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Published version

DAVIES, K Fitton, FOWEATHER, L, WATSON, PM, BARDID, F, ROBERTS, SJ, DAVIDS, Keith, O'CALLAGHAN, L, CROTTI, M and RUDD, JR (2021). Assessing the motivational climates in early physical education curricula underpinned by motor learning theory: SAMPLE-PE. Physical education and Sport Pedagogy.

Assessing the Motivational Climates in Early Physical Education Curricula underpinned by Motor Learning Theory: SAMPLE-PE

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Funding statement: This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

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Abstract

Background: Traditionally, Physical Education (PE) has adopted a multi-skills approach, where children generally engage in decontextualised practice of sport techniques to develop specific movement skills and facilitate sports participation. This approach has been critiqued for having a weak conceptual and philosophical justification, and lack of empirical proof of its educational value. The SAMPLE-PE research project set out to challenge this by creating two PE curricula distinguished by contrasting theories of motor learning: information processing theory and ecological dynamics. While both approaches have shown promise in enhancing children's movement skills, to date there has been little consideration of their impact on motivational climate of primary PE lessons. This study explored to what extent traditional PE, ecological dynamics, and information processing theory-based approaches create empowering and disempowering motivational climates when viewed through a self-determination and achievement goal theory lens. **Method:** Forty-four PE lessons were video recorded and coded by two trained researchers using the Multidimensional Motivational Climate Observation System. ANOVA, MANOVA and Bonferroni post-hoc tests were run to explore differences in data on motivational climate under the three different pedagogical approaches. **Results:** The group taught with concepts from ecological dynamics (referred to as Ecological) displayed a significantly lower disempowering motivational climate in comparison to the group taught with a basis in information processing theory (referred to as IPT) and the traditional PE groups. The ecological group revealed significantly more autonomy support than the traditional PE and the IPT group. The IPT group methods provided significantly more structure than traditional PE and the ecological group. **Conclusion:** The findings of this study have shown how the approach

taken in delivering PE in primary schools may differentially affect motivational climates. Results imply that underpinning PE with theories of motor learning provides differing, viable and beneficial alternatives to create positive learning environments, compared to traditional PE practices.

Key words: self-determination theory, achievement goal theory, motivation support, ecological dynamics, information processing

Introduction

This study explored the motivational climates of children's first formal experiences of Physical Education (PE) at the ages of five to six years. Across the globe, government publications, national standards, professional bodies and curriculum documents in education have recognised that the development and learning of a broad range of movement/motor skills, including locomotion, object control, stability, needs to start in early childhood (Australian Curriculum, Assessment and Reporting Authority, 2012; Department of Education 2014; Society of Health and Physical Educators, 2013; UNESCO, 2013). This broad-skills foundational focus is important as competency in multiple movement skills is linked to a range of positive health outcomes including children's physical activity (PA) participation (Jones, Innerd, Giles et al., 2020; Logan, Webster, Getchell et al 2015), physical fitness (Utesch, Bardid and Strauss 2019), weight status (Cattuzzo, dos Santos Henrique, Ré et al 2016) and physical self-perception (De Meester, Barnett, Brian et al 2020). Despite this rationale, data from multiple countries shows that children are not becoming proficient in a diverse range of movement skills (Bryant, Duncan, Birch et al 2016; Foulkes, Knowles, Fairclough et al 2015; Morley, Till, Ogilvie et al 2015; see Bolger, Bolger, O'Neill et al 2020, for a systematic review). As such, current PE pedagogical practice may not provide children with appropriate support or learning contexts that aid the development of a broad range of movement skills. This is worrisome, not just from a physical development perspective but also from an affective one.

An important affective component for continued participation in any activity is motivation. According to Self-Determination Theory (SDT; Deci and Ryan 1985; Ryan and Deci 2017), motivation lies on a continuum, from amotivation (the absence of motivation), to controlled motivation (externally driven action, lower levels of durability), to autonomous motivation (internally driven action, higher levels of durability). Associations between motivation and movement have been made previously. For example, different profiles of actual and perceived movement skill competence and organised sport participation have been examined, revealing that children with average to high levels on all these outcomes displayed the most optimal health-related profile (a healthier weight status and elevated levels of autonomous motivation; Coppens, De Meester, Deconinck et al 2021). Moreover, the teaching context has been found to be an important consideration for children's motivation. For example, it has been observed that controlling teaching behaviours is associated with controlled motivation (De Meyer, Tallir, Soenens et al 2014). Given that children's motivation is linked to the motivational climate they experience, it is important to understand what type of motivational climates different PE approaches foster.

Current PE Practice

Physical Education is the only subject in school where children effectively learn through movement (Rudd, Woods, Correia et al 2021). Traditionally, PE has been defined as a process of acquiring specific sport techniques and is based on a multi-skills approach where children generally engage in decontextualised practice of sport techniques (Kirk 2013). This inordinate emphasis on sport technique in PE has been heavily critiqued for lacking the conceptual and philosophical justification as well as empirical proof of its educational value (e.g., Kirk 2010). This type of pedagogical approach in PE is based on vague assumptions of how children learn to move, reinforced by traditional previous PE experiences (Randall and Maeda 2010). Through this approach, learning is episodic and does not aid progression of learning through the curriculum. In order to improve movement skills, movement learning theories that are grounded in a theoretical position and supported by empirical evidence should be explored. For example, two motor learning theories that dominate the PE landscape are information processing theory and ecological dynamics.

An IPT Approach to Learning

At the heart of the Information Processing Theory (IPT) perspective, is the view that the human mind is a system that processes information according to a set of logical rules and limitations similar to those of computer software (Adams 1971; Schmidt 1975; Schmidt, Lee, Winstein et al 2018; Wulf and Lewthwaite 2016). The theories emerging from this approach fit well within our current education system as they share the same foundations as current education learning theories, such as cognitive load theory (Ofsted 2019; Sweller 2010). Both IPT and cognitive load theory suggest that information enters through the sensory system and is selected, encoded and stored in either short-term memory or long-term memory, depending upon its importance (Goodway, Ozmun and Gallahue 2019). The IPT offers a top-down approach to movement with a representational construct located inside the brain, such as a schema or a trace, which is encoded and strengthened as a result of the learning process (Fitts and Posner 1973).

When we align ourselves to this worldview of how movement skill is acquired, it provides us with a framework to support and guide our pedagogy. For instance, learning movement skills progresses through three distinct stages: cognitive, associative, and autonomous. At the cognitive stage, there is a constant need to attend to the rehearsal and reproduction of specific movement components (e.g., practising FMS in a closed environment). Movements are proposed to be better aligned with verbal and visual cues provided by the teacher at the associative stage, before becoming more automatic with experience and practice. At the autonomous stage, an internal schema of the movement is fully developed and the recall of the schema is an automatic process (Fitts and Posner 1973; Schmidt 1975; Schmidt et al 2019). Within the IPT approach, educators use knowledge of skill learning to make informed judgements on the level or stage children currently reside in. This information is used to design and scaffold appropriate learning environments to facilitate learners' progression towards the stage of skill automaticity, employing tools such as Gentile's taxonomy (Gentile 2000) and Guadagnoli and Lee's (2004) challenge point framework (see Rudd, Crotti, Fitton-Davies et al 2020, Rudd, O'Callaghan, Williams et al 2019 for more PE related examples). Alongside using the tools outlined above, characteristically within the IPT approach, the teacher emphasises repetitive practice of an 'optimal' movement pattern through use of drills and corrective feedback to automatise performance. Curricula in PE that have used delivery characteristics in line with IPT have shown to improve FMS in five to 13-year-olds (Ayers, Housner, Gurvitch, et al 2005; Gusthart and Sprigings 1989; Kalaja, Jaakkola, Liukkonen et al 2012; Matvienko and Ahrabi-Fard 2010).

An Ecological Dynamics Approach to Learning

A contemporary view of movement learning advocates a more biophysical basis of human behaviour, proposing that children learn through an ecological framework. In ecological dynamics the focus is on developing a functional relationship, between the individual and environment (Gibson 1979). Learning within this theory is not dependent on the strengthening of internalised representations, as presented in IPT. Learning in an ecological approach emerges with changes to the whole system through self-organisation of the brain, body, and environment, thus strengthening the perceptual, cognitive and physical interactions between each individual and the environment (Kelso et al., 1995; O'Sullivan et al., 2020). Pedagogical approaches built upon ecological theory emphasise exploration, search, discovery and adaptation during motor learning (Rudd, Woods, Correia et al 2021).

The key role of the PE teacher is to design environments that are rich with information, offering each learner a landscape of opportunities to interact with the environment (known as affordances). The design of activities and tasks can help learners use affordances to achieve their intended goals by perceiving information and moving within the learning environment

(Chow, Davids, Button et al 2015). This idea is exemplified by teachers setting out varying levels of height in a gymnastics lesson to invite high movements (e.g., climbing and jumping) and low movements (e.g., crawling, body sliding). In an ecological approach, skills are not entities that are acquired and represented internally, but rather are adaptive relations that gradually emerge and are strengthened during an individual's continuous interactions with the environment and task. This interaction process results in learning which emerges as learners adapt from one stable state of movement organisation to another (more advanced state of organisation). Nonlinear Pedagogy (Chow et al 2015) offers a principled tool box for an educator to design, develop, implement, and manipulate constraints on each learner in ecological approaches to PE (see Chow, Komar, Davids et al 2021, Rudd et al 2020). This perspective of motor learning has also shown promising results in improving FMS (Barris, Farrow and Davids 2014; Clark, McEwan and Christie 2019; Greenwood, Davids and Renshaw 2016; Práxedes, Álvarez, Moreno et al 2019).

Finding a PE curriculum that can both support children to become proficient movers in an environment, and that is motivationally empowering, is integral for continued participation in PE and PA outside of school (Jaakkola, Washington and Yli-Piipari 2013; Standage, Duda and Ntoumanis 2003).Through adopting either of these two approaches (IPT or ecological), educators can create informed and developmentally appropriate PE curricula, which, in turn, will improve the quality of movement interactions in the PE experiences of five- to six-year-old children. Aligning with motor learning theory negates a major critique levelled at traditional PE approaches of the past: that they are too operational and lack a substantive conceptual basis. This conceptual deficit may weaken the pedagogical principles for planning, delivery and assessment (Kirk 2010). However, it is currently less clear how the pedagogical choices made by a teacher may impact on the motivational climate in PE (Teraoka et al., 2020).

