Impact of Nonlinear Pedagogy to teaching Fundamental Movement Skills (FMS)

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ABSTRACT

The purpose of this study was to investigate the effects of using the nonlinear pedagogy (NP) in the teaching of fundamental movement skills (FMS) in children. In the first phase, a total of 26 Primary 2 students went through 7 intervention lessons consisting of activities related to catching and overhand throwing. The Test of Gross Motor Skills – 2nd edition (TGMD-2) and a checklist of 3 developmental stages were used as the assessment tools in the second phase, which involved the students being assessed on 6 object control skills that included catching and overhand throwing. Results for the group’s total average raw score of catching and overhand throwing increased by 28.57% from pre-to post-intervention. Positive impacts of NP approach were seen with the students performing better in the post-intervention, as well as the achievement of successful outcomes without conformity of the TGMD-2 criteria.

INTRODUCTION

In 2014, Singapore’s Ministry of Education (MOE) implemented a revised Physical Education (PE) Syllabus for schools to provide a strong foundation for student’s continual growth and holistic development. One of the key changes was in the emphasis towards the teaching and acquisition of Fundamental Movement Skills (FMS). In the syllabus, FMS was categorized into 3 categories, namely, locomotor (e.g. running and hopping), non-locomotor (e.g. stretching and swinging) and manipulative skills (e.g. throwing and catching). These skills are to be introduced at the lower primary levels through instructions on how to perform the components of the movement patterns correctly, starting from the Primary 1 level and continuous reinforcements throughout the upper levels.

Past studies such as Lubans et. al (2010), Hardy et. al (2010) and Stodden et. al (2008) have shown the importance of the mastery of FMS and how it affects the children’s participation in physical activities during their later stages in life and its health benefits. Hence, these factors may validate the importance of teaching FMS to children from a young age. In the past, instructional programs have been implemented in various approaches, such as direct instructions (Connor-Kuntz and Dummer, 1996; Kelly et. al, 1989) and parent as teachers (Hamilton et. al, 1999). These programs have all resulted in positive changes in the participants’ FMS.

However, over the last decade, advancement in the literature of motor control and learning provided strong evidence on the dynamism and complexities in the learning of movement skills which focuses on the individual differences among learners (Davids, Button & Bennett, 2008; Chow & Attencio, 2012). Specifically, the complexities entails that learning occurs in nonlinear fashion, within complex and dynamic environments. Consequently, effective teaching pedagogies should be strongly considered to enhance the learning of the learners with considerations of their individualized movement patterns.

One pedagogical approach, which has increasingly been advocated by practitioners, would be Nonlinear Pedagogy (NP) approach, which is underpinned by principles from the dynamical systems theory (Chow et. al, 2007). A nonlinear pedagogical approach provides a lesson framework that practitioners, such as researchers and teachers, can draw upon so that students can explore goal-directed behaviours. These design principles include, (a) the need to plan representative tasks that are situated in the game contexts; (b) manipulating appropriate constraints; (c) ensuring that students develop relevant information-movement couplings and thus the key affordances in the learning activities; (d) ensuring movement variability that helps students to transit from one movement behaviour to another and; (e) attentional focus.

In planning representative tasks that are situated in the game contexts, learning and acquisition of knowledge takes place when the learner is exposed to the learning environment, due to the interaction between the learner...
and the environment. The manipulation of constraints typically involves the alteration of task constraints, such as instructions, rules of the activity and varying of equipment. These constraints are what practitioners have a lot of control of in manipulating, and in doing so, can perturb learners so that they can explore other possibilities of movement behaviours. The learning environment would also establish functional information-movement couplings that relates to the concept of affordance and its role in movement control for individuals. The role of functional movement variability is another aspect of NP, which enhances acquisition of coordination and discovery of individualized functional solutions for the learner. Finally, in the NP framework, instructions provided are based on external focus of attention, so as to reduce the learner’s conscious and explicit control of movement.

Previous studies of NP have covered its application in the physical education and sports context. For example, Atencio et. al (2014) produced sample lesson activities that encompassed the principles of NP in track and field, tennis and netball. However, little is known about its application in the teaching and learning of FMS. Therefore this research serves to enhance the understanding of the teaching of FMS using the NP framework, and thereafter, shares on the impact of NP approach in the teaching of FMS to a group of lower primary school students from a Singaporean school.

It is hypothesized that there will be an increase in the children’s overall scores for their post-intervention assessments.

**METHODS**

**SUBJECTS**

As the pre-assessment results were taken from a previous study (Toh, 2016), the same group of students was selected to take part in the study. 26 children (13 boys and 13 girls) between the ages of 7-9 years old ($M = 7/05$) from a primary school located in the northeastern side of Singapore participated in the study.

