the Linear Pedagogy (LP) group. Phase 1 consisted of pre-, post- and retention test sessions, with a 4-week intervention after the pre-test. Following the pre-test, the participants underwent a 4-week intervention, with 15-minute practices twice a week, to learn a forehand groundstroke in lessons delivered with either the NP or LP approach. The NP condition provided instructions and practices based on the pedagogical principles underpinning NP, while the LP condition focused on providing a prescribed and directed learning experience typically seen in most skills acquisition contexts. (The same distinction between NP and LP was maintained in Phase 2 and Phase 3.). For both the NP and LP groups, each practice session consisted of 80 forehand groundstroke trials with instructions provided from either the NP or LP approach. Performance accuracy scores, movement performance scores and kinematic (i.e., movement) data of each student were collected. A comparison between the two pedagogical conditions was undertaken in relation to these dependent variables: performance accuracy, movement performance, and kinematics.

Phase 2

Phase 2 was an intervention study with a quasi-experimental design. The level of analysis was group level, with specific focus on the interaction of several pairs of individuals. Twenty-four 10-year-old female novices (12 pairs) with no tennis background were recruited from four Primary 4 classes in a local school. Participants from two classes (6 pairs) were assigned to the NP intervention group while the participants from the remaining two classes (6 pairs) were assigned to the LP intervention group. Pre-, post- and retention tests were administered with three test sessions (test1, test2, test3) held during the intervention period during which the movement behaviour of participants was recorded. During all test sessions, participants worked in assigned pairs in a modified-tennis court with the pair standing on opposite sides of the net. Following the pre-test session, the participants took part in 14 intervention (practice) sessions over 8 weeks conducted with either the NP or LP approach depending on the intervention group the participants were in. Rally length, number of successful trials, number of successful first serves, number of unforced errors and movement behaviours were noted. Positional trajectories in terms of x- and y- coordinates of the players were obtained from the post-processed tracked data captured on a top-view video footage. Performance accuracy scores, movement performance scores and movement data of each pair of students were recorded. As in Phase 1, a comparison between the two pedagogical conditions was undertaken in relation to these dependent variables.

Phase 3

Phase 3 was an intervention study with a quasi-experimental design. The level of analysis was the class, with 2 classes in each intervention group, and the individual teacher. 133 participants, age 9 to 10 years, from four classes in a primary school were recruited for this study. Two classes were assigned to the NP intervention group (Class A: N = 28; Class B: N = 39) and the other two classes to the LP intervention group (Class C: N = 28; Class D: N = 38). Two experienced PE teachers from the school taught the intervention to the four classes. All students in each class participated in 7 weeks of practice (14 lessons). All lessons were taught twice a week by the two teachers during the school's PE period. The intervention provided was similar to that in Phase 2 but adapted to a PE class setting. Rally length and movement behaviour were observed (as in Phase 2).

In addition, following the intervention, all participants completed a 24-item questionnaire, adapted from the Intrinsic Motivation Inventory (IMI) questionnaire (Deci & Ryan, 1985), to measure intrinsic motivation experienced during the lessons. Interviews with students and teachers were also conducted. The purpose of the interviews was to obtain information that was not easily observable, for example, personal feelings, opinions, values and beliefs (Patton, 1990). Questions to determine the learning processes, degree of enjoyment and perceived competence were posed to student interviewees. Teachers were asked questions mainly to find out their perception of the children's learning processes and enjoyment during the lessons, and their perception of the applicability of the two pedagogical approaches to teaching and learning games in PE. As in Phase 1 and 2, the dependent variables were compared across the two intervention groups to arrive at a better understanding of the differences between the two pedagogical approaches and the possible efficacy of the NP approach.

KEY FINDINGS

Phase 1

There are indications that an NP approach is effective for teaching a specific sport skill (such as the modified-tennis forehand stroke in the current study). Participants in the NP group demonstrated more varied coordination patterns to achieve the task goal of successfully hitting the ball to target positions. The LP group produced higher movement performance scores indicating a movement pattern closer to the ideal prescribed forehand movement form, as seen in the higher movement performance scores (see Figure 1), but both groups improved in accuracy scores. Participants from the NP group were just as successful as participants from the LP group but compared to the LP participants, engaged in more exploratory search for functional movement solutions. The higher frequency of movement solutions shown by the NP group can potentially produce greater flexibility and transferability to other game skills within a PE setting.