Motivational Climates

As mentioned, an important affective component for continued participation in any activity is motivation. According to SDT, there are some more functional types of motivation than others, i.e., autonomous types of motivation that lead to adaptive affective, cognitive and behavioural outcomes (Vallerand, 1997, 2007), such as enjoyment, sustained participation, and use of leisure-time PA (Vasconcellos, Parker, Hilland et al 2019). However, to foster autonomous motivation, and by extension, adaptive outcomes, PE teachers must provide an empowering motivational climate over a disempowering motivational climate (Duda 2013). Duda (1992; in Ntoumanis, 2001; 2016, 2018) integrated two prominent theories of motivation – SDT and Achievement Goal Theory (AGT) – to develop an empowering and disempowering motivational climate framework (Figure 1). This framework explains that a PE practitioner, who encourages task-involvement, uses autonomy support, and displays socially supportive behaviours (i.e., relatedness support), could provide an empowering motivational climate that, in turn, fosters autonomous motivation and optimal functioning. A PE practitioner who displays ego-involvement and controlling behaviours is more likely to foster controlled motivation or even amotivation (i.e., a complete lack of motivation) and compromised functioning. An interesting question of theoretical and practical relevance concerns whether differing pedagogical approaches in primary PE might foster different motivational climates.

Motivational climates may occur to varying degrees due to the different behavioural characteristics emphasised by the pedagogies outlined above. Smith and colleagues (2017) examined differences in motivational climate (empowering and disempowering) provided by UK-based grassroots soccer coaches between competition and training environments, observing higher levels of disempowering and lower levels of empowering motivational climates in competition environments in comparison to training environments. Fenton and co-workers (2017) found a significant increase in moderate-to-vigorous-physical-activity in children (aged 9 to 16 years) who experienced more autonomous motivation due to an empowering motivational climate. Their study indicated that providing empowering motivational climates can, not only positively impact children's affect, but also their physical health.

[Insert Figure 1]

PE Approach Characteristics and their Theoretical Motivational Alignment

From Duda's (2013) empowering and disempowering motivational framework, the PE approaches outlined in this study may theoretically and differentially support the empowering and disempowering environmental dimensions (see Table 1 for compilation of teaching characteristics for the seven environmental dimensions). The following section elaborates on how different PE approaches may support these environmental dimensions, focusing on three of the seven dimensions. An important empowering environmental dimension is *autonomy support*, based on characteristics such as "providing meaningful choices" and "initiative taking" (Cheon, Reeve and Ntoumanis 2018; Smith, Tessier, Tzioumakis et al 2015). Characteristically, an ecological approach would theoretically provide multiple opportunities for meaningful choice and initiative taking as it encourages children to explore, discover and innovate free from prescriptive teacher input, through providing a wider, and more open, field of affordances (see Figure 2). Arguably, there may be fewer opportunities for meaningful choice and initiative taking within the IPT approach due to the higher levels of structure within it; however, this is not to say that the PE teacher could not offer some choice, for example, by offering choice over equipment or partners to work with.

[Insert Table 1]

Structure has been categorised as an empowering environmental dimension (Smith et al 2017) and its characteristics include "provides instructions and organisation" and "provides guidance throughout drills/activities/exercises". Characteristically, due to the overall rigid structure of the IPT approach (warm-up, drills, game; see Figure 2), theoretically, the effects of structure would be well supported. Arguably, structure may differ by being much more implicit within the ecological approach, having a greater emphasis on facilitating exploration of uncertain performance contexts for learners to discover affordances and harness self-organising tendencies.

An example of a disempowering environmental dimension is *controlling* which includes characteristics such as "uses controlling language (e.g., want, need, must)" and "use of extrinsic rewards" (Smith et al 2015; Reeve and Jang 2006). The IPT approach potentially runs the risk of creating a disempowering climate where the teacher and child may be confined by a technique-based curriculum, with a narrow, technical focus, training the child towards complying with production of an 'optimal' or desirable movement pattern. As such, teachers' interactions with children are likely to rely on the use of controlling language to prescribe specific movement solutions, focusing on specific body parts e.g., 'to hit the distant target with the ball you need to extend your throwing arm further back'. The intricacies of language during movement learning should not be underestimated, as demonstrated by Hooyman, Wulf and Lewthwaite (2014). They found that use of autonomy-supportive language (e.g., "feel free to go at your own pace") over neutral (e.g., "perform each series of throws in an efficient and consistent manner") or controlling language (e.g., "you must maintain a consistent pace") led to greater perceptions of choice, higher self-efficacy, more positive affect and enhanced learning. Motor learning, from an ecological approach, does not prioritise an established body of *knowledge about* the task, transmitted to a passive recipient from an authorised agent, such as an educator (Chow et al., 2016). Rather, it is a progressively deepening embodied attentiveness, where an individual learns to self-regulate by becoming more responsive to people and environmental features by 'looking, listening and feeling'. In facilitating this exploratory process, the teacher takes on the role of *learning designer*, guiding, nudging, modelling or showing. This is a 'softer' pedagogical approach that unveils a world to be further explored and discovered by the child (Rudd et al 2021).

[Insert Figure 2]

Due to the typical lack of pedagogical theorising on the value of a multi-skills curriculum, current PE practice tends to be varied and sporadic (Kirk 2013). It is, therefore, more difficult to theoretically align such an approach with this motivational framework. Following, it can be assumed that the environmental dimensions included within empowering and disempowering motivational climates would be weakly supported in traditional PE, culminating in low empowering and disempowering motivational climates. With regards to disempowering motivational climates, low levels are better; however, the addition of low levels of empowering motivational climate could consequently lead to dissatisfaction in learners and disengagement (Cheon, Reeve, Lee et al 2019).

The aim of this study was to investigate to what extent both ecological and IPT PE curricula support the emergence of empowering and disempowering motivational climates in comparison to usual PE practices.

Methods

This study formed an aspect of the process evaluation of the Skill Acquisition Methods fostering Physical Literacy in Early-Physical Education (SAMPLE-PE) cluster randomised controlled trial (Rudd et al 2020) with data collected during a 15-week PE intervention that ran between February and May 2018. Twelve schools were randomly allocated into an intervention condition (IPT: n=3 schools; Ecological Dynamics: n=3 schools) or control group (n=6 schools) using a computer-based random number-producing algorithm by an independent researcher not associated with the study. The intervention contained three blocks of five weeks, where a different movement discipline was the focus (dance, gymnastics, and ball skills) for both Ecological Dynamics and IPT groups. The control group carried on with their normal PE provision; however, consistency was sought with regards to time allocations between all groups, with PE lessons held twice a week for 60 minutes. This study was approved by the institutional research ethics committee (Reference 17/SPS/031). Gatekeeper consent was obtained from headteachers, informed consent from parents and recruited practitioners and informed assent from children before participation in the PE lessons and data collection.

Intervention

The research team, with expertise in IPT and Ecological Dynamics, developed the PE curricula and their content over three months, as well as a training course for prospective practitioners within the study. All recruited practitioners attended a bespoke five-week training programme which consisted of one session a week lasting three hours, split evenly between theory and practice. Three qualified sport practitioners received Ecological Dynamics theoretical and practical training, and two qualified practitioners received IPT theoretical and practical training. Trained practitioners were assigned to schools according to their availability as schools scheduled PE on different days and times throughout the week. At the end of the training period (15 hours over five weeks), each practitioner received a scheme of work and pedagogical framework for each PE subject (dance, gymnastics, and ball skills), plus a resource pack covering key elements of their respective pedagogical approach. Each practitioner was supported by the research team in designing lesson plans. Recordings of the theoretical and practical training sessions were accessible to them online.

The Information Processing Theory Curriculum (IPT group)

The IPT lessons were guided by a transmission-based approach (see Appendix A), which consisted of a teacher-led warm-up, skill and technique development (i.e., drills), and finished with a performance environment structure (i.e., a game). Emphasis was placed upon the practitioner to demonstrate optimal movement templates for the children to replicate within low environmental variability activities. As skill improved, practitioners placed the children in gradually more variable and dynamic learning environments based upon Gentile's (2000) taxonomy. In each lesson, previously taught content was reinforced and children were taught a new skill movement following this taxonomy for linear progression before transitioning into a game or dance/gymnastics performance. Practitioners were trained to identify children's current stage of learning, using Fitts and Posner's stages of skill learning model (Fitts and Posner 1973). They then identified the optimal challenge to support learning through understanding of the challenge point framework (Guadagnoli and Lee 2004).

The Ecological Curriculum (ecological group)

The ecological lessons followed a lesson plan created for SAMPLE-PE (see Appendix B). The research team worked with the practitioners to identify common constraints on learning between schools (e.g., class sizes, lesson duration) and children (e.g., age, socioeconomic demographic) in order to design each lesson plan. This constraint manipulation approach created an expected range of variation that could be planned for in order to design individualised lessons for the children. Practitioners created representative learning environments that would encourage children, first, to explore (safely), but then to also afford movement opportunities that were aligned to foundational movement themes such as jumping, sending a ball, intercepting an object in space. To exemplify a task design, the practitioner set out benches and spots on the ground, spaced at specific distances to afford different types of jumping for individual children, based on their level of movement competency and the scaling of their lower limbs. Practitioners were trained to follow and utilise two models within their teaching comprising: Newell's model of motor learning (Newell 1986) in order to identify movement stages of self-organisation (coordination, control or skill), and the STEP framework

(Space, Task, Equipment, and People; Youth Sport Trust 2018). The STEP framework involves the manipulation of constraints, which alter task difficulty, increasing and decreasing the range of available affordances within an environment. Manipulations were designed to make it easier or more challenging for the children to seek, explore and adapt a functional movement solution.

The Traditional Curriculum (control group)

The control schools were asked to provide their typical PE provision where the only requirement was that they ensured that the children took part in two sessions of PE a week, and last 60 minutes each so that the dose was comparable with the intervention groups. The control schools followed mainly ball-skills and running activities during the study period (Table 2) with no gymnastics or dance lessons, or apparent indications of planning or implementation of pedagogical principles.