The purpose of this was to ensure that the validity of this study was not compromised. Participants’ information (Table 1) were recorded.

**PROCEDURES**

The study involved two distinctive phases. The first was the intervention phase, where a trained Physical Education (PE) teacher conducted several lessons, using a nonlinear pedagogy approach. The second was the TGMD-2 assessment, carried out to record the results post-intervention.

In the first phase, participants went through seven PE lessons over a span of three weeks (3 sessions per week, except for the 3rd week), each lasting at 30 minutes or an hour. The intervention lessons were focused on two FMS skills, which were catching and overhand throwing. In total, 4 sessions (2 hours consisting of 4 half hour sessions) were assigned for the teaching of the overhand throwing skill and the remaining 3 sessions (3 hours from 3 sessions of 1 hour per session) were assigned for the catching skill. The intervention lessons

<table>
<thead>
<tr>
<th>Table 1. Participants’ Information</th>
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<tbody>
<tr>
<td><strong>Participants’ Information</strong></td>
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<tr>
<td><strong>Age (Year/Month)</strong></td>
</tr>
<tr>
<td><strong>Height (m)</strong></td>
</tr>
<tr>
<td><strong>Weight (kg)</strong></td>
</tr>
<tr>
<td><strong>Body Mass Index (BMI)</strong></td>
</tr>
<tr>
<td><strong>BMI Weight Indicator</strong></td>
</tr>
<tr>
<td><strong>Based on Health Promotion Board’s BMI-for-Age Charts</strong></td>
</tr>
</tbody>
</table>
Overweight: 1 (1 Male)
Underweight: 3 (2 female, 1 male)

PA Participation outside school (participants)

Yes (23; 88.5%)
No (3; 11.5%); of which 1 had both parents also not engaging in PA

Type of PA (Participants)

*Some participants engage in more than 1 sport

Ball games (Female: 1; Male: 3)
Racket games (Female: 0; Male: 3)
Swimming (Female: 6; Male: 9)
Track & Field (Female: 1; Male: 2)
Others (Female: 6; Male: 5):
  - Golf (1 Male)
  - Martial arts (3 Male)
  - Cycling (1 Male)
  - Skating (1 Female)
  - Running (1 Female)
  - Dance (4 Female)

PA Participation for Parents

Yes (15; 57.7%)
No (9; 34.6%)

Type of PA (Parents)

*Some parents engage in more than 1 sport

Ball games (8)
Racket games (6)
Swimming (9)
Track & Field (7)
Others (4):
  - Martial arts (2)
  - Weight training (1)
  - Running (3)

No. of Participants with Older Siblings

Brother (Female: 4, Male: 2)
Sister (Female: 4, Male: 3)

No. of Participants with Younger Siblings

Brother (Female: 4, Male: 4)
Sister (Female: 1, Male: 2)
*1 female participant with 1 younger brother and 1 younger sister

*1 male participant with 1 older sister and 1 younger sister

were structured with pedagogical principles that underpinned a NP approach. Activities that the participants were engaged in during the intervention were planned prior to the lessons in the form of lesson plans, which were carefully vetted to ensure the interventions were strictly aligned to the NP principles, which included manipulation of task constraints, representative learning design, functional variability and the provision of instructions that were based on an external focus of attention. The structure of the lesson plan (Figure 3) included the duration of activity, description of activity, teaching cues/instructions, organization/equipment and pedagogical NP principles that were relevant in the activity.

Figure 1. Sample of a lesson plan used for the NP approach lessons

The second phase was the post-intervention assessment. The previous study (Toh, 2016) contributed data that were important for this study. The scores attained from the TGMD-2 assessment done in the aforementioned study were used as their pre-intervention results. In this study, the results that were attained from the assessments done were taken as the participants’ post-intervention results.

To measure the movement proficiency level of the participants for the different skills, the TGMD-2 assessment tool was used. The skills assessed were striking a stationary ball, stationary dribbling, underwater rolling, kicking, catching and overhead throwing. The assessment was administered at the
school’s indoor sports hall. Over the course of 3 sessions, students were assessed either in pairs or individually during their lessons. The assessment requirements were briefed to the participants and one of the assessors present demonstrated the 6 object control skills. Participants were then given a practice trial before the two actual trials that formed their assessment.

Each participant performed all six skills. A video recording of every participant’s main trials for each skill was taken for a thorough analysis of the participants’ performance.

One out of the two assessors from the pre-intervention assessment was tasked to assess the participants’ performance for the post-intervention assessment. This is to ensure the reliability and consistency of assessment.