The advantage of the higher number of movement solutions has been confirmed by the results of cluster analyses on movement patterns which show that participants in the NP condition demonstrated a greater number of movement clusters and still improved in their performance scores (i.e., they used more varied solutions to solve movement problems).

Phase 2

Analysis and interpretation of the collected data suggest that an NP approach encourages students to better establish affordances (opportunities for action) in a game situation that enhances learning. Data on performance outcome reveal that NP

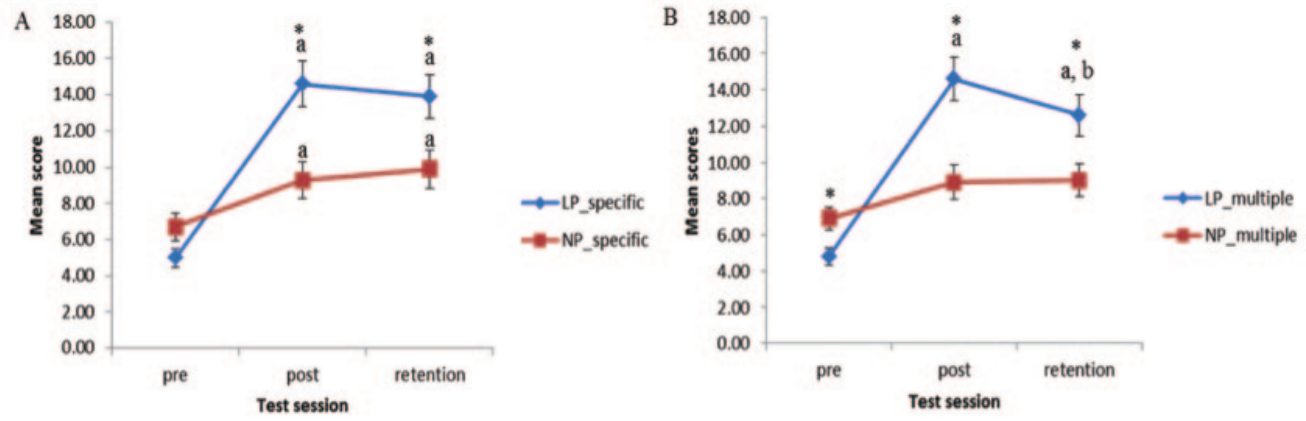

Figure 1. Mean movement performance scores for specific (A) and multiple target (B) trials at pre-, post- and retention-test. (a) indicates significant differences from pre-test ($p < 0.05$), (b) indicates significant differences from post-test ($p < 0.05$) and (*) indicates significance.

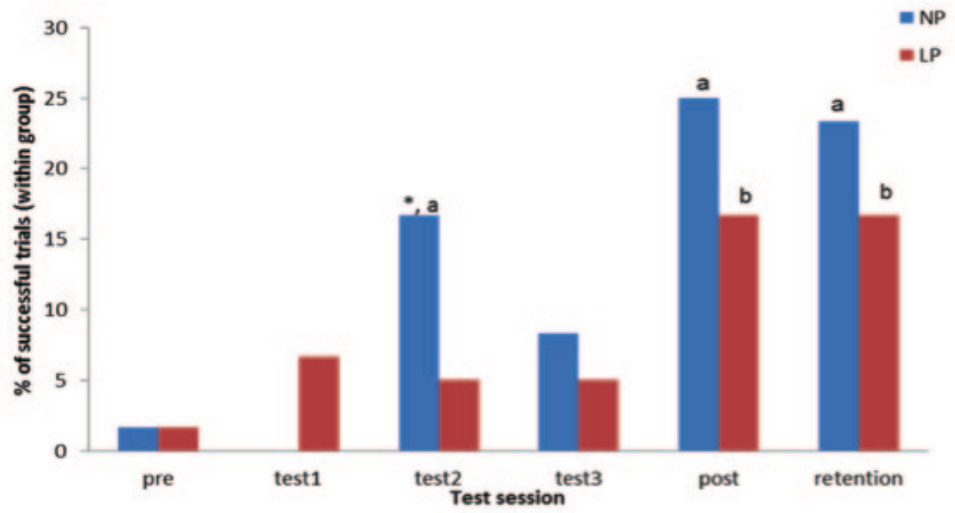

Figure 2. Number of successful trials, as a percentage of total trials within each group, at pre, test1, test2, test3, post and retention tests for racquet trials. (*) indicates significant difference between groups (p < 0.05), (a) indicates significant differences from pre-test for NP and (b) for LP (p < 0.05).

participants performed as well as LP participants with NP participants showing higher percentages of success (see Figure 2). In particular, one key finding shows how NP participants possess better control and consistency to hold a rally and improved tactical awareness (i.e., returning to base position for better court coverage), strongly indicating effective learning within a game context (see arrow in Figure 3).