[Insert Table 2]

Participants

Practitioners

Three practitioners were recruited from the in-house coaching provider within a University in North West England who were also enrolled on an undergraduate sports coaching course, alongside two practitioners who were members of the research team (practitioners 1-5). All held the minimum operating standard to coach (i.e., a level 2 qualification), meaning that they had the experience of independently planning, preparing, and delivering sessions as well as basic emergency first aid, safeguarding, and protecting children certification.

Procedure

PE lessons were video-recorded via a stationary GoPro positioned at an optimum position within the PE hall or outside area so that the whole class of children and the practitioner were covered throughout the lesson duration. Video recordings were captured so that motivational climate coding could be conducted at a later date. Each practitioner was asked to wear a wireless radio mic (Sennheiser, series ew 100 G2) during the PE lesson so that audio and video recordings could be analysed using the Multidimensional Motivational Climate Observation System (MMCOS; Smith et al. 2015). Researchers recorded the start and end time of PE lessons to record the duration of each lesson across the ecological, IPT, and control groups. The aim was to run and capture 60 minutes per PE lesson; however, due to reasons such as school schedule and variation in children's changing procedures and times, the duration of lessons varied across all groups, ranging from 19 minutes and 29 seconds to 48 minutes and 1 second. However, when lesson duration was averaged across the 15 lessons, no statistically significant differences were found between the groups for amount of time spent in PE (p = .06). Although 45 lessons were recorded, one lesson within the control group could not be used due to a microphone malfunction, resulting in 44 captured lessons.

Measurement

Pedagogical Fidelity

Thirteen of the 44 PE lessons were coded by two research assistants to establish pedagogical fidelity. Each lesson was quartered by time, and pedagogical behaviours were coded, on a sliding scale between Pedagogy A and Pedagogy B, according to an especially developed pedagogical checklist. The checklist (which can be found in Appendix C) consisted of seven motor learning categories that were coded for every quarter lesson (e.g., Pedagogy A: *Children learn the skill first in closed decontextualised environments then apply new skills in a performance environment*; Pedagogy B: *Movements are always learnt in context (music, storytelling, scenarios or games)*), and two global categories (e.g., Pedagogy A: *Lesson progression is through a clear and linear structure, warm-up, drills, game/performance and* *cool down*; Pedagogy B: *Lesson evolves through storytelling, scenarios or games*). Global categories were judged for the overall lesson, rather than within quartiles. Both coders were blind to school allocation within the intervention. For information on coder training, please see Appendix D.

Interrater reliability was determined by using the coded video data from 10 PE lessons. Intraclass correlation coefficients (ICC) were run with a two-way mixed, average measures for absolute agreement, with 95% confidence intervals. All category items (n=7) and both global items had ICCs of .97 and above, which is considered excellent (Cicchetti 1994). One inter-rater reliability check was made, consisting of three PE lessons to avoid drift.

Motivational Climates

The MMCOS (Smith et al 2015) integrates SDT and AGT to assess the psychological potency of the environment the practitioner has created. The MMCOS has a hierarchical structure. The observer codes the practitioner according to two higher-order factors (empowering and disempowering), seven environmental dimensions (autonomy support, relatedness support, task-involving, controlling, relatedness thwarting, ego-involving, and structure) and 32 lower-order practitioner behaviour strategies. The coder splits the video-recorded session into quarters and for every quarter provides a code for each of the seven environmental aspects based on observations of the 32 practitioner behaviours via a 4-point potency scale (0=*not at all*, 1=*weak potency*, 2=*moderate potency*, 3=*strong potency*). After the full session has been viewed, the coder provides an overall rating for the amount the climate was perceived to be empowering or disempowering, based on the same 4-point potency scale used for the individual environmental dimensions. Therefore, the tool produces seven mean scores (one per environmental dimension) and two overall hierarchical mean scores (the extent to which the whole lesson was considered empowering or disempowering). Higher and lower scores on both the empowering and disempowering motivational dimensions indicate stronger and weaker potency, respectively. Two coders (first author and postgraduate researcher) followed the training and coding protocol outlined by Smith et al (2015). Coder training consisted of stages 1 to 5 in Figure 3 while independent coding was carried out in stage 6. The first author could not be blinded against the allocation of schools into their respective groups, whereas the second coder was blinded to group allocation.

Interrater reliability (Stage 4 of Figure 3) was determined by using the coded video data from stage 3. Intraclass correlation coefficients (ICC) were run with a two-way mixed, average measures for absolute agreement, with 95% confidence intervals resulting in ICCs between 0.75 and 1 for autonomy support, task-involving, relatedness support, relatedness thwarting, and structure which is deemed excellent (Cicchetti 1994). As there was zero variance for ego involving and controlling behaviours between independent raters, SPSS could not generate an ICC for these dimensions; however, the scores had 100% agreement between raters. Intra-rater reliability checks (test-retest) took place 5-7 days after coding for interrater reliability. Both coders were above 0.75 for all dimensions, except for controlling and relatedness thwarting where zero variance was found for both coders and one coder respectively on those dimensions (there was 100% agreement on scores over the two time points). Two inter-rater reliability checks were made to avoid drift: the first after independently coding nine videos each and the second check after a further four videos. Interrater reliability checks consisted of independently coding the same PE lesson and comparing scores.

[Insert Figure 3]

Main Outcomes Statistical Analysis

All statistical tests were completed using SPSS, version 26 [IBM SPSS Statistics Inc., Chicago, IL, USA]. Descriptive statistics, including mean and standard deviation, were calculated for each variable. Overall mean scores of the three time points were used in order to capture an overview of the motivational climates within PE pedagogies over a relatively long period, in this case, almost four months. To investigate the overall motivational climates of each PE approach, two separate ANOVAs were run for hierarchical empowering and disempowering motivational climate scores, and Bonferroni post-hoc tests were conducted to explore any significant differences between intervention groups. To investigate the empowering and disempowering environmental dimensions, two separate MANOVAs were run, due to multiple dependent variables, the first for empowering dimensions and the second for disempowering dimensions. Again, Bonferroni post-hoc tests were conducted to explore any significant differences between intervention groups. Separate MANOVAs were conducted as dependant variables should be theoretically related and it was of interest to discern between the prevalence of disempowering and empowering dimensions between groups. Due to the fact that the *structure* dimension did not correlate, as expected, with the other empowering dimensions (nor with the disempowering dimensions), it was removed from the empowering dimension MANOVA analysis and instead was inputted as the dependent variable within a one-way ANOVA, followed by a Bonferroni post-hoc test. Assumptions are described below for each analysis.

Results

Observed PE lessons

The number of observed lessons delivered by each practitioner within the intervention groups and the control group can be seen in Table 3. Due to staffing issues during the intervention, practitioner 3 in the ecological group had to deliver two lessons (out of the 15) in the IPT group, and practitioner 5 had to deliver one lesson (out of 15) in the ecological group. Practitioners 3 and 5 were members of the research team and considered experts in their knowledge and practical experience of the ecological and IPT approaches. When checked statistically, removal of these crossover lessons bore no influence upon the overall results for discerning empowering and disempowering climates or upon the individual environmental dimensions within each climate.

[Insert Table 3]

Pedagogical Fidelity

Means and standard deviation values for each category and global items can be seen in Table 4 (fidelity items can be found in Appendix C). It can be seen that for each category, each pedagogy has a mean score within its own section of the sliding scale (ecological: 4 and 5, IPT: 1 and 2), indicating that ecological characteristics were represented in the ecological group and information processing characteristics were represented in the IPT group. Global mean scores also indicate that the overall pedagogical judgement based on these categories was aligned with the expected pedagogy. The control group indicated a stronger representation of IPT characteristics than ecological. Overall, pedagogical impression judged the ecological approach to be 100% ecological in its delivery. The IPT group was found mostly to have characteristics of IPT in its lesson delivery; however, there was also some evidence of characteristics related to ecological approaches (3.33%). The atheoretical PE group was found to display mostly IPT characteristics.

[Insert Table 4]

Overall Hierarchical Empowering and Disempowering Climate

Motivational climate descriptive data for each time point and overall mean are presented in Table 5. Two one-way ANOVAs were conducted with the intervention group (atheoretical, ecological, and information processing theory) as the fixed factor and overall hierarchical empowering climate score as the dependent variable in the first ANOVA and hierarchical disempowering climate scores as the dependent variable in the second ANOVA.

Empowering

There were no outliers, as assessed by boxplot; data were normally distributed for each group, as assessed by Shapiro-Wilk test ($p > .27$); and there was homogeneity of variances, as assessed by Levene's test of homogeneity ($p = .74$). There were no significant differences in hierarchical empowering climate score between the different PE approaches, $F\,(2,11) = 2.43$, $p = .13$, partial $\eta^2 = .31$.

Disempowering

There were two outliers (one in the ecological group and one in the IPT group), as assessed by boxplot; however, they were kept within the analysis as they were not a result of data-entry or measurement error; and there was homogeneity of variances, as assessed by Levene's test of homogeneity ($p = .10$). There was a significant difference in hierarchical disempowering climate score between the different PE approaches, $F\,(2,11) = 9.45$, p = .004, partial $\eta^2 = .63$. Bonferroni post hoc analysis revealed that the atheoretical group was significantly more disempowering than the ecological group ($p = .03$, 95% CI [.03, .51]), and the IPT group was significantly more disempowering than the ecological group ($p = .005$, 95% CI [.11, .56]). No other group differences were statistically significant.

[Insert Table 5]

Empowering and Disempowering Dimensions

Table 5 also includes the means and standard deviations of the overall distribution of scores for each environmental dimension within empowering and disempowering climates (a score of 2 indicates moderate potency). High mean scores (>2) can be seen for the *relatedness* *supportive* dimension across all groups within the empowering motivational climate construct. Lower mean scores (<2) can be seen for *autonomy-support*ive within the control and IPT groups.

Two one-way MANOVAs were conducted with the intervention group (control, ecological, and IPT) as the fixed factor and overall hierarchical empowering dimension provision scores as dependant variables in the first MANOVA, and disempowering dimension provision scores as dependent variables in the second MANOVA.