MEASUREMENTS

The previous study’s (Toh, 2016) mode of assessment was the second edition of the Test of Gross Motor Development (TGMD-2). The scores attained from the TGMD-2 assessment done in the aforementioned study were used as their pre-intervention results. In this study, the results for the performance of the participants in the post-intervention assessment was scored using the TGMD-2.

TGMD-2 is an assessment tool that measures gross motor skill competence. It consists of two subtests: assessment of performance for locomotion skills comprising of jumping, running, hopping, sliding, leaping and galloping. The other subtest assesses object control skills, which comprises of catching, throwing, dribbling, striking, kicking and underhand rolling. Previous studies (Simons et. al, 2008; Valentini, 2012; Kim et. al, 2014; Houwen et. al, 2012) have shown its validity and reliability in assessing fundamental movement skills of children. In addition to the TGMD-2, a checklist with three developmental stages for each skill, namely, Initial, Transition and Mature were incorporated as well into the assessment. The ‘Mature’ stage reflected the TGMD-2’s skill criteria. The skills that were assessed were overhand throw, catch, stationary dribble, kicking, underhand roll and striking a stationary ball. For the purpose of this study, only two out of six skills (i.e. catch and overhand throw) were analyzed.

DATA ANALYSIS

One dependent variable was the mean scores of overhand throwing and catching of the participants during the assessment sessions, which included the pre-intervention assessment scores attained from the previous study (Toh, 2016). The other dependent variable is the number of participants in the Mature stage of the developmental stages for the 2 skills, based on pre- and post intervention assessments. The independent variable manipulated was time (i.e. pre-intervention and post intervention assessment).

The raw mean scores of the participants were categorized based on genders to determine whether gender differences was a factor in their performances. Based on previous studies, it was shown that boys were more object control proficient (i.e. throwing, catching, kicking, dribbling, underhand rolling and striking) than girls (Spessato et. al, 2012; Barnett et. al, 2010).

The video recordings were also used to identify the number of participants who were able to produce successful outcome for catching (i.e. being able to catch the ball), regardless of the participants displaying all the criteria of catching from the TGMD-2.

RESULTS

The mean scores for the pre- and post-intervention assessments are summarized in Table XYZ. The scores are based on the participants’ ability to display the various performance criteria derived from the TGMD-2.

<table>
<thead>
<tr>
<th>Skill</th>
<th>Pre-intervention</th>
<th>Post-intervention</th>
<th>Initial</th>
<th>Transition</th>
<th>Mature</th>
<th>Percentage Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Catch</td>
<td>2.88</td>
<td>4.19</td>
<td>0.37</td>
<td>0.4</td>
<td>0.4</td>
<td>60%</td>
</tr>
<tr>
<td>Striking</td>
<td>3.04</td>
<td>3.04</td>
<td>0.54</td>
<td>0.4</td>
<td>0.5</td>
<td>12%</td>
</tr>
<tr>
<td>Kicking</td>
<td>3.52</td>
<td>3.52</td>
<td>0.54</td>
<td>0.6</td>
<td>0.7</td>
<td>60%</td>
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</table>

The mean score of post-intervention for catching was 4.19 ± 0.37 (where 4.19 is the mean score and 0.37 is the standard error) (range = 0-6) as compared to pre-intervention, which was 2.88 ± 0.57 (range = 0-6). The mean score of post intervention for overhand throw was 3.04 ± 0.51 (range =0-8) as compared to pre-intervention, which was 2.69 ± 0.54 (range = 0-8). Both catching and overhand throwing shows an increase in the mean scores at 45.33% and 12.86% respectively, after the NP approach intervention lessons.

<table>
<thead>
<tr>
<th>Skill</th>
<th>Initial</th>
<th>Transition</th>
<th>Mature</th>
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<tbody>
<tr>
<td>Overhand throw</td>
<td>2.50</td>
<td>2.88</td>
<td>3.04</td>
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</table>

The video recordings were also used to identify the number of participants who were able to produce successful outcome for catching (i.e. being able to catch the ball), regardless of the participants displaying all the criteria of catching from the TGMD-2.
Catching

<table>
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Overhand throw

<table>
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<th></th>
<th>Pre-I</th>
<th>Post-I</th>
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Note. Pre-I: Pre-intervention; Post-I: Post-intervention

The results from the three developmental stages revealed that there was an increase in the number of participants being able to perform the catch (i.e. from 12 to 20). The results also show that the number of participants being able to perform the overhand throw remained at 7.

The identification of participants in the different developmental stages also provides a general overview of the progress of the group as a whole. For example, even though the number of participants performing the overhand throws correctly remains at 7 (mature stage reflects the participants meeting all the performance criteria for the skill), the increase from 15 to 18 participants reveals that some of the participants made improvements in terms of fulfilling some of the performance criteria.