Phase 3

In terms of performance outcome, both groups improved but the NP group performed significantly longer rallies than the LP group, indicating that the NP group was able to hold longer cooperative rallies (Figure 4). Although no significant differences between the two pedagogical conditions were seen in motivation as reported in questionnaire responses, the interview data provide some indication of the underlying social-emotional factors. Findings from the teachers' interview data indicate that NP provides ample opportunities for the students to engage in exploratory learning behaviours. In addition, an interesting finding that emerged was that NP participants seemed to work more cooperatively with each other while the LP participants often seemed to be in disagreement. This observation accords with a key concept of NP relating to learners' interaction with their environment to produce emergent behaviours.

IMPLICATIONS

For Policy

- Positive findings from this study on the efficacy of NP can provide insights to how the new PE curriculum can be further enhanced. While the content of the PE curriculum contains an emphasis on fundamental movement skills and the teaching of game skills, little information is provided on the

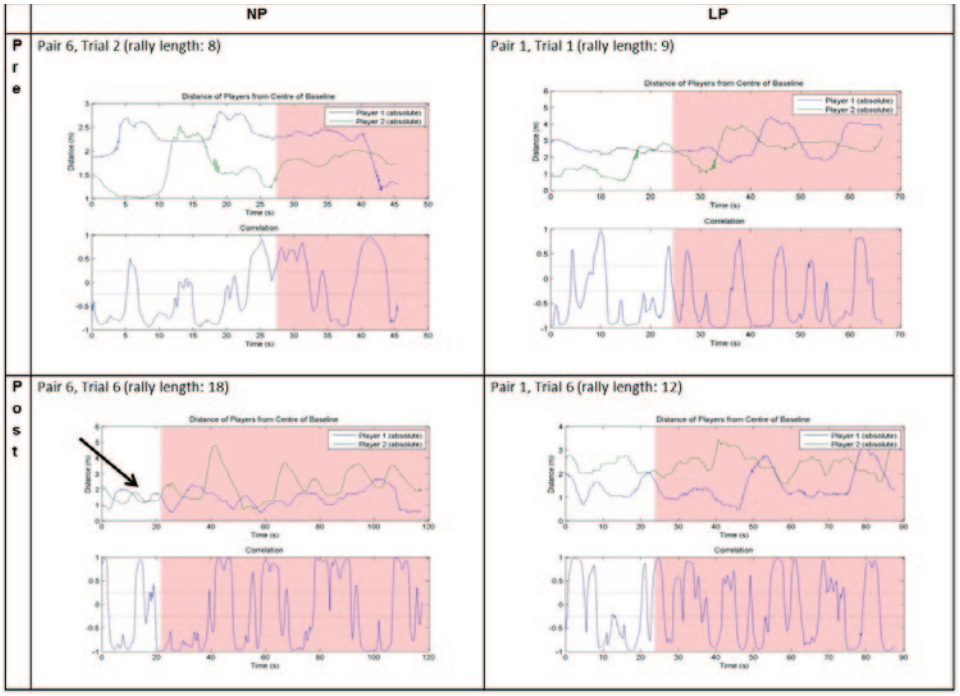

Figure 3. Distance of players to middle of baseline and the respective correlation coefficient for pair 6 (NP) and pair 1 (LP) from pre- and post-tests.