Empowering

There were five outliers (one in the ecological group and four in the IPT group) as assessed by boxplot; however, they were kept within the analysis as they were not a result of data-entry or measurement error; data was normally distributed for each group, as assessed by Shapiro-Wilk test (p > .07), except for the *relatedness supportive* dimension within the ecological group (p = .002). Multicollinearity was assessed by Pearson correlation where the *structure* dimension was found to negatively correlate with two other dimensions and was consequently removed from this analysis (to be analysed separately in a one-way ANOVA); no other multicollinearity was detected. There were linear relationships, as assessed by scatterplot; there were no multivariate outliers in the data, as assessed by Mahalanobis distance (p > .001); there was homogeneity of variance-covariances, as assessed by Box's test of equality of covariance (p = .66); there was homogeneity of variances, as assessed by Levene's test of homogeneity of variance (p > .20). There was a statistically significant difference between groups on the combined dependent variables, F (6, 20) = 3.58, p = .01; Pillai's Trace = 1.04, partial η^2 = .52. Follow-up univariate ANOVAs showed that there was a statistically significant difference between groups on the autonomy-supportive dimension only, F (2,11) = 10.74, p = .003; partial η^2 = .66.

Bonferroni post-hoc test showed that mean scores for the *autonomy-supportive dimension* were significantly different between the control and the ecological approach (p = .03, 95% CI [-5.06, -.20]), with the ecological approach scoring significantly higher than control, and between the ecological and IPT approach (p = .003, 95% CI [1.37, 5.96]), where the ecological approach scored significantly higher than the IPT approach. However, no statistically significant differences were found between the IPT approach and control (p = .77).

Disempowering

There were two outliers (both in the ecological group) as assessed by boxplot; they were kept within the analysis as they were not a result of data-entry or measurement error; data was normally distributed for each group, as assessed by Shapiro-Wilk test (p > .20); there was no multicollinearity, as assessed by Pearson correlation (r > .11, p > .14); there were linear relationships, as assessed by scatterplot; there were no multivariate outliers in the data, as assessed by Mahalanobis distance (p > .001); there was homogeneity of variance-covariances, as assessed by Box's test of equality of covariance (p = .56); there was homogeneity of variances, as assessed by Levene's test of homogeneity of variance (p > .09). There was a statistically significant difference between groups on the combined dependent variables, F (6, 20) = 2.98, p = .03; Pillai's Trace = .94, partial η^2 = .47. However, follow-up univariate ANOVAs showed no significant differences between groups on any of the dimensions: ego-involving (F (2,11) = 3.73, p = .06; partial η^2 = .40), controlling (F (2, 11) = .89; p = .44; partial η^2 = .14), and relatedness thwarting (F (2, 11) = 2.95; p = .09; partial η^2 = .35).

Structure

There were no outliers, as assessed by boxplot; data were normally distributed for each group, as assessed by Shapiro-Wilk test (p > .49); and there was homogeneity of variances, as assessed by Levene's test of homogeneity (p = .29). There was a significant difference in hierarchical disempowering climate score between the different PE approaches, F (2,11) = 14.70, p = .001, partial η^2 = .73. Mean scores for the *structure dimension* were statistically significantly different: (i) between the control and the IPT approach (p = .001, 95% CI [-5.73, -1.80]), with the IPT approach scoring significantly higher than control, and (ii) between the ecological and IPT approaches (p = .04, 95% CI [-3.72, -.02]) with the IPT approach scoring significantly higher than the ecological approach. There was no statistically significant difference between the control and the ecological approach (p = .60).

Discussion

This study explored the extent to which traditional PE teaching approaches, and PE underpinned by motor learning theory, supported empowering and disempowering motivational climates. Findings revealed that there were high levels of empowering motivational climate across the approaches. The level of disempowering motivational climate was low, although IPT and traditional approaches demonstrated significantly more disempowering motivational climate than the ecological approach. When the individual environmental dimensions were investigated, the ecological approach provided significantly more autonomy support than the IPT and traditional approaches. The IPT approach provided significantly more structure than the ecological and traditional approaches. The next section will explore and discuss possible reasons as to why these between group differences in the environmental dimensions were found.

A Pedagogical Continuum

Based on the findings, a continuum of practice design describes the different pedagogical approaches that can be used in PE curricula (Figure 2). At one end are technical models of movement competence, which emphasise a highly structured and isolated set of practice tasks. At the other end are exploratory movement models, which emphasise practice tasks that are less structured and have less teacher involvement. In between, are guided discovery methods, which are grouped together, although they are grounded in different philosophical views of learning, that provide some structure but also more autonomy for learners to search the task. The PE teacher does not have to be constrained to one type of pedagogical approach, instead moving along the continuum to suit the needs of a specific group of learners.

A continuous Ecological Approach

The data on the empowering environmental dimensions (autonomy-supportive, task-involving, relatedness supportive, and structure), revealed that 15 weeks of PE lessons in the ecological approach provided significantly more of the autonomy-supportive dimension. Autonomy-supportive potency scores were derived from judgements made across the lower-order behavioural characteristics (*provides meaningful choices/provides a rationale for tasks, requests and constraints/emphasises and encourages intrinsic task interest/creates opportunities for input/encourages initiative taking, and acknowledges feelings and perspectives*; Smith et al., 2015).

The wider literature has shown that children who experience autonomy-supportive teaching within PE are significantly more likely to feel more autonomy, competence and relatedness need satisfaction (Chang, Chen, Tu and Chi 2016; Haerens, Aelterman, Vansteenkiste et al 2015), self-determined motivation and enjoyment (Fin, Moreno-Murcia, León et al 2019) and PA (Escriva-Boulley, Tessier, Ntoumanis and Sarrazin 2018) in comparison to regular PE lessons. Many articles within the literature have investigated the impact of using choice as an isolated behavioural characteristic, demonstrating positive results. For example, choice alone has indicated positive relationships with intrinsic motivation, effort and task performance (Patall, Cooper and Robinson 2008). The latter is arguably important, from the teachers' perspective, as FMS (a performance outcome) is a significant aim of PE. The literature has also demonstrated the positive motivational effects from *different* types of choices that teachers can provide children, for example, type of activity (Ward, Wilkinson, Graser and Prusak 2008), the student role during the lesson (How, Whipp, Dimmock and Jackson 2013), and who children want to work/play with during the lesson (Mouratidis, Vansteenkiste, Sideridis and Lens 2011). Interestingly, De Meester, Van Duyse, Aelterman, De Muynck and Haerens (2020) found that children aged 12-13 years with better motor skills felt more controlled motivation when offered the prospect of choice (choice over who to work with, at what level and when) than children with lower motor skills. The authors theorised that this finding may be because higher skilled children felt pressured to choose the more challenging level of activities due to their motor skills status. It is clear from previous literature that choice generally leads to positive outcomes; however, the majority of research has been conducted with older children aged 10 years and above. Younger children, especially those aged 5-6 years as is the case in this current study, cannot yet fully judge their own competence level (Harter, 1988) and as such, may not feel the pressure that the older children felt in the study by De Meester et al. (2020) that theoretically led to feelings of controlled motivation. From the data in this study, it is not possible to determine which of the autonomy-supportive lower-order behavioural characteristics were most potent. However, from a practical perspective, providing choice is a concrete characteristic which supports volition (Taylor and Ntoumanis 2007; Taylor, Ntoumanis and Standage 2008), and is arguably easy to implement in practice. The current study somewhat supports the theoretical assertion described in the introduction; that designing fields of multiple opportunities for action (affordances) within learning environments for children, allows them space and time to seek, discover and explore functional movement solutions (i.e., volition and opportunities for different types of choice)."

This inference can be made with confidence as the ecological and IPT approaches were coded in-line with their respective sides of the sliding scale for Global item 1 of the fidelity check (Pedagogy A (IPT): *PE teacher/coach prescribes children to perform fundamental movement skill or set of fundamental movement skills. Children learn an optimal movement template or technique of a particular skill or series of skills*; Pedagogy B (ecological): *PE teacher/coach creates an environment for children to perform functional movement solutions through interaction with the environment and task. Children learn to explore and interact with their environment to find functional solutions*). Lessons where children explored (i.e., the ecological group) their learning environments encouraged the *initiative-taking* behavioural characteristic of the motivation coding system (MMCOS). Ecological lessons were judged to *provide meaningful choices* (here, meaningful is considered a 'real' choice, rather than an externally-pressured choice provided by the teacher where, in fact, it is not a choice at all). This lesson design was achieved through making all equipment available to children to allow them to decide which to use in exploring movement solutions. Supporting this sort of choice may not seem meaningful to adults; however, it has been found that instructionally-irrelevant choices (e.g., colour of beanbag) influence children's autonomy need satisfaction and intrinsic motivation (Cordova and Lepper 1996; Patall et al 2008). Therefore, these fundamental choices may be considered meaningful to young children, especially in an environment that is usually highly controlled (e.g., *physical-education-as-sport-technique* in PE).

The *task-involving* and *relatedness-supportive* environmental dimensions did not differ significantly between the ecological group and the other two groups. This lack of difference may be because, for the *relatedness-supportive* dimension, levels were already high across the groups, indicating that most, if not all the PE practitioners, had warm and caring demeanours towards their pupils. This is the generally expected demeanour towards early years children and, therefore, should not be a surprise. Regarding the *task-involving* environmental dimension, it may be that none of the three approaches inherently supported the behavioural characteristics of the dimension, indicating that differences would not be found and that practitioners across the groups could do more to support this particular empowering dimension. However, this work is not definitive and should be further explored in future research studies.