The raw scores of participants based on gender, for the 2 skills (i.e. overhand throw and catching) are summarized in Figure 4.

![Figure 4. Raw scores of participants by gender](image)

**RAW SCORES OF PARTICIPANTS (PRE-INTERVENTION)**

From Figure 4, it can be seen that the female participants performed better than the male participants in catching. Out of a total of 6 points, the female participants scored an average of 3.2 while the male participants scored an average of 2.6. As for the overhand throwing skill was compared, the male participants outperformed the female participants with an average score of 4.5 and 0.9 respectively. The pre-intervention assessment showed that 53.85% of boys were already able to perform the overhand throw and only 7.69% of girls were proficient. Overall, the male participants performed better than the female participants with total raw scores of 7.1 and 4.1 respectively out of a total of 14 points.

**RAW SCORES OF PARTICIPANTS (POST-INTERVENTION)**

From Figure 4, it can be seen that both the males and female participants performed similarly in catching with the same average score of 4.2 out of 6. As for the overhand throwing skill, the male participants performed better than the female participants, with a score of 4.2 and 1.8 respectively. Overall, the male participants performed better than the female participants with total raw scores of 8.4 and 6.1 respectively.

**COMPARING THE PRE- AND POST-INTERVENTION SCORES**

Both male and female participants improved on their skills with higher total raw scores of the two skills when compared pre-intervention and post-intervention. The male participants improved by 18.31% (i.e. from 7.1 to 8.4 for pre- and post-intervention respectively) on their total average raw scores. The female participants improved by 48.78% (i.e. from 4.1 to 6.1 for pre- and post-intervention) on their total average raw scores. Overall, the group’s total average also increased by 28.57% (i.e. from 5.6 to 7.2 from pre- to post-intervention). The comparison of performances between the boys and girls seems to mirror with some studies, showing that boys are better performers in object control skills than girls.

**SUCCESSFUL CATCHES WITHOUT FULFILLING ALL PERFORMANCE CRITERIA FROM TGMD-2**

4 participants who were not classified under the ‘Mature’ stage were still able to perform the catch, even though they did not meet some of the performance criteria. For example, in the preparation phase, one of the participants extended his arms fully, and elbows were not flexed while another participant caught the ball by trapping it between his forearms and chest. These participants showed movement variability, as they still achieved the outcome of catching with different movement solutions. It further highlighted the principles of NP, such as establishing relevant information-movement couplings, being used during the intervention lessons. Typically seen as ‘noise’ in a
linear system, it plays a functional role in the dynamical systems, by enhancing the probability of system transitioning between multiple states (Schollhorn et al., 2009).

Even though the TGMD-2 has shown its validity and reliability from various studies (Simons et al., 2008; Valentini, 2012; Kim et al., 2014; Houwen et al., 2012), it does not consider the individualized affordances and movement variability of participants, which allows them to have successful outcomes without showing all of the performance criteria laid out from the assessment tool.

CONCLUSION

While this study has generated potential benefits of using NP in the teaching of FMS, there are also good indicators of the directions on how NP can be utilized to further enhance its impact in the educational field. Firstly, the post-intervention assessment has shown improvements for specific object control skills (i.e. throwing and catching) for the general samples used. However, it is useful to note that the lack of control group in this study does not allow comparisons of performance between two groups. Also, the accuracy of the baseline performance, which is the pre-intervention assessment results taken from a previous study (Toh, 2016), might not be a true reflection of the participants’ ability in their performance of FMS before the intervention because of the delay between the baseline performance and the treatment.

Secondly, the study provided greater clarity in the participants’ performances by breaking down their performances into the three different phases (i.e. initial, transition and mature). This allows easier and clearer identification of the participants’ progress with regards to the NP intervention implemented. In addition, practitioners of NP, such as teachers in this context, are able to identify the students’ weak areas in their performance, and consequently, plan their non-linear pedagogical lesson activities for students to explore more movement variability that works for them to achieve the outcomes. This can be done by a more knowledgeable decision in the teacher’s instructions and manipulation of constraints.

Thirdly, the results based on gender differences shows similarity with the literature that are already published. Boys generally performed better than girls in object control skills. Moving forward, practitioners can work on bridging the gap for girls to be as proficient as the boys. Is it possible for NP to be incorporated to address this issue?

Lastly, observations on successful outcomes of catching by some of the participants questions the ‘standard’ norms of the performance criteria brought about by assessment tools such as TGMD-2, that must be present to be considered the ideal of the specific skills. At the same time, as shown by some of the participants, these observations also provided a clear indication of the positive impacts of nonlinear pedagogical framework in encouraging participants to discover movement variations that are unique to them, and at the same time, allows them to be successful in their learning outcomes.

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REFERENCES