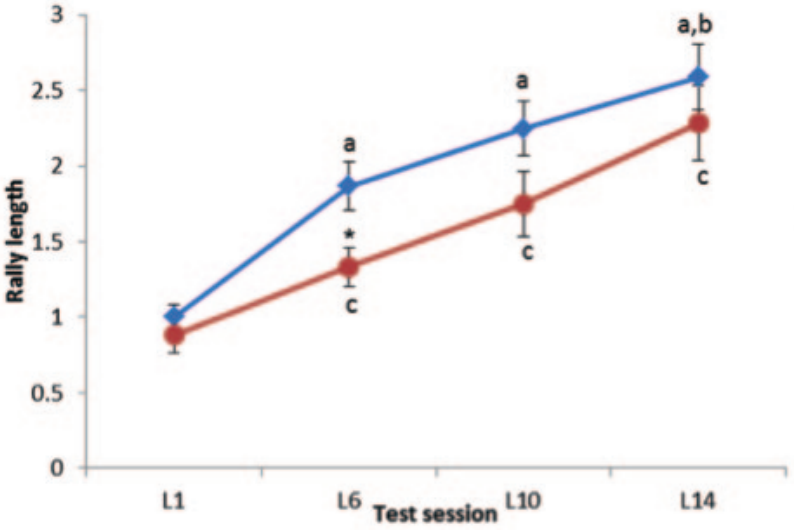

Figure 4. Mean rally length at L1, 6, 10 and 14. (*) indicates significant differences between groups ($p < 0.05$). (a) indicates significant differences from L1 and (b) from L6 for NP ($p < 0.05$). (c) indicates significant differences from L1 for LP ($p < 0.05$). Error bars represent Standard Error Measure (S.E.M).

pedagogical approach to teaching the content. The use of NP and its pedagogical principles can guide teachers to better organize their instructional practices to promote more effective learning.

- Physical education assessment criteria need reconsideration to include important elements like adaptability, transfer, creativity and problem-solving, all of which are traditionally under emphasized in PE curricula.

For Practice

The benefits of NP need not be limited to a net-barrier game (i.e., modified tennis in this project). Future research can examine the efficacy of NP for other categories of games. Importantly, future work may aim to determine the transferability of game skills across different games but within the same game category (e.g., basketball and handball within the category of invasion games). This proposed research would yield results with important implications on how students can broaden their repertoire of game skills within the PE context.

For Teacher Training

- The potential benefits of an NP approach have important implications for how teacher education (in PE) is conducted in Singapore. NP's benefits point to a need to re-examine how exploratory and facilitative types of pedagogical practices can be undertaken to equip trainee teachers with the expertise to create effective learning contexts for students.
- There are also implications for how professional development for trained PE teachers should be undertaken, including how the Physical Education and Sports Teachers Academy (PESTA) plans professional development for in-service teachers. Two workshops on NP have already been conducted for Prograrmme Managers (PESTA) and in-service teachers at PESTA in 2013.

REFERENCES

Bunker, D., & Thorpe, R. (1982). A model for the teaching of games in the secondary schools. *The Bulletin of Physical Education*, 5–8.

Chow, J. Y. (2013). Nonlinear learning underpinning pedagogy: Evidence, challenges and implications. *Quest*, 65, 469–484.

Chow, J. Y., Davids, K., Button, C., Rein, R., Hristovski, R., & Koh, M. (2009). Dynamics of multi-articular coordination in neurobiological systems. *Nonlinear Dynamics, Psychology and Life Sciences*, *13*(1), 27–52.

Chow, J. Y., Davids, K., Button, C., Shuttleworth, R., Renshaw, I., & Araújo, D. (2007). The role of nonlinear pedagogy in physical education. *Review of Educational Research*, *77*, 251–278.

Chow, J. Y., & Tan, C. (2009). Enhancing game play in PE and sport: A holistic approach. In N. Aplin (Ed.), *Perspectives on Physical Education and Sports Science in Singapore: An Eye on the Youth Olympic Games 2010* (pp. 106–117). Singapore: McGraw Hill.

Deci, E. L., & Ryan, R. M. (1985). *Intrinsic motivation and self-determination in human behavior*. New York, NY: Plenum.

Patton, M. (1990). *Qualitative evaluation and research methods*. Beverly Hills, CA: Sage.

Renshaw, I., Chow, J. Y., Davids, K., & Hammond, J. (2010). A constraints-led perspective to understanding skill acquisition and game play: A basis for integration of motor learning theory and physical education praxis? *Physical Education and Sport Pedagogy*, *15*(2), 117–137.

ABOUT THE AUTHORS

CHOW Jia Yi, *Clara TAN Week Keat*, and *Miriam LEE Chang Yi* are with the National Institute of Education, Nanyang Technological University, Singapore. *Chris BUTTON* is with the University of Otago, New Zealand.

Contact Jia Yi at **jiayi.chow@nie.edu.sg** for more information about the project.

This brief was based on the project OER 15/09 CJY: An Investigation of Nonlinear Pedagogy and its Application in Singapore Schools.