A continuous IPT Approach

Compared to the ecological and traditional approaches, the IPT approach provided significantly more of the *structure dimension*. The IPT approach provided children with more structure as the lessons followed clear task-by-task instructions and set sequencing, not only for how to learn movement skills but also for the transitions between practice tasks and environments. This inference is supported by Global item 2 of the fidelity check (Pedagogy A (IPT): *Lesson progression is through clear and linear structure, warm-up, drills, game/performance and cool down*; Pedagogy B (ecological): *Lesson evolves through storytelling, scenarios or games*). This amount of structure meant that children knew what was expected of them at a set time (a structure characteristic; Jang, Reeve and Deci 2010). Structure provision supports competence (Vasconcellos et al 2019) and, mediated by autonomous motivation, positively predicts enjoyment, perceived importance of PE and intention to participate in PA outside of school (Sanchez-Oliva, Sanchez-Miguel, Leo et al 2014). It seems evident that PE teachers should provide as much structure as they can; however, structure is also likely to provide support for other behavioural dimensions where structure can be delivered in an autonomy-supportive, ego- or task-involving manner (Smith et al 2015). Using the circumplex approach (for information on the circumplex approach please see Aelterman, Vansteenkiste, Haerens et al 2019), it has been demonstrated in a sample of Belgian and French PE teachers (Escriva-Boulley, Descas, Aelterman et al 2021) that the *clarifying* (a subdomain of need-supportive structure) and *demanding* (a subdomain of need-thwarting control) teaching styles are positively and moderately correlated. This association empirically illustrates the risk taken when providing a high directiveness (i.e., a higher level of teacher input) approach to teaching. Cheon, Reeve and Vansteenkiste (2020) highlight the potential difficulty in integrating autonomy-support and structure. However, Cheon and colleagues demonstrate that when teachers are trained on how to deliver structure in an autonomy-supportive way, not only do the children benefit (e.g., improvements in their autonomy and competence need satisfaction, classroom engagement, skill development, anticipated PE performance, and future intention to exercise), the teachers also benefit (e.g., improvements in their teaching efficacy, harmonious passion, job and relationship satisfaction, and intrinsic goals).

Therefore, although PE teachers should provide structure in their lessons, they should be mindful of how they provide that structure. According to Cheon et al (2020), teachers can integrate autonomy-support and structure through providing expectations, guidance and feedback, and while doing so, take the children's perspective, vitalize autonomy, provide explanatory rationales, acknowledge any negative feelings and rely on invitational language. Currently, research investigating the effects of competence support is scarce (Vasconcellos et al 2019) in younger populations and requires further study.

The Threat posed by Disempowering Motivational Climates

It should be reiterated that all the groups scored low on the disempowering motivational climate potency scale. However, there was a significantly greater disempowering motivational climate in the traditional and IPT groups in comparison to the ecological group. To the authors' knowledge, this is one of the first studies to explore the empowering and disempowering motivational climates in early years PE, making comparisons across studies difficult. However, the literature does indicate that practitioners must be mindful of the possible disempowering characteristics they display, which can accumulate into an overall disempowering motivational climate. Positive associations have been found between perceptions of disempowering motivational climates and negative social behaviours such as quick-temperedness and disruptiveness in 11-year-old children within PE (Kolovelonis et al 2015) and disposition to cheating (Borrueco et al 2018) in 13-19-year-olds within a soccer club.

In younger children, a systematic review of motivational climate interventions in PE found that maladaptive outcomes such as anxiety, ego-orientation, competitive strategies and boredom were largest in performance climate conditions, argued to be disempowering (Braithwaite, Spray and Warburton 2011). Although this review included studies conducted in younger children (five years old), these maladaptive outcomes were not addressed within these particular studies (i.e., studies with younger children focused upon movement skills). Maladaptive outcomes were also not assessed in the current study and should be targeted in future research to obtain a more holistic understanding of children's pedagogical experiences and determine the potential consequences (detrimental or otherwise) of prolonged experience using IPT or traditional approaches. Additionally, although there were significant differences in overall disempowering motivational climates, there were no significant differences between PE groups on any of the disempowering environmental dimensions. This lack of significant difference may stem from very low scores on each dimension across the groups. More research is necessary to specifically investigate the level of representation for each dimension in order to understand and inform best practice for practitioners.

Moving forwards with the Pedagogical Continuum and Practical Implications

A better integration of pedagogical and psychological knowledge has been called for (Van den Berghe, Vansteenkiste, Cardon et al 2014), and this study has taken a first step towards understanding the motivational climates that traditional PE and PE supported by motor learning theory can provide. As motor learning theory is intertwined with psychology, educational approaches underpinned by motor learning theory could provide a good platform for integrative practice of pedagogy and psychology. As a result, although this study is by no means definitive, it has highlighted nuances in motivational support between different pedagogical approaches.

School PE curricula include a range of educational outcomes, including physical, affective, cognitive and social (Bailey, Morley and Dismore 2009). In order to support children in achieving these outcomes, it is important to foster a positive learning environment in PE lessons. This study has indicated that using a pedagogical approach underpinned by motor learning theory has promising positive effects when regarding motivational climates. The implication of this observation is that there is a time and place to move along the pedagogical continuum, varying the number of affordances that are available to children in PE, reflected by the needs of the PE teacher and the *effectivities* (Gibson, 1979) (e.g., confidence, motivation and movement repertoire) of learners. PE teachers should, therefore, be relatively confident that using such approaches are beneficial to children physically and affectively. Overall direct practical suggestions from this work would be for practitioners to offer as much autonomy as possible, but as a bare minimum, offer choice over equipment, partners and groups. Practitioners should also incorporate some level of structure so as not to invite dysfunctional chaos in learners who may not be used to this level of autonomy. This approach could include providing consistently broad guidance and informational feedback on an individual, group and whole class level.

Strengths, Limitations, and Future Research

This study provides a valuable contribution towards the investigation and integration of pedagogy and motivation. It has demonstrated that different pedagogical approaches can provide inherently different motivational climates which should be considered when implemented by PE teachers. Education of in-service PE teachers, as well as trainees, needs to take into consideration that different pedagogical approaches can provide different learning opportunities for children, depending on their needs (see Moy, Renshaw and Davids 2016). The fact that this study sampled multiple observations over time (15 weeks) should be considered as a strength as it lends confidence to the outcomes and it is more representative than just a snap-shot in time (i.e., one observation). Motivational climates facilitated by the different approaches may have a differing accumulative effect which may impact children's learning and motivation to engage in PA in the long-term. The use of video analysis and excellent inter-rater reliability (Cicchetti 1994) is also seen as a strength, as self-report can be unreliable due to bias (Koziol and Burns 1986; Teraoka et al 2020; Van de Mortel 2008). It is also the first study to investigate the motivational climates within pedagogies underpinned by motor learning theory within the practical educational setting of a primary school, which indicates good ecological validity. A fidelity check confirmed that both pedagogies carried out their respective set of pedagogical characteristics, which is considered a major strength.

The main limitation of this study was that, because there were many practitioners involved in delivering PE across the groups, and because there were only five observation points per time point per group, it was not possible to control for the effect of individual practitioner. Future research should look to observe more PE lessons and limit the number of practitioners involved in order to control for this effect. A benefit to the literature would be for future research to specifically include class teachers, which would help us better understand the diverse nature of practitioners in schools. Applying these strategies with class teachers would also negate any potential effect from using outside practitioners. As the number of observations was not large enough, investigation of motivational climates per PE topic could not be conducted. Vallerand (1997, 2007) stated that motivation can be considered on a global, contextual, or situational level. Future research should consider how motivational climates are represented in curricular topics such as dance, gymnastics, and ball skills. Future research should also aim to capture children's basic psychological need satisfaction; however, no such validated assessment currently exists for younger children and would also be a future direction for research. Future research should also aim to assess maladaptive outcomes to capture potential adverse effects of more disempowering motivational climates.

Conclusion

To our knowledge, this is the first study to investigate motor learning theory-based pedagogies from a motivational perspective within primary school settings. Overall, the observed PE lessons in this study demonstrated more empowering than disempowering motivational climates, which demonstrates a positive outlook of PE within this study. Nevertheless, PE practitioners should keep in mind the motivational consequences of the pedagogies that they use. We now have a better understanding of how motor learning theory-based pedagogies support motivational climates and potentially provide valuable information towards supporting meaningful experiences that will help to set children upon a lifelong journey of healthy and active living.

Acknowledgements

The authors thank the schools, teachers, and children for participating in this research. The authors also thank Mary Rossiter Gurrell for her help in coding the observed PE lesson videos, and Kiersten Jones and Frederike Marie Stell for their help with the pedagogical fidelity check.

Declaration of interest statement: The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper

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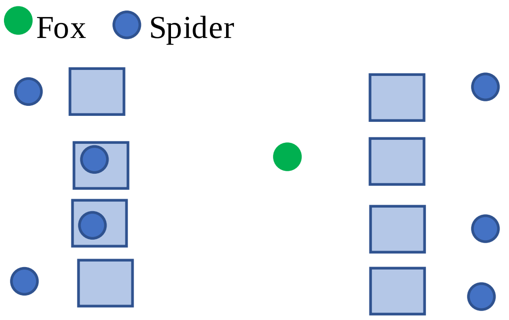
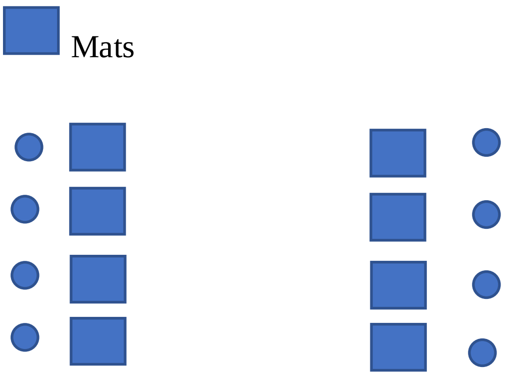
Appendices

Appendix A: Information Processing Theory Plan

	Gymnastics
B3: Lesson No	*Lesson 3*
Lesson Outcome	Demonstrate mastery in balance and rolling
Desired outcome	To be able to maintain the balance on different surfaces and on different parts of the body a roll and a static
Progression based on Gentiles' taxonomy	Foster children motor skills learning by increasing the difficulty of the task over the lessons using Gentile's taxonomy: **Body**: from no-body transport → to body transport **Object**: from no object → to manipulation of object **Motion**: from environment still → to environment moving **Intertrial Variability**: from no intertrial variability → to intertrial variability
B8: Whole Class Task Activity	**Warm up** The thieves Foxes and spiders. Spiders have to move from a nest to another but the fox will try to stop them. If a spider gets tagged by a fox it remains stuck and only the other spiders can help him.  **Drill 1** Children occupy all the space in the hall. Roll like a log in the forest, rolling 2 times on the left and then two times on the right. • Arms on the waist • Arms extended over the head • Arms crossed on the chest 

Drill 2

Progression to get to a frontal roll

A little egg in the chest start moving.

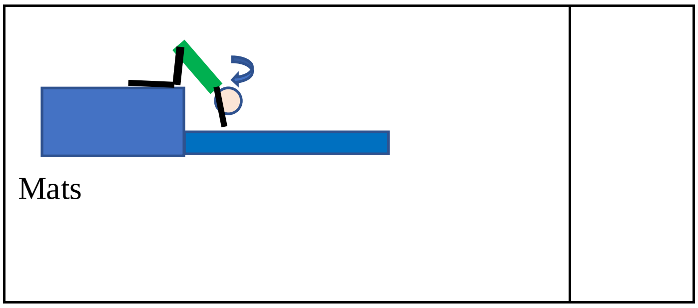
From a squatting position roll on the back and try to get back to the starting position.

Drill 3 ***(ONLY do this in one group at a time if you think they are able. The rest to carry on with previous drill).***

From a big mat and with the help of the teacher the child rolls to another mat

In black the limbs

And in green the torso

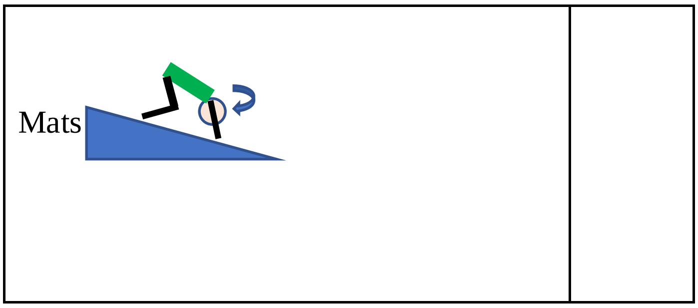


The head cannot touch the lower mat. Arms flexed.

Hip higher than the shoulders

The teacher might help children who cannot perform the roll by putting a hand behind their neck and one on their leg

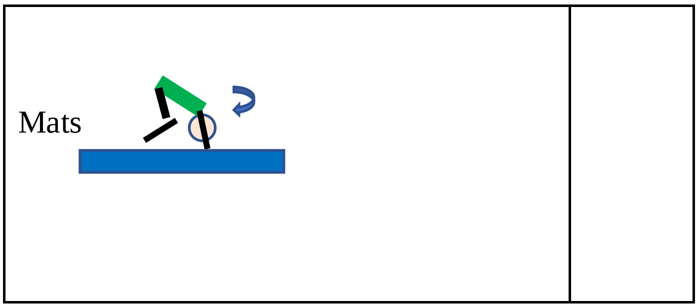
From a smaller mat that was used in the previous drill and with the help of the teacher the child rolls to another mat



The head cannot touch the lower mat.

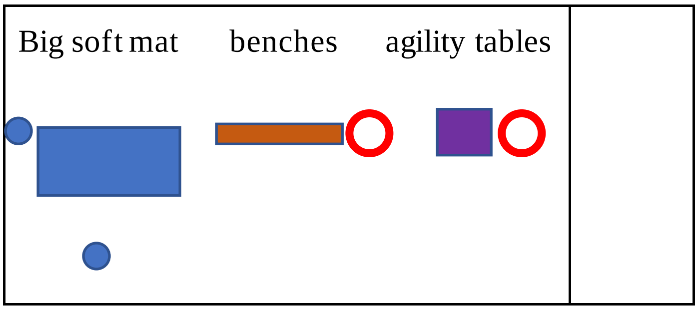
Drill 4

From a smaller mat that was used in the previous drill and with the help of the teacher the child rolls to another mat



The head cannot touch the lower mat.

Performance

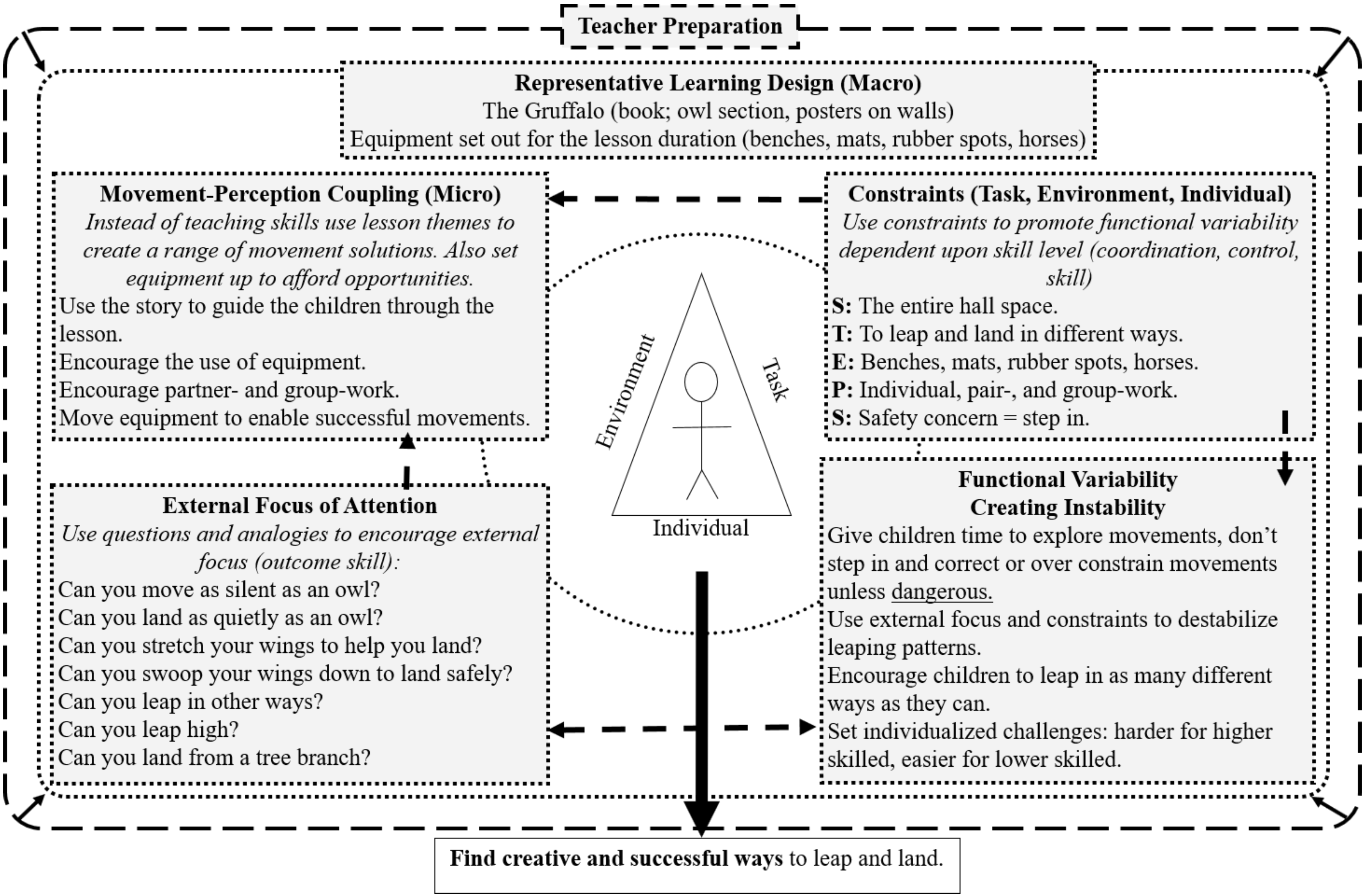


Roll on the mat, move as a spider to get to the bench, walk like an owl with hands open, jump and land with knee bent and arms pointing in the front, move like a rabbit and then jump as a frog on the agility table, from there jump down with legs bent and hands pointing forward.

Cool down

Walking around the space, quietly. Take a seat.
The teacher asks questions about the lesson.

Appendix B: Ecological Dynamics Lesson Plan


Teacher Preparation
Representative Learning Design (Macro)
The Gruffalo (book; owl section, posters on walls)
Equipment set out for the lesson duration (benches, mats, rubber spots, horses)
Movement-Perception Coupling (Micro)
Instead of teaching skills use lesson themes to create a range of movement solutions. Also set equipment up to afford opportunities.
Use the story to guide the children through the lesson.
Encourage the use of equipment.
Encourage partner- and group-work.
Move equipment to enable successful movements.
Constraints (Task, Environment, Individual)
Use constraints to promote functional variability dependent upon skill level (coordination, control, skill)
S: The entire hall space.
T: To leap and land in different ways.
E: Benches, mats, rubber spots, horses.
P: Individual, pair-, and group-work.
S: Safety concern = step in.
Environment
Task
Individual
External Focus of Attention
Use questions and analogies to encourage external focus (outcome skill):
Can you move as silent as an owl?
Can you land as quietly as an owl?
Can you stretch your wings to help you land?
Can you swoop your wings down to land safely?
Can you leap in other ways?
Can you leap high?
Can you land from a tree branch?
Functional Variability
Creating Instability
Give children time to explore movements, don't step in and correct or over constrain movements unless dangerous.
Use external focus and constraints to destabilize leaping patterns.
Encourage children to leap in as many different ways as they can.
Set individualized challenges: harder for higher skilled, easier for lower skilled.
Find creative and successful ways to leap and land.

2

Appendix C: Pedagogical Fidelity Checklist

Item	Lesson Type		Lesson Duration (Divide by 4 to work out quartiles)	Quartiles			
	Pedagogy A	**Sliding Scale**	**Pedagogy B**	**Q1**	**Q2**	**Q3**	**Q4**
1	To support learning of fundamental movement skills, PE teacher/coach will manipulate the child's movements through breaking the skill into component parts.	**1 2 3 4 5**	To support the emergence of functional movement solutions, the PE teacher/coach will manipulate the task or environment but not the child.				
2	Children learn the skill(s) first in closed decontextualized environments then apply new skills in a performance environment.	**1 2 3 4 5**	Movements are always learnt in context (music, storytelling, scenarios or games).				
3	All children transition between activities and task at roughly the same time.	**1 2 3 4 5**	Transitions may be whole class, group of children or individual child and involve manipulations of tasks and activities but could on the surface be quite minor.				
4	PE teacher/coach controls what equipment is used and when it is introduced to the children.	**1 2 3 4 5**	PE teacher/coach allows children to choose which equipment to use and when they want to use it to help with finding solution to the task.				
Teaching Behaviours							
5	Demonstrations of fundamental movement skill by adult or a competent child is the preferred option in a closed environment.	**1 2 3 4 5**	Demonstration are done in context to encourage children to explore unique performance solutions.				
6	The use of verbal instruction is prescriptive and focused on correct technical movement pattern.	**1 2 3 4 5**	Verbal instruction is short and not prescriptive, focused on the environment or task.				
7	Feedback is skill focused and prescriptive to learn ideal template.	**1 2 3 4 5**	Feedback is used to support alternative functional movement solutions.				

Lesson Objectives		**Sliding Scale** **1 2 3 4 5**	
1 Global	PE teacher/coach prescribes children to perform fundamental movement skill or set of fundamental movement skills. Children learn an optimal movement template or technique of a particular skill or series of skills	**1 2 3 4 5**	PE teacher/coach creates an environment for children to perform functional movement solutions through interaction with the environment and task. Children learn to explore and interact with their environment to find functional solutions
2 Global	Lesson progression is through clear and linear structure, warm up, drills, game/performance and cool down.	**1 2 3 4 5**	Lesson evolves through storytelling, scenarios or games.

Tables

Table 1

Compilation of Teaching Characteristics for the Seven Environmental Dimensions

Environmental dimension	Teaching/coaching characteristic
Autonomy support	Acknowledges feelings and perspective, provides meaningful choices, emphasises intrinsic task interest, provides rationales for tasks, constraints, and requests, provides opportunities for input, encourages initiative taking (Smith, Tessier, Tzioumakis et al 2015)
	Listening, creating time for independent work, opportunities for students to talk, praising signs of improvement and mastery, encouraging effort, offering progress-enabling hints, responsive to students' questions and comments (Reeve and Jang 2006)
	Asks questions, pays attention to what students say, provides choice, provides opportunities for independent practice (Haerens, Aelterman, Van den Berge et al 2013)
Relatedness support	Individualised conversation, task-related support, promoting cooperation and teamwork, teacher enthusiasm, teacher awareness, teacher care, general friendly communication (Sparks, Dimmock, Lonsdale and Jackson 2016; Sparks, Dimmock, Whipp, Lonsdale and Jackson 2015)
	Unconditional regard, engages in non-instructional conversation, a warm and constructive positive communication style, actively inclusive, shows care/concern (Smith, Tessier, Tzioumakis et al 2015)
	Being empathic, asks questions, pays attention to students, close proximity between teacher and student, enthusiasm (Haerens, Aelterman, Van den Berge et al 2013)
Structure	Instructs on organisation, provides expectations for learning before, during and after learning process, provides guidance throughout learning process (Smith, Tessier, Tzioumakis et al 2015)
	Provides clear verbal instructions, provides positive feedback, provides clear overview of lesson (Haerens, Aelterman, Van den Berghe et al 2013)
Task-involving	Task-focused competence feedback, explains role importance, emphasises/recognises effort/improvement, encourages cooperative learning (Smith, Tessier, Tzioumakis et al 2015)
Controlling	Intimidation, negative conditional regard, controlling use of rewards, controlling language, devalues player perspective, overt personal control (Smith, Tessier, Tzioumakis et al 2015)
	Monopolises learning materials, provides solutions to problems before students have time to work on the solution, uses controlling words such as "should" and "have to" (Reeve and Jang 2006)
Relatedness thwarting	Shows a lack of care/concern, belittles, adopts a cold and critical negative communication style, actively excludes students from certain activities, restricts opportunities for engagement between students and teacher/coach (Smith, Tessier, Tzioumakis et al 2015)

Ego-involving	Encourages inter/intra-team rivalry, emphasises/recognises superior/inferior ability, punishes mistakes (Smith, Tessier, Tzioumakis et al 2015)

Table 2

Control group observed lesson content over three time points

	Time point Wider content – focus		
School	T1	T2	T3
1	Obstacle course relay – Jump	Object control send and receive – Bean bags	Obstacle course relay - Running
2	Ball games – Mat-ball	Obstacle course relay – Balance component	Obstacle course relay – Running
3	Tag games – “Foxes and rabbits”	Object control send and receive – Different passages with the ball	Tag games – “Jail break”

Note. T1=Time1, T2=Time2, T3=Time3

Table 3

The number of observed lessons for each practitioner within each approach.

	Pedagogical approach		
	Ecological	IPT	Control
Practitioner	No. of lessons		
1	3		
2	7		
3	4	2	
4		9	
5	1	4	
6			4
7			3
8			6
9			2

Note. No.= Number, IPT = Information Processing Theory

Table 4

Means and standard deviations for each category and global item of the fidelity checklist for each intervention group

	Category items Mean (SD)							Global items Mean (SD)	
	1	2	3	4	5	6	7	1	2
Ecological	5.00 (.00)	5.00 (.00)	4.90 (.28)	3.95 (.78)	4.05 (.77)	4.73 (.41)	4.58 (.43)	5.00 (.00)	5.00 (.00)
IPT	1.40 (.64)	1.48 (.85)	1.20 (.41)	1.77 (.94)	1.20 (.41)	1.63 (.88)	1.63 (075)	1.40 (.74)	1.33 (.82)
Control	2.10 (.83)	2.15 (1.04)	2.19 (.88)	1.44 (.97)	2.33 (.87)	2.21 (.75)	2.50 (.54)	2.00 (1.08)	1.92 (1.11)

Note. Category means were calculated from four scores (per quartile) and across classes per group, global means resulted from one score per item across classes per group. Scoring ranged from 1-5[1]
SD = Standard Deviation, IPT = Information Processing Theory

[1] Scores lay along a sliding scale with 1-2 aligning with pedagogy A (IPT) and 4-5 aligning with pedagogy B (ecological). A score of 3 aligned with neither pedagogy A or B. Coders were blinded to which pedagogy each lesson was supporting. Therefore, mean scores under 3 were more likely to be supportive of pedagogy A and mean scores over 3 were more likely to be supportive of pedagogy B.

Table 5

Means and standards deviations of empowering and disempowering environmental dimensions and overall hierarchical empowering and disempowering climates according to intervention approach.

Group (no. classes)	Empowering Environmental Dimensions Mean (SD)				Hierarchical Empowering Construct	Disempowering Environmental Dimensions Mean (SD)			Hierarchical Disempowering Construct
Control[1] (*n*=4)	AS	TI	RS	S		C	EI	RT	
T1	1.69 (.31)	1.06 (.55)	2.44 (.66)	1.94 (.51)	2.00 (.00)	.56 (.24)	.50 (.35)	.38 (.60)	1.00 (.00)
T2	1.75 (.59)	2.00 (.47)	2.35 (.42)	2.00 (.59)	2.00 (.00)	.95 (.33)	.30 (.41)	.20 (.21)	1.00 (.00)
T3	1.10 (.72)	.75 (1.15)	2.90 (.14)	1.50 (.83)	1.80 (.84)	.85 (.42)	.35 (.34)	.35 (.22)	1.00 (.00)
Total Mean (SD)	1.46[(1,2)*] (.29)	1.29 (.44)	2.58 (.18)	1.71[(1,3)**] (.34)	1.92 (.32)	.77 (.08)	.33 (.15)	.31 (.13)	1.00[(1,2)*] (.00)
Ecological[2] (*n*=5)									
T1	2.05 (.21)	1.25 (.31)	2.70 (.33)	2.35 (.29)	2.00 (.00)	.80 (.48)	.10 (.14)	.10 (.22)	1.00 (.00)
T2	2.30 (.41)	1.40 (.22)	2.75 (.35)	1.60 (.49)	2.60 (.55)	.65 (.52)	.10 (.22)	.00 (.00)	.60 (.55)
T3	2.00 (.53)	2.40 (.58)	2.65 (.29)	2.60 (.49)	2.60 (.55)	.60 (.45)	.10 (14)	.25 (.35)	.60 (.55)
Total Mean (SD)	2.12[(1,2; 2,3)*] (.28)	1.68 (.27)	2.70 (.25)	2.18[(2,3)*] (.16)	2.40 (.28)	.68 (.27)	.10 (.11)	.12 (.11)	73[(1,2; 2,3)*] (.15)
IPT[3] (*n*=5)									
T1	1.00 (.18)	1.75 (.68)	1.90 (.78)	2.70 (.41)	1.60 (.55)	.90 (.68)	.40 (.29)	.25 (.43)	1.20 (.45)
T2	1.55 (.60)	2.15 (.58)	2.55 (.62)	2.35 (.58)	2.40 (.55)	.85 (.34)	.45 (.27)	.05 (.11)	1.00 (.00)
T3	1.05 (.72)	1.75 (.68)	2.65 (.34)	2.90 (.22)	2.40 (.55)	1.00 (.43)	.00 (.00)	.10 (.22)	1.00 (.00)

Total Mean (SD)	$1.20^{(2,3)*}$ (.38)	1.88 (.59)	2.37 (.22)	$2.65^{(1,3)**(2,3)*}$ (.27)	2.13 (.38)	.92 (.37)	.28 (.15)	.13 (.15)	$1.07^{(2,3)*}$ (.15)

Note. $^{(1,2)}$ Significant difference between control and ecological, $^{(1,3)}$ Significant difference between control and IPT, $^{(2,3)}$ Significant difference between ecological and IPT
No. = number of, IPT = Information Processing Theory, T1=Time point 1, T2=Time point 2, T3=Time point 3, AS=Autonomy Supportive, TI = Task-Involving, RS = Relatedness Supportive, S = Structure, C = Controlling, EI = Ego-Involving, RT = Relatedness Thwarting, SD = Standard Deviations
$^{*}p < .05$, $^{**}p = .001$

Figures

Figure 1.

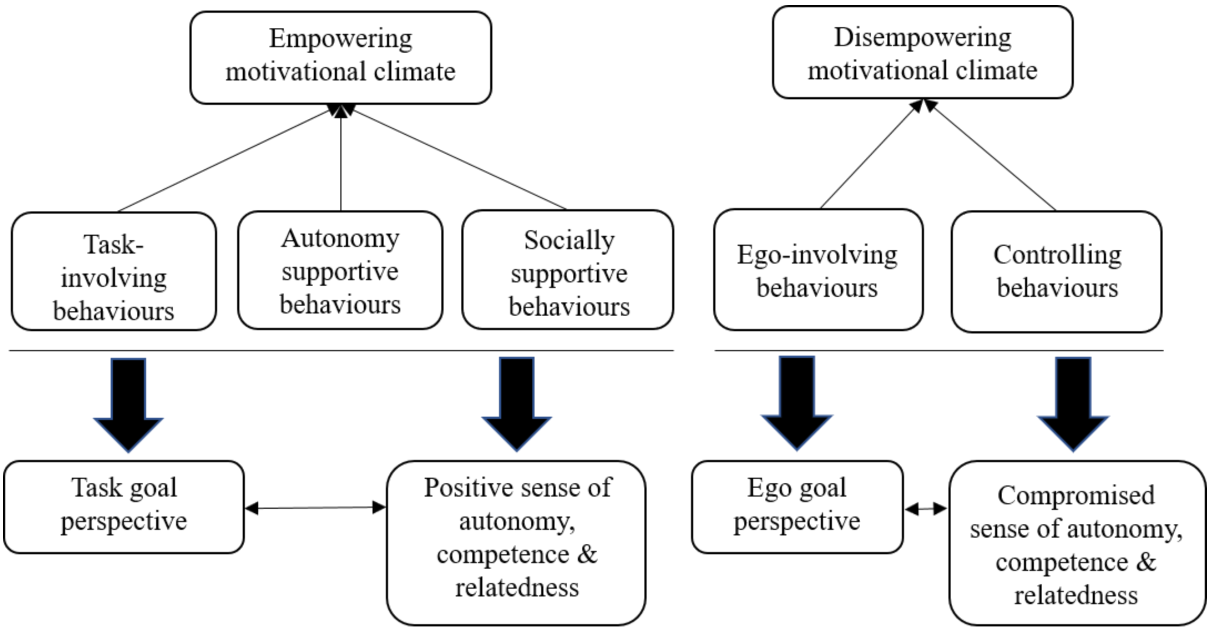


Figure 2.

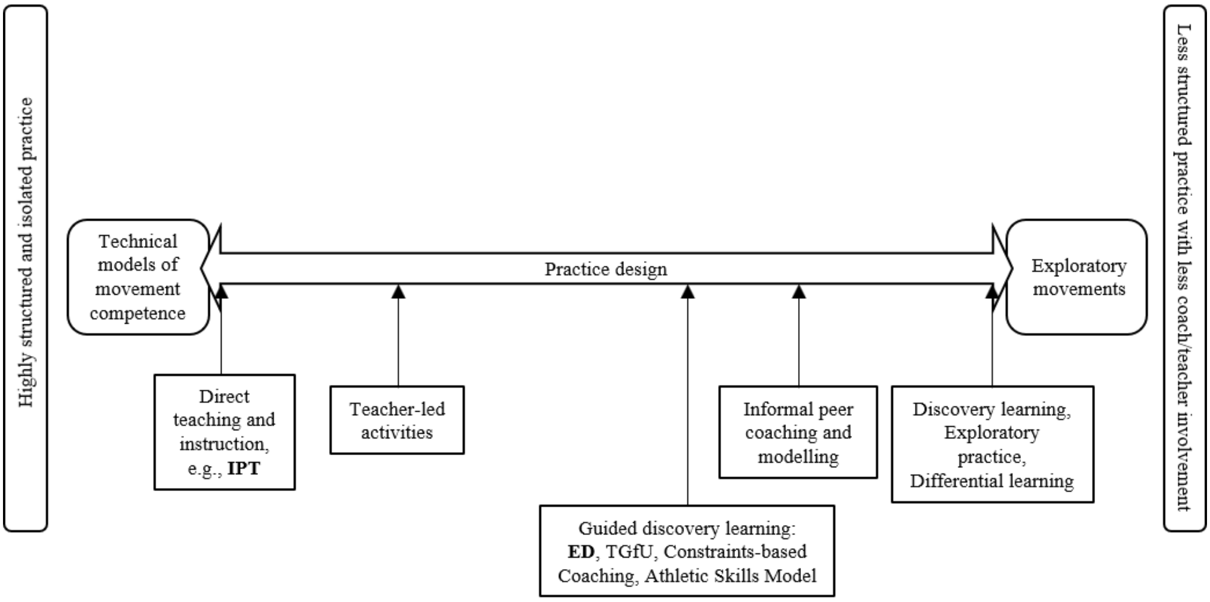
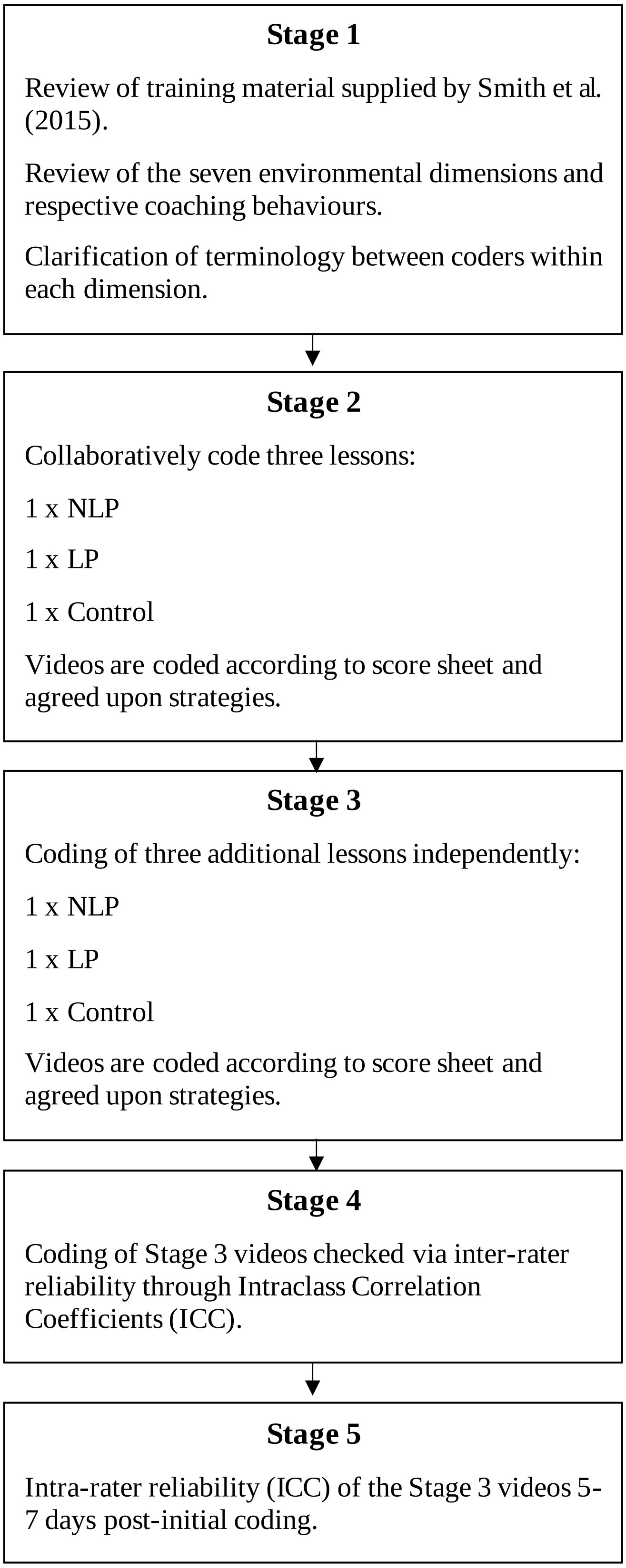

Highly structured and isolated practice
Technical models of movement competence
Practice design
Exploratory movements
Less structured practice with less coach/teacher involvement
Direct teaching and instruction, e.g., IPT
Teacher-led activities
Guided discovery learning: ED, TGfU, Constraints-based Coaching, Athletic Skills Model
Informal peer coaching and modelling
Discovery learning, Exploratory practice, Differential learning

Figure 3.


Stage 1
Review of training material supplied by Smith et al. (2015).
Review of the seven environmental dimensions and respective coaching behaviours.
Clarification of terminology between coders within each dimension.
Stage 2
Collaboratively code three lessons:
1 x NLP
1 x LP
1 x Control
Videos are coded according to score sheet and agreed upon strategies.
Stage 3
Coding of three additional lessons independently:
1 x NLP
1 x LP
1 x Control
Videos are coded according to score sheet and agreed upon strategies.
Stage 4
Coding of Stage 3 videos checked via inter-rater reliability through Intraclass Correlation Coefficients (ICC).
Stage 5
Intra-rater reliability (ICC) of the Stage 3 videos 5-7 days post-initial coding.

Stage 6

Independent coding of a portion of the remaining videos (n=38) by both coders.

Figure Captions

Figure 1. The Empowering and Disempowering Model of Motivational Climate

Note. Adapted from *Empowering and Disempowering Coaching Climates: Conceptualization, Measurement Considerations, and Intervention Implications,* JL Duda and PR Appleton, 2016, p.377, Academic Press

Figure 2. Continuum of affordances within PE and location of varied pedagogical approaches. *Note*. Bolded text emphasises the pedagogical focus within this study.[2]

IPT=Information Processing Theory, ED=Ecological Dynamics, TGfU=Teaching Games for Understanding

Figure 3. Motivation observation measure coder training diagram

[2] Although NLP, TGfU, Constraints-based Coaching, and the Athletic Skills model are placed within the same family of approaches (in terms of pupil outcomes), they are grounded in very different philosophical views of learning (e.g., TGfU grounded in social constructivism